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INNOVATION PRIZES IN PRACTICE AND THEORY

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I. INTRODUCTION

Innovation prizes have long been used as a conceptual foil for the patent system. In recent years, especially, an academic cottage industry has sprung up to compare the relative social welfare benefits of patents, prizes, and to a lesser extent, grants.[1] But prizes are no longer just theoretical objects of academic fancy. Prizes are now actual tools of government innovation policy, thanks to the America COMPETES Reauthorization Act of 2010,[2] which empowered all federal agencies to offer prizes for new technologies.[3] In just five years following the grant of this new authority, thirty agencies conducted over one hundred prize competitions.[4] Yet actual innovation prizes are still not well understood.

The prizes implemented under the COMPETES Act are very different from their theoretical counterparts. Prizes in theory are offered after invention as compensation to inventors, who must place their inventions in the public domain. Prizes in practice are competitions in which the amount of the prize is set before any investments are made and inventors compete to be the first or best to implement a particular goal. This disparity between the scholarly literature and practice has left actual prizes under-studied and under-theorized, leaving policymakers with a range of implementation and governance challenges.

This Article begins to fill these gaps. We use a detailed case study of the Progressive Insurance Automotive X Prize ("Auto X Prize"), a $10 million prize offered for the invention of high fuel-efficiency cars, to develop a deeper understanding of how prizes marshal resources for and can implement governance approaches that overcome the uncertainty and information asymmetries that plague technological innovation.[5] This richer understanding of the role that prizes play as one of a range of programmatic and policy mechanisms in the innovation ecosystem in turn allows us to put forward a stronger theoretical justification for prizes. We argue that prizes are useful institutional

1. *See, e.g.*, Benjamin N. Roin, *Intellectual Property Versus Prizes: Reframing the Debate*, 81 U. CHI. L. REV. 999, 1001–07 (2014) (surveying the "growing number" of academics that have proposed replacing intellectual property systems with prize systems); Daniel J. Hemel & Lisa Larrimore Ouellette, *Beyond the Patents-Prizes Debate*, 92 TEX. L. REV. 303, 326–52 (2013) (proposing a framework for comparing patents, prizes, grants, and research and development ("R&D") tax credits). For an overview of the literatures in economics and law, see *infra* Part I.

2. Pub. L. No. 111-358, 124 Stat. 3982 (2011) (codified in scattered sections of 15, 20, 23, 42, and 51 U.S.C.) [hereinafter "COMPETES Act"].

3. 15 U.S.C. § 3719(b) (2012).

4. *See* OFFICE OF SCI. & TECH. POLICY, IMPLEMENTATION OF FEDERAL PRIZE AUTHORITY: FISCAL YEAR 2014 PROGRESS REPORT 36 (2015) [hereinafter OSTP REPORT].

5. *See infra* Part III.

mechanisms by which the government can achieve exogenously identified technology policy goals. And we articulate a novel framework for identifying when prizes or other mechanisms should be used to accomplish those goals.

Innovation prizes have a long historical pedigree.[6] Most famously, the English Parliament offered £20,000 in 1714 for the development of a method to calculate longitude at sea.[7] Although governments and private entities offered prizes extensively through the 18th and 19th centuries,[8] prizes fell largely by the wayside in the 20th and early 21st centuries, replaced by patents and procurement (in the form of research grants and contracts) as our principal means of incentivizing innovation.[9]

The contemporary renaissance in innovation prizes is often attributed to the X PRIZE Foundation, which in 2004 awarded a $10 million prize to the team that built SpaceShipOne, the first private reusable spacecraft to be launched and returned to Earth twice in two weeks.[10] That competition attracted twenty-six teams that collectively invested $100 million into commercial spaceflight research and arguably jump-started a new industry.[11] Netflix attracted several thousand entrants when it offered a $1 million prize to design a better matching algorithm for its movie recommendations.[12] Platforms such as InnoCentive and TopCoder provide "crowd-contest services" to engage

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6. *See, e.g.*, SUZANNE SCOTCHMER, INNOVATION AND INCENTIVES 9–10 (2004); Fiona Murray et al., *Grand Innovation Prizes: A Theoretical, Normative, and Empirical Evaluation*, 41 RES. POL'Y 1779, 1780–81 (2012). For a detailed catalogue of historical and contemporary innovation prizes, see generally KNOWLEDGE ECOLOGY INT'L, KEI RESEARCH NOTE 2008:1: SELECTED INNOVATION PRIZES AND REWARD PROGRAMS (2008), http://keionline.org/misc-docs/research_notes/kei_rn_2008_1.pdf [http://perma.cc/A44G-USCQ].

