INNOVATION AND THE LIMITS OF PREDICTIVE GOVERNANCE[†]

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CONTENTS

[†] Invited response to Peter Lee, *Innovation in the Service of Society*, 104 B.U. L. REV. 695 (2024).

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INTRODUCTION

Since the post-war era, when Vannevar Bush championed public investment in science,[1] government funding has served as the quiet engine of U.S. innovation.[2] For decades, a bipartisan consensus held that U.S. progress and well-being depended on the ideas generated in basic scientific laboratories funded by the federal government.[3] This consensus is now fractured. The Trump Administration's deep cuts to science funding exposed the fragility of this post-war settlement.[4] But this disruption has also created an opportunity to critically examine how federal funding structures the U.S. innovation ecosystem and what researchers owe the public when their research is publicly funded.

Peter Lee's Article, *Innovation in the Service of Society*,[5] takes up this challenge. The Article unearths a long-standing but little-studied feature of National Science Foundation ("NSF") grants—the conditioning of grant funding on a requirement that grant applicants provide evidence of their project's "broader impacts"[6]—and argues that this feature should be expanded to other federal agencies.[7] Professor Lee's proposal seeks to nudge investment towards responsible innovation by requiring innovators to disclose potential social

[1] *See* VANNEVAR BUSH, SCIENCE: THE ENDLESS FRONTIER 4 (1945).

[2] *See* Fred Block, *Swimming Against the Current: The Rise of a Hidden Developmental State in the United States*, 36 POL. & SOC'Y 169, 170 (2008) [hereinafter Block, *Swimming*] ("On both sides of the Atlantic, governments have played an increasingly important role in underwriting and encouraging the advance of new technologies in the business economy. . . . In Europe, both national governments and the European Community are open and explicit about their developmental agendas . . . . In the United States, in contrast, the developmental state is hidden . . . ."); Fred Block, *Innovation and the Invisible Hand of Government*, *in* STATE OF INNOVATION: THE U.S. GOVERNMENT'S ROLE IN TECHNOLOGY DEVELOPMENT 1, 3 (Fred Block & Matthew R. Keller eds., 2011) ("For many technologies, it has not been Adam Smith's invisible hand, but the hand of government that has proven decisive in their development."); MARIANA MAZZUCATO, THE ENTREPRENEURIAL STATE: DEBUNKING PUBLIC VS. PRIVATE SECTOR MYTHS 1 (Penguin Books 2024) ("From the Internet to biotech and even shale gas, the US State has been the key driver of innovation-led growth—willing to invest in the most uncertain phase of the innovation cycle and let business hop on for the easier ride down the way.").

[3] *See* Block, *Swimming*, *supra* note 2, at 172 ("Europe and the United States have created . . . a Developmental Network State (DNS)[] [whose] main focus . . . is to help firms develop product and process innovations that do not yet exist, such as new software applications, new biotech medications, or new medical instruments.").

[4] *See* Dan Garisto, *Trump Moves to Slash NSF: Why Are the Proposed Budget Cuts So Big?*, NATURE (June 5, 2025), https://www.nature.com/articles/d41586-025-01749-x; *Trump's Proposed Budget Would Mean 'Disastrous' Cuts to Science*, SCIENCE (May 2, 2025, at 17:40 ET), https://www.science.org/content/article/trump-s-proposed-budget-would-mean-disastrous-cuts-science.

[5] Peter Lee, *Innovation in the Service of Society*, 104 B.U. L. REV. 695 (2024).

[6] *See id.* at 698.

[7] *See id.* at 701.

benefits and harms in their grant or patent applications.[8] The Article's most incisive contribution is its emphasis on the social harms wrought by technological innovation and the failure of the U.S. innovation ecosystem to harness the wealth of information contained in scientific networks to mitigate those harms before they become entrenched.[9]

I share Professor Lee's critique that ex post regulation squanders opportunities to gather private information and to foster early debates about the harms of innovation.[10] But I diverge from his solution. In this Response, I argue that mitigating innovation's harms and fostering socially responsive research requires: (1) understanding the potential for Lee's proposal to chill risky, exploratory research; (2) institutions capable of aggregating and acting on individual-level information; and (3) sociological strategies that embed new norms through epistemic networks rather than top-down mandates.

First, Lee assumes we are better off linking the ex ante allocation of funds to predictions about broader social impacts than generously funding basic research with no strings attached.[11] Put differently, Lee assumes tying funding to predictions about broader social impacts will yield net social benefits because more scientists will reorient their work toward social benefit and mitigation, increasing welfare overall. However, this effect is not the only possible—or even the most likley—outcome. Measuring innovation's costs and benefits may necessarily put a thumb on the scale towards the easily quantifiable, chilling exploratory research whose social benefits are inherently unpredictable and all but impossible to measure.[12]

Second, although Professor Lee's proposal has the clear advantage of eliciting privately held information about innovation's harms and benefits,[13] Lee is too sanguine about the type of information individual researchers can provide. In many cases, evaluating harms and benefits will require a team approach that incorporates not only economic analysis (as Professor Lee recognizes) but also multiple scientific disciplines.[14] Lee's proposal could go further by leveraging information embedded in scientific networks. The real value in bringing

8 *See id.*

9 *See id.* at 703.

10 *See id.* at 723 ("[C]entralized regulation suffers from lags and timing. Such regulation tends to be ex post, reacting after the harms of some technology have manifested.").

11 *See id.* at 729 (framing issue of funding research as problem of assessing proposals rather than issue of allocating more funding to basic research).

12 *See infra* Section II.A.

13 *See* Lee *supra* note 5, at 740 ("[E]mbedding these factors in the broader impacts criterion exploits information distributed among thousands of scientists and engineers applying for NSF grants.").

14 *See id.* at 736-37 ("NSF should incorporate more nonscientists with expertise in research evaluation in review 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. It would also help scientists serving on review panels to understand and apply the criterion." (footnote omitted)).

individual-level information into the open may lie in the ability of relevant actors to aggregate this data and work across institutional boundaries to address what are likely to be similar harms that emerge from many individual proposals.[15]

Third, from a theoretical perspective, Professor Lee describes his proposal as a decentralized form of norm entrepreneurship in which government action—considering the broader social impacts of innovation—can over time shift baseline expectations (or norms) of scientific communities.[16] Whether such a norm will emerge and be internalized or face resistance requires further analysis. How would a new norm of "socially responsive" research interact with "curiosity-based" research?[17] How would this norm impact risk-taking in scientific proposals? What other factors might predict whether this norm is adopted or rejected? Meaningful governance of innovation harms requires new aggregation infrastructures and sociological strategies to embed new community norms in addition to better disclosure.[18]

Part I briefly summarizes the argument; Part II elaborates the three critiques and proposes refinements; Part III concludes.

I. INFORMATION AGGREGATION AS A GOVERNANCE PROBLEM: LEARNING FROM DECENTRALIZED SYSTEMS

Why should the government subsidize innovation? Traditional legal analyses justify governmental incentives to innovate as a correction to the failure of markets alone to foster efficient levels of innovation.[19] At its core, technological innovation involves producing new information that can then be used to make better products or processes. Information, however, is a public good.[20] And public goods are notoriously underproduced by market competition alone.[21]

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[15] *See infra* Section II.B.

[16] *See* Lee, *supra* note 5, at 743-44.

[17] *See id.* at 711 (calling for more "socially responsive science and technology"); *id.* at 718-19 (acknowledging NSF was structured to promote "curiosity-based research" driven by "the conception that science is most robust when subject to minimal regulation").

[18] *See infra* Section II.C.

[19] *See, e.g.*, Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* NAT'L BUREAU OF ECON. RSCH., THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC & SOCIAL FACTORS 609, 609-10 (1962) (theorizing why markets fail to allocate optimal resources for invention); Roberto Mazzoleni & Richard R. Nelson, *Economic Theories About the Benefits and Costs of Patents*, 32 J. ECON. ISSUES 1031, 1034 (1998) (asserting understanding patents as motivating useful invention "unquestionably is the most familiar" patent theory); William Fisher, *Theories of Intellectual Property*, *in* NEW ESSAYS IN THE LEGAL AND POLITICAL THEORY OF PROPERTY 168, 178 (Stephen R. Munzer ed., 2001) (describing "incentive theory" of intellectual property as most common economic approach to patents).

[20] *See* Daniel A. Farber, *Free Speech Without Romance: Public Choice and the First Amendment*, 105 HARV. L. REV. 554, 558 (1991).

[21] *See id.* at 558-59.

Some form of governmental subsidy is needed to prevent the dynamic losses created by copying (and free riding) on others' investments.[22]

Yet another way to think about why the government should intervene in the market for inventions has to do with information disclosure: Precisely because of free riding, private actors have an incentive to keep secret crucial aspects of their innovations.[23] But secret knowledge, while helpful to prevent free riding, also slows innovation, which thrives when multiple actors can build upon existing information.[24] Under these two frameworks, then, governments should intervene to foster both the creation and the disclosure of technological innovation.

These two theoretical frameworks—preventing free riding and promoting information disclosure—have set the stage for legal debates around the ideal *form* of governmental intervention.[25] Governments can grant property rights in information (in the form of intellectual property), subsidize research through grants or tax incentives, or issue prizes for successful research.[26] A classic approach to this debate is to focus on the ability of patents to rely on market signals to efficiently influence the direction of innovation.[27] In contrast, governments rely on bureaucratic decision-making which, the story goes, can never surpass the market's power as an aggregator of individual preferences. This traditional story has old roots: In a classic formulation, Hayek described the core challenge of economic organization as "a problem of the utilization of

[22] *See* Fisher, *supra* note 19, at 178 (explaining government protection for inventor profits "stimulates an increase in inventive activity").

[23] *See* WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 294 (2003) (suggesting "a more illuminating way of thinking about the patent system [than the traditional free riding analysis] is as a response to economic problems inherent in trade secrecy and market structure"); Jeanne C. Fromer, *Patent Disclosure*, 94 IOWA L. REV. 539, 541 (2009) ("Patent law encourages this cumulative innovation, both by dangling the patent right before the inventor as an incentive to invent in the first instance and by requiring him to disclose his invention to the public so that science can progress by building on the divulged knowledge.").