7. *See generally* DAVA SOBEL, LONGITUDE: THE TRUE STORY OF A LONE GENIUS WHO SOLVED THE GREATEST SCIENTIFIC PROBLEM OF HIS TIME (1995); Jonathan R. Siegel, *Law and Longitude*, 84 TUL. L. REV. 1 (2009).

8. *See* KNOWLEDGE ECOLOGY INT'L, *supra* note 6; MCKINSEY & COMPANY, "AND THE WINNER IS . . .": CAPTURING THE PROMISE OF PHILANTHROPIC PRIZES 15 (2009); Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137, 1143–44 (1998).

9. The most generous assessment of total prize spending is $1–2 billion. *See* MCKINSEY & CO., *supra* note 8, at 16. By contrast, the federal government spent $49.4 billion on R&D in 2011, and the private sector spent $294 billion. *See* NATIONAL SCI. FOUND., SCIENCE AND ENGINEERING INDICATORS 2014, at 4–8 tbl.4-1 (2014).

10. *See* Alan Boyle, *SpaceShipOne Wins $10 Million X Prize*, NBC NEWS (Oct. 5, 2004), http://www.nbcnews.com/id/6167761/ns/technology_and_science-space/t/spaceshipone-wins-million-x-prize/#.VM1DFmTF_wy [https://perma.cc/2TH6-PNEV].

11. *See Ansari XPRIZE*, X PRIZE FOUND., http://space.xprize.org/ansari-x-prize [https://perma.cc/35D6-WKXH]; *see also* Mike Wall, *How SpaceShipOne and X Prize Launched Commercial Spaceflight 10 Years Ago*, SPACE.COM (Oct. 3, 2014), http://www.space.com/27339-spaceshipone-xprize-launched-commercial-spaceflight.html [https://perma.cc/H9WV-Z255].

12. Steve Lohr, *Netflix Awards $1 Million Prize and Starts a New Contest*, N.Y. TIMES (Sept. 21, 2009), http://bits.blogs.nytimes.com/2009/09/21/netflix-awards-1-million-prize-and-starts-a-new-contest [https://perma.cc/MZ97-CBSC].

participants in a blend of innovation prizes and crowdsourcing.[13] All told, McKinsey & Company recently estimated the total "prize sector" to be "worth as much as $1 to $2 billion."[14]

These private sector efforts served as models for a new generation of government-sponsored innovation prizes. The Obama administration made prizes a key part of its National Strategy for American Innovation in 2009,[15] and Congress responded in 2010 when it passed the COMPETES Act. The statute grants all federal agencies the authority "to award prizes competitively to stimulate innovation that has the potential to advance the mission of the respective agency."[16] Federal agencies as diverse as the Department of Energy, the Department of Housing and Urban Development, the Federal Trade Commission, the National Endowment for the Arts, and the Department of Transportation have offered at least one hundred prize competitions under the authority of the COMPETES Act.[17] Nine of the COMPETES Act challenges in fiscal year 2014 had prize purses worth more than $100,000.[18] Government-sponsored innovation prizes appear to be gaining popularity among lawmakers: As of this writing, the House of Representatives has passed a bill which would expand the use of prizes even further by creating a dedicated biomedical prize innovation fund for the National Institutes of Health.[19]

An example of a COMPETES Act prize is the My Air, My Health challenge, in which the Environmental Protection Agency and the Department of Health and Human Services jointly sought an innovative solution to connect timely, location-specific air pollution data with human health measurements to provide a detailed picture of the effect that air quality has on individual health.[20] Over five hundred competitors submitted design proposals for low-cost sensors that could be worn or carried and that would integrate air quality measurements and health data.[21] Four finalists were awarded $15,000 each

13. *See, e.g.*, Kevin J. Boudreau & Karim R. Lakhani, *Using the Crowd as an Innovation Partner*, HARV. BUS. REV., Apr. 2013, at 61, 64 (2013).