[24] Dominique Foray, David C. Mowery & Richard R. Nelson, *Public R&D and Social Challenges: What Lessons from Mission R&D Programs?*, 41 RSCH. POL'Y 1697, 1700 (2012) ("The social returns to R&D that yields results of wide applicability are likely to be greater when those results are broadly available than when they are restricted.").

[25] *See, e.g.*, LANDES & POSNER, *supra* note 23, at 294.

[26] *See* Daniel J. Hemel & Lisa Larrimore Ouellette, *Beyond the Patents-Prizes Debate*, 92 TEX. L. REV. 303, 307 (2013); W. Nicholson Price II, *Grants*, 34 BERKELEY TECH. L.J. 1, 3-4 (2019).

[27] *See* Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J.L. & ECON. 1, 10 (1969) (explaining patents and penalties for patent infringement create signal directing market investment in other means of innovation); Fisher, *supra* note 19, at 178-79 (describing protections for intellectual property signal to producers what consumers want therefore optimizing patterns of productivity, and citing Demsetz as its major proponent).

knowledge not given to anyone in its totality."[28] Hayek reasoned that markets should generally be preferred to centralized government planning because of their efficiency in aggregating individual preferences through price.[29] In brief, traditional legal analyses set up a dichotomy between the government as suffering from bureaucratic inertia and poor access to accurate information on one hand, and the private market as the nimble aggregator of information on the other.

As further developed in the next few paragraphs, Professor Lee's analysis strikes precisely at this dichotomy. One key takeaway of his Article is this: The aggregation of decentralized information is not the unique province of the market; rather, in some instances, government (or government infrastructure) can more efficiently elicit and aggregate information that resides in networks of innovators.[30] Lee's proposal is an attempt to improve the government's ability to access and aggregate information distributed among individual scientists. In so doing, he implicitly builds upon analyses of innovation that frame the core problem facing technological innovation not as preventing free riding or fostering information disclosure, but rather as a problem of identifying who holds the information necessary to allocate inventive resources effectively.[31]

Professor Lee begins by describing familiar shortcomings of our innovation ecosystem. Because "[t]he overwhelming majority of innovation expenditures are market-based allocations by private actors,"[32] our system underinvests in areas without robust markets—such as developing cures for and treating diseases affecting the poor. And because socially valuable innovations often have diffused or distant private benefits, markets also neglect infrastructure or basic scientific research.[33] While direct government funding is better suited to

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[28] F. A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519, 520 (1945).

[29] *See id.* at 526 ("Fundamentally, in a system where the knowledge of the relevant facts is dispersed among many people, prices can act to coordinate the separate actions of different people . . . .").

[30] *See* Lee, *supra* note 5, at 701-02 (proposing a distributed model of governance which gathers information from inventors); BRETT M. FRISCHMANN, INFRASTRUCTURE: THE SOCIAL VALUE OF SHARED RESOURCES 12 (2012) ("[T]he *social returns* on infrastructure investment and use may exceed the *private returns* because society realizes benefits above and beyond those realized by providers and users.").

[31] *See, e.g.*, Ernest Liu & Song Ma, *Innovation Networks and R&D Allocation* 1 (Nat'l Bureau of Econ. Rsch., Working Paper No. 29607, 2023) (focusing on understudied question of how to "optimally allocate[] scarce resources across sectors to take advantage of cross-sector knowledge spillovers and achieve long-term growth"); Réka Juhász, Nathan J. Lane & Dani Rodrik, *The New Economics of Industrial Policy* 2-4 (Nat'l Bureau of Econ. Rsch., Working Paper No. 31538, 2023) (describing the rise of new economic analysis of industrial policy as centered on flexible public-private partnerships).

[32] Lee, *supra* note 5, at 706.

[33] *See id.* at 707.

support these domains, it is not immune from bureaucratic capture and rent seeking.[34]

Lee's more distinctive contribution lies in foregrounding a question that innovation law scholarship sidesteps, the possibility that some innovations may not be a net positive worth fostering.[35] "Innovation" has a positive ring to it—conjuring up images of progress and ingenuity. But innovation has a dark underbelly: Humankind's ingenuity has also polluted waterways,[36] destroyed natural habitats,[37] and created increasingly costly energy demands.[38] By shifting our attention from innovation's promise to its harms, Lee invites an inquiry into who may be best positioned to anticipate and mitigate those harms. In innovation law scholarship, this inquiry is often overlooked and quickly addressed with references to ex post regulation.[39] Lee's reframing is generative: It leads to an examination of different institutional designs aimed at better aligning innovation with societal benefits.

Professor Lee's core claim is that governmental support for innovation—through grants, but also through the administration of the patent system—should pay more attention to a project's predicted social benefits and harms instead of simply considering its scientific merit.[40] He finds inspiration in the NSF's "broader impacts criterion" for grant funding, a requirement that emerged in 1967 when the NSF began taking into account whether "a laboratory's work resulted in 'tangible social benefits.'"[41] In its present form, codified in the CHIPS and Science Act of 2022,[42] the "broader impacts" criteria requires grant evaluators to consider both "the research proposal's social benefits" and the "ethical and societal considerations," which include possible harms to society and mitigation strategies.[43] Professor Lee's proposal expands upon the actual "broader impacts" criteria by disaggregating "broader impacts" into three

[34] *See id.*

[35] *See id.* at 708-10.

[36] *See* Li Lin, Haoran Yang & Xiaocang Xu, *Effects of Water Pollution on Human Health and Disease Heterogeneity: A Review*, 10 FRONTIERS ENV'T SCI., June 30, 2022, at 1, 1.

[37] *See* Colin G. Scanes, *Human Activity and Habitat Loss: Destruction, Fragmentation, and Degradation*, *in* ANIMALS AND HUMAN SOCIETY 451, 451 (Colin G. Scanes & Samia R. Toukhsati eds., 2018).

[38] *See* Alex de Vries, *The Growing Energy Footprint of Artificial Intelligence*, 7 JOULE 2191, 2191-92 (2023).

[39] This phenomenon has spawned efforts to conceptualize a framework for how to develop ex post regulation. *See* Rebecca Crootof & BJ Ard, *Structuring Techlaw*, 34 HARV. J.L. & TECH. 347, 348-51 (2021); *see also* Brian Galle, *In Praise of Ex Ante Regulation*, 68 VAND. L. REV. 1715, 1729-30 (2015) (noting academic consensus that "government's lack of information [about the distribution of costs and benefits] usually counsels in favor of ex post regulation").

[40] *See* Lee, *supra* note 5, at 702-03.

[41] *Id.* at 730.

[42] CHIPS and Science Act of 2022, Pub. L. No. 117-167, 136 Stat. 1366.

[43] *See* Lee, *supra* note 5, at 732.

factors: (1) social benefits; (2) social harms; and (3) distributional effects.[44] He then further suggests that "broader impacts" evaluation should be a component not only of grant review but also of peer reviews for scientific journals and conferences, as well as an element in the Patent and Trademark Office's ("PTO") review process.[45]

In Lee's reformulation, the tripartite "broader impacts" criteria serve as an information-forcing mechanism that conditions funding, conference attendance, and patents on disclosing private information about an invention.[46] It is in this sense that Lee's proposal is about decentralized innovation. Because a large number of networked scientists routinely apply for grants and conference presentations, this information-forcing mechanism has the potential for revealing *early* in the lifecycle of a project valuable hidden information about its social value and potential harms. This could be particularly impactful for harm mitigation because current ex post approaches rely on centralized regulation where technological solutions to harms are not necessarily in conversation with those who developed the technology that caused the harm in the first place.[47] In addition to providing potentially actionable proposals for harm reduction, Lee also posits that over time the requirement to understand the social benefits and distributional outcomes of research projects will lead to a new scientific social norm that prioritizes socially beneficial research.[48] Government grants for scientific research then serve as a kind of scaffold around which new social practices and eventually social norms can emerge.

With this proposal, Professor Lee makes an important contribution to a small but growing body of legal scholarship that reframes innovation not just as a problem of incentives, but of information: how to access, aggregate, and act on

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[44] *See id.* at 737-40.

[45] *See id.* Parts V, VI.

[46] *See id.* at 726-27.

[47] *See* Wendy E. Wagner, *Commons Ignorance: The Failure of Environmental Law to Produce Needed Information on Health and the Environment*, 53 DUKE L.J. 1619, 1623-25 (2004) (arguing absence of ex ante information-forcing mechanisms leads to reactive, rather than preventive, regulation); Joel Tickner & David Kriebel, *The Role of Science and Precaution in Environmental and Public Health Policy*, *in* IMPLEMENTING THE PRECAUTIONARY PRINCIPLE: PERSPECTIVES AND PROSPECTS 42, 45 (Elizabeth Fisher, Judith Jones & René von Schomberg eds., 2006) (emphasizing need for interdisciplinary and anticipatory science to identify and mitigate harms upstream, rather than relying solely on ex post regulatory responses); Jack Stilgoe, Richard Owen & Phil Macnaghten, *Developing a Framework for Responsible Innovation*, 42 RSCH. POL'Y 1568, 1569 (2013) (arguing traditional, post hoc models of governance focus on accountability for harms after they occur but are ill-suited to innovation contexts where uncertainty and technological lock-in make retrospective regulation inadequate).

[48] *See* Lee, *supra* note 5, at 747 ("[G]overnment action can lead to a norm of socially responsive science among researchers and scientific institutions.").

socially relevant knowledge.[49] Like others in this emerging literature, Lee focuses on scientific networks as the locus of that information.[50] In what follows, I build on Lee's insights by probing the limits of this approach and proposing refinements aimed at realizing its potential without chilling exploratory science or over relying on individual researchers.

II. BROADER IMPACTS ASSESSMENTS: THREE CRITIQUES

A. *Framing the Problem: The Limits of Predictive Governance*

In his critique of centralized innovation systems, Professor Lee emphasizes the unpredictability of basic scientific research, an unpredictability that resists centralized planning.[51] It is this very resistance that renders ex ante direction inefficient, as it would likely miss opportunities—or more precisely, potential opportunities—for progress that grow out of autonomous, curiosity-driven

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[49] *See, e.g.*, Mazzucato, *supra* note 2, at 9-10 (arguing critics have evaluated efficacy of government investment in innovation too narrowly by ignoring the "crowding in" and "spillover" effects of investment); YOCHAI BENKLER, THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM 3 (2006) (asserting economic development drastically changed after advent of internet, now "decentralized individual action . . . plays a much greater role"); Michael J. Madison, Brett M. Frischmann & Katherine J. Strandburg, *Constructing Commons in the Cultural Environment*, 95 CORNELL L. REV. 657, 659-64 (2010) (theorizing how groups of people using formal and informal means create cultures of shared information); Orly Lobel, *The New Cognitive Property: Human Capital Law and the Reach of Intellectual Property*, 93 TEX. L. REV. 789, 792-93 (2015) (explaining controls on human capital like noncompete agreements limit exchange of information). Some of my own work also takes this approach. *See, e.g.*, Laura G. Pedraza-Fariña, *Patent Law and the Sociology of Innovation*, 2013 WIS. L. REV. 813, 820 [hereinafter Pedraza-Fariña, *Sociology of Innovation*] (conceptualizing technological innovation as emerging from communities of practice rather than individual scientists); Laura G. Pedraza-Fariña & Ryan Whalen, *A Network Theory of Patentability*, 87 U. CHI. L. REV. 63, 66 (2020) (proposing network model and measure of breakthrough innovation); Laura G. Pedraza-Fariña, *Spill Your (Trade) Secrets: Knowledge Networks as Innovation Drivers*, 92 NOTRE DAME L. REV. 1561, 1562 (2017) [hereinafter Pedraza-Fariña, *Knowledge Networks*] (modeling innovation as networked process of information exchange).

[50] *See* sources cited *supra* note 49. Many of Professor Lee's prior works take a similar approach. *See, e.g.*, Peter Lee, *Patent Law's Externality Asymmetry*, 43 CARDOZO L. REV. 1923, 1990-93 (2022) (suggesting patent law should mandate inventors disclose potential harms arising from their inventions by including societal impact statement); Peter Lee, *Innovation and the Firm: A New Synthesis*, 70 STAN. L. REV. 1431, 1435-37 (2018) (integrating organizational and institutional perspectives on how firms manage, share, and govern technological knowledge, and moving beyond incentive-based accounts); Peter Lee, *Toward a Distributive Commons in Patent Law*, 2009 WIS. L. REV. 917, 922-24 (arguing patent law should promote not only private appropriation but also broad distribution and recombination of technical knowledge by cultivating "distributive commons" for cumulative innovation).

[51] *See* Lee, *supra* note 5, 716-17.

inquiry.[52] Centralized or pre-planned science also risks politicizing the scientific enterprise by aligning the goals of the scientist with the goals of the state—or, more troublingly, the goals of whichever political actors hold power at a given moment.[53] Deprived of their autonomy, scientists may lose the freedom to pursue questions guided by unbridled curiosity about the workings of our world.

Lee presents his decentralized broader impacts proposal as an improvement over these centralized models, which aim to steer science toward socially beneficial outcomes.[54] He argues that requiring scientists to articulate the social impact of their work—and to propose steps to mitigate associated harms—is less constraining than centralized models.[55] On his account, this approach not only preserves scientific autonomy, but also leverages dispersed information about the likely effects of a given project: information that is accessible to scientists but unavailable to centralized bureaucracies.[56]

However, it is not clear that conditioning grant approvals on articulated benefits and harms, in particular when it comes to upstream or basic scientific research, can meaningfully escape the risks of centralized planning. Precisely because such research is inherently unpredictable, the potential benefits and harms it may produce are extremely difficult to assess in advance, nearly impossible to quantify, and even less amenable to mitigation at the time a specific grant proposal is being reviewed. Depending on how much weight is assigned to such ex ante measurements, these requirements risk distorting the funding process. Indeed, incorporating broader impacts into grants risks succumbing to myopia. Projects more amenable to precise measurement may outcompete basic, curiosity-driven efforts aimed at understanding fundamental mechanisms whose relevance remains undetermined.

An example of what we may call this "quantification fixation" or "trust in numbers"[57] influenced funding in global health projects. In the history of global health, donor organizations' emphasis on measurable-impact programs shifted

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[52] *See id.* at 719.

[53] *See id.* at 721-22.

[54] *See id.* at 724.

[55] *See id.* at 727-28.

[56] *See id.* at 728-29.

[57] *See* Linda W. Chang, Erika L. Kirgios, Sendhil Mullainathan & Katherine L. Milkman, *Does Counting Change What Counts? Quantification Fixation Biases Decision-Making*, 121 PROCS. NAT'L ACAD. SCIS. OF THE U.S. 1, 1-2 (2024) https://www.pnas.org/doi/10.1073/pnas.2400215121 [https://doi.org/10.1073/pnas.2400215121] (arguing "people tend to value even superfluous metrics in decision-making, overlooking their irrelevance and failing to dwell on what a number does not represent"); THEODORE M. PORTER, TRUST IN NUMBERS: THE PURSUIT OF OBJECTIVITY IN SCIENCE AND PUBLIC LIFE 5-6 (2020) ("Mapping the mathematics onto the world is always difficult and problematic. Critics of quantification in the natural sciences as well as in social and humanistic fields have always felt that reliance on numbers simply evades the deep and important issues.").

investments towards easily measurable technologies (such as drugs and specific artifacts like mosquito nets) and away from preventive health services.[58]

Unpredictable basic scientific research, upstream from applied technologies, is particularly susceptible to this type of quantification fixation. A look back at basic scientific projects that turned out to have an outsized impact on society, reveals that many of them were not initially considered particularly groundbreaking as their effects on society were hard to predict and to quantify ex ante. Take, for example, the discovery of global warming—the type of complex phenomena that Lee emphasizes as under incentivized in our current innovation ecosystem.[59] The scientific shift in the late 1960s to focusing on global warming as a significant problem emerged from the aggregation of observations and studies made in very different subject areas—all of them outside climate science and originally not even designed to measure climate change.[60] Studies of nuclear weapons yielded crucial data on infrared absorption.[61] Techniques first developed for archaeological radiocarbon dating unexpectedly became foundational for later climate science, including identifying fossil-fuel carbon dioxide through its depleted C-14 signature.[62] And concerns about nuclear waste disposal led to findings about the movement of carbon dioxide from the atmosphere to the ocean and the discovery of the ocean's more limited capacity to act as a carbon sink than initially predicted.[63] In short, basic scientific research often has unpredictable, diffuse spillovers in disciplines far afield from the original area of research. Ex ante, it is often impossible to both predict these effects and quantify them.

This critique suggests that broader impacts analysis may be best suited for translational rather than basic research—potentially making the PTO or other agencies downstream from basic scientific research such as the Food and Drug

[58] *See* RANDALL M. PACKARD, A HISTORY OF GLOBAL HEALTH: INTERVENTIONS INTO THE LIVES OF OTHER PEOPLE 311 (2016) ("By privileging those things that can be counted, such as the numbers of pills taken, vaccines administered, and nutritional supplements provided, evidence-based public health contributed to the search for biomedical solutions to health problems and to the further medicalization of global health.").

[59] *See* Lee, *supra* note 5, at 706.

[60] *See* William Glen, *A Triptych to Serendip: Prematurity and Resistance to Discovery in the Earth Sciences*, *in* PREMATURITY IN SCIENTIFIC DISCOVERY: ON RESISTANCE AND NEGLECT 92, 93-94 (Ernest B. Hook ed., 2002) ("The 1960s marked a shift in understanding and interpretation of warming. . . . [T]his scientific turn was a lucky break, because it resulted from research that was aimed at entirely different questions—in short, the rediscovery of the global-warming problem was serendipitous.").

[61] *See* Paul N. Edwards, *Entangled Histories: Climate Science and Nuclear Weapons Research*, 68 BULL. ATOMIC SCIENTISTS 28, 37 (2012).

[62] *See* Emily M. Kern, *Archaeology Enters the 'Atomic Age': A Short History of Radiocarbon, 1946-1960*, 53 BRIT. J. HIST. SCI. 207, 212-16 (2020) (discussing collaboration between archeologists and physicists in demonstrating efficacy of carbon dating).

[63] *See* JACOB DARWIN HAMBLIN, POISON IN THE WELL: RADIOACTIVE WASTE IN THE OCEANS AT THE DAWN OF THE NUCLEAR AGE 92-93 (2008).

Administration ("FDA") ideal institutions to implement broader impacts assessments. Professor Lee considers this objection in part, acknowledging that basic research can generate significant externalities and that "social benefit is notoriously difficult to measure."[64] His proposal, however, leans into economic cost-benefit analyses, precisely the type of quantification that may put a thumb on the scale towards easily measurable, less risky projects.[65] Professor Lee puts the onus of articulating basic science's significant positive externalities on researchers. And as the story of climate research illustrates, in many cases, positive externalities are not visible to researchers until after the fact.

Above all, the danger of chilling basic research calls for more empirical data. Most existing evaluations of the NSF's broader impacts requirement focus on its earlier iteration, before its recent statutory update.[66] Far more data is needed before extending Lee's model to other agencies. We need answers to key questions: Early data suggested resistance among scientists, what was the source of this resistance and has it continued or abated as the NSF refined its standard? What kinds of proposals have been funded or rejected based on broader impacts criteria? Have any harm mitigation strategies been implemented?

B. *The Limits of Decentralized Expertise: Infrastructure and the Role of Institutional Collaboration in Fostering Socially Responsive Innovation*

Scientists and inventors often have important information about their research projects that is not made public. Sharing this information with the public to further scientific progress and to mitigate potential harms are the clear advantages of information-forcing mechanisms.[67] In many ways, as Professor Lee acknowledges, scientists are in the best position to understand the broader social benefits and harms of their innovations and to design mitigation strategies.[68] Identifying this information earlier in the lifecycle of an innovation has clear social benefits. However, individual grantees will likely be unable to appreciate the full extent of social benefits and harms or possess the technological expertise to develop effective harm reduction proposals, particularly for complex problems with the potential for both immense social benefits and harms.

Returning to the earlier climate change example, fully understanding mechanisms of climate change required expertise that spanned several disciplines housed in distinct innovation communities, including physics,

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[64] Lee, *supra* note 5, at 738.

[65] *See id.*

[66] *See id.* at 733-34 (acknowledging "as presently structured, the broader impacts criterion has delivered mixed results and received significant criticism," and citing several reports criticizing initiative).

[67] *See* Pedraza-Fariña, *Knowledge Networks*, *supra* note 49, at 1562 (modeling innovation as product of a network process); Tickner & Kriebel, *supra* note 47, at 45 (arguing sharing information across disciplines and throughout inventive process would improve regulation).

[68] *See* Lee, *supra* note 5, at 729.

chemistry, geology, and archeology.[69] Harm mitigation strategies in climate change similarly require diverse boundary-crossing expertise. What is needed, then, is not only a mechanism of information disclosure, but also one of information exchange across relevant communities and of aggregation of relevant information.

Professor Lee's proposal highlights the value of eliciting privately held information about potential harms and benefits.[70] But it relies on centralized actors—grant reviewers, conference organizers, and patent examiners—to interpret and act on that information.[71] This overlooks two critical limitations. First, these centralized actors likely lack the subject-matter expertise to fully grasp the implications of the disclosures, particularly in complex domains. Second, and more importantly, the information elicited is not systematically aggregated, circulated, or returned to the scientific communities that produced it.

What is needed is the creation of infrastructure to both aggregate information and return that information to the decentralized communities from whence it emerged, creating a potentially virtuous cycle between centralized aggregation and decentralized production and analysis. Agencies could create shared databases tracking the benefits and harms of different projects, encouraging individual scientists to consult those databases for future submissions, and even earmarking grants for creative, collaborative projects across disciplinary boundaries for harm mitigation. Conference organizers could plant the seeds of collaboration and discussion by holding separate panels on social impacts and harm mitigation strategies. The biggest contribution of integrating a "broader impact" criterion into conference submissions may be in the myriad hallway conversations and collaborations about social harms and benefits that it might spark.

C. *The Emergence of and Resistance to Scientific Social Norms*

The success of embedding a broader impacts requirement into grant and patent applications, as well as journal and conference submissions, relies in large part on the willingness of the scientific community to take this requirement seriously and incorporate it into their background practices. Otherwise, the requirement risks being seen as another top-down, burdensome bureaucratic hurdle, bearing little relationship to what really matters for scientific research. Professor Lee relies on theories of norm entrepreneurship to argue that the

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[69] *See supra* notes 60-63.

[70] *See* Lee, *supra* note 5, at 740 (highlighting gatekeeper emphasis on broader social "exploits information distributed among thousands of scientists" and likely would generate "ideas for research projects to enhance social welfare that would never occur to centralized policymakers").

[71] *See id.* at 725 (proposing "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").

government can act as a norm entrepreneur by "actively defining and promulgating communal norms."[72] But governmental entrepreneurship may not be enough for this new norm to take root. New norms often require credible anchoring by respected peers and validation from high-status actors within the field.[73]

Before concluding that the government will, in fact, succeed as a norm entrepreneur in this space, however, I suggest that three questions must be addressed. First, we need to understand the reported initial resistance from scientists to the "broader impacts" criteria.[74] This resistance may presage the emergence of what the literature has called "norm antipreneurs."[75] In the norms literature, antipreneurs are predicted to have a tactical advantage when a new, emerging norm is challenging a well-established norm.[76] Importantly, for Lee's proposal, we may be able to predict whether there will be resistance or wide acceptance to a "broader impacts" assessment by gathering or consulting empirical data about NSF implementation.

Second, as explored in Part I, there is a potential conflict between the existing norm of "curiosity-driven research" and a new norm that nudges scientists towards socially beneficial research and harm reduction. A potential clash of norms would make it more likely that norm antipreneurs will emerge and weaken the adoption of the new norm.[77] Then again, this clash may be a good thing. As discussed in Part I, it may be the case that evaluating basic scientific research based on its broader social impacts is not the unmitigated good that it may at first glance appear to be.

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[72] *See id.* at 743.

[73] *See* Laura G. Pedraza-Fariña, *COVID-19 and Boundary-Crossing Collaboration*, *in* INTELLECTUAL PROPERTY, COVID-19, AND THE NEXT PANDEMIC: DIAGNOSING PROBLEMS, DEVELOPING CURES 86, 104 (Haochen Sun & Madhavi Sunder eds., 2024) (arguing breakthrough innovation often requires "involvement of a high-status intellectual actor, or an 'anchor tenant' (such as a university or research institute), with a high degree of trustworthiness and a network of preexisting relationships that can increase trust and mitigate the risk of boundary-crossing projects"); Scott Frickel & Neil Gross, *A General Theory of Scientific/Intellectual Movements*, 70 AM. SOCIO. REV. 204, 211 (2005) (arguing emergence and stabilization of new scientific norms often require leadership and endorsement by high-status actors within epistemic communities).

[74] *See* Lee, *supra* note 5, at 733-34.

[75] *See* Alan Bloomfield, *Norm Antipreneurs and Theorising Resistance to Normative Change*, 42 REV. INT'L STUD. 310, 311 (2016) (theorizing literature discussing norm change has failed to understand actors who organize around defending normative status quo).

[76] *See id.* at 312 (arguing "institutional context matters; specifically, the degree to which the normative status quo is *entrenched* or *institutionalised* matters profoundly because antipreneurs enjoy special strategic and tactical advantages when defending entrenched norms" (emphasis in original)).

[77] *See id.*

Finally, sociological studies on norm emergence suggest a number of factors are needed for norms to emerge and crystalize.[78] Many of these factors relate to the interplay between the concepts of trust and authority.[79] More specifically, existing norms are usually enforced and promulgated by a "core set" of actors.[80] Similarly, backing of emerging norms by a "high status" intellectual actor can go a long way into enhancing a norm's acceptance in a given community.[81] Given Lee's reliance on norms as an adoption and enforcement mechanism, it will be important to understand: (1) What is the source of the initial resistance? (2) In areas where the norm has been taken up (such as in the A.I. research case study discussed by Professor Lee),[82] what are the mechanisms of norm adoption? More specifically, was there original resistance to the norm and how was it overcome? (3) And, lastly, whether federal agencies and conference organizers or peer reviewers may need to recruit and mobilize core sets of scientists and high-status intellectual actors to enhance the adoption of a new norm.

CONCLUSION: INNOVATION GOVERNANCE AT A CROSSROADS

Professor Lee's Article, *Innovation in the Service of Society*, prompts us to rethink what scientists owe the public when engaging in government-supported innovation. His most powerful contribution is to foreground two underexplored hurdles to socially beneficial innovation: Innovation can produce serious social harms, and these harms often go unmitigated because we fail to identify and act on early distributed signals of risk. Departing from the standard focus on free riding and information disclosure, Lee reframes innovation governance as a problem of asymmetric information—how to surface and act on knowledge embedded in decentralized scientific networks. His proposal seeks to extract this latent knowledge by conditioning grant funding, publication, conference access,

[78] *See generally* Stephanie Plamondon Bair & Laura Pedraza-Fariña, *The Sociology and Psychology of Innovation: A Synthesis and Research Agenda for Intellectual Property Scholars*, 60 HOUS. L. REV. 261, 265-73 (2022) (summarizing sociological and psychological studies that sought to understand how communities of researchers and artists develop and maintain social norms to organize their work).

[79] *See id.* at 267-68 (highlighting role trust plays in building productive networks); Pedraza-Fariña, *supra* note 73, at 104 (arguing emerging norms often need endorsement from community leadership).

[80] *See* Pedraza-Fariña, *Sociology of Innovation*, *supra* note 49, at 821 ("What constitutes legitimate lines of research or credible experimental designs often depends on the opinion of a 'core-set' of practitioners within the discipline. Opposition from such a core-set can create powerful social barriers to innovation.").

[81] *See* Laura G. Pedraza-Fariña, *Constructing Interdisciplinary Collaboration: The Oncofertility Consortium as an Emerging Knowledge Commons*, *in* GOVERNING MEDICAL KNOWLEDGE COMMONS 259, 263 (Katherine J. Strandburg, Brett M. Frischmann & Michael J. Madison eds., 2017) (arguing success of interdisciplinary research programs often rely on a leader with "high degree of trustworthiness" and "a network of preexisting relationships" with program participants).

[82] *See* Lee, *supra* note 5, at 747-49.

and accelerated patent review on disclosures of social benefit, harm, and distributional impact. In doing so, Lee opens a generative path forward—one that views innovation governance as the construction of informational infrastructure capable of aligning innovation with public values.

But, as this Response has argued, this path forward must consider the complexity of scientific ecosystems and the limitations of predictive governance. Conditioning research funding on *quantifiable* assessments of social benefit risks chilling exploratory research, whose full social benefits are radically unpredictable and only legible in hindsight. For this reason, I have suggested that the proposal is better suited for translational research, and for applications in agencies that deal with innovations that are closer to a commercial product, such as the PTO or the FDA. Paradoxically, despite celebrating decentralized governance, Lee's proposal ends up channeling information from distributed networks into centralized bureaucratic agencies. This approach could benefit from some additional refinements. First, centralized agencies should serve as infrastructure to aggregate and collate information but then loop this aggregated information back to decentralized scientific networks for analysis and critique, creating a virtuous feedback process. If innovation is indeed a governance problem of distributed knowledge, then our challenge is not only to elicit more information but to build the institutional scaffolding that makes that information actionable. And, second, if the ultimate goal is to shift scientific norms toward greater social responsiveness, this scaffolding must also include mechanisms for legitimation and diffusion within scientific communities, not just formal mandates from above.