14. MCKINSEY & CO., *supra* note 8, at 16.

15. *See* OFFICE OF SCI. & TECH. POLICY, A STRATEGY FOR AMERICAN INNOVATION: DRIVING TOWARDS SUSTAINABLE GROWTH AND QUALITY JOBS 17–19 (Sept. 2009), https://www.whitehouse.gov/assets/documents/SEPT_20__Innovation_Whitepaper_FINAL.pdf [https://perma.cc/G5HT-NXSR].

16. 15 U.S.C. § 3719(b) (2012).

17. *See* OSTP REPORT, *supra* note 4, at 7, 36.

18. *See id.* at 42–49. Some prizes are much larger, as much as $10 million. *Id.*

19. *See Actions Overview: H.R. 6 - 114th Congress (2015–2016): 21st Century Cures Act*, CONGRESS.GOV, https://www.congress.gov/bill/114th-congress/house-bill/6/actions [https://perma.cc/EW24-8ZU5].

20. *My Air, My Health: An HHS/EPA Challenge*, INNOCENTIVE (June 5, 2012), https://www.innocentive.com/ar/challenge/9932947 [https://perma.cc/BSL5-QWLB].

21. *My Air, My Health Challenge*, NAT'L INST. OF ENVTL. HEALTH SCIS., https://www.niehs.nih.gov/funding/challenges/myair_myhealth/index.cfm [https://perma.cc/H2MW-733Z].

and asked to develop working prototypes.[22] The $100,000 prize was awarded to the team that developed Conscious Clothing, a "wearable, breathing analysis tool that calculates the amount of particulate matter a person inhales."[23]

The existing theoretical literature mostly ignores these actual innovation prizes. Instead, (often after invoking famous historical prizes in the introduction[24]) the economics literature focuses on a very different kind of "prize" — an economic model of compensation for inventors after their inventions are placed in the public domain.[25] In theory, if the government could set the amount of the award correctly, such a system would result in optimal incentives to invent without the deadweight loss associated with exclusive rights. But doing so presents significant information problems. Much academic work therefore attempts to define the conditions in which the government might obtain accurate information about the value of the invention so that it can set the appropriate price of the ex post reward.[26] This literature also compares the social welfare effects of prizes, patents, and grants under different assumptions about the information environment.[27] This model of prizes, however, has never been attempted at a significant scale in practice.[28] To the extent that the economic literature has anything to say about COMPETES Act- and Longitude-type prizes, it is negative.[29]

One might expect the policy literature to provide a thicker justification. However, at best, this literature identifies rules of thumb for determining when prizes might be useful policy interventions. It fails to directly engage with the problems of managing and governing innovation prizes.[30] History suggests those problems are substantial. Take, for example, the Longitude Prize. The economic operation of the prize was and remains easy to state: an award of £20,000 for the first inventor to develop a sound method of determining longitude at sea.[31] But determining *how* to structure, govern, and award the prize proved much more difficult than determining what the prize should be. Harrison, whom history credits with solving the longitude problem by designing a chronometer that could be used at sea, tried numerous

22. *Id*.

23. *Id*.

24. *See, e.g.*, Steven Shavell & Tanguy van Ypersele, *Rewards Versus Intellectual Property Rights*, 44 J.L. & ECON. 525, 526–27 (2001); Kremer, *supra* note 8, at 1143.

25. *See infra* note 51 and accompanying text.

26. *See infra* Part I.

27. *Id.*

28. Congress considered and rejected one such proposal — the Medical Innovation Prize Fund Act of 2005, H.R. 417, 109th Cong. (2005). *See* Marlynn Wei, *Should Prizes Replace Patents? A Critique of the Medical Innovation Prize Fund Act of 2005*, 13 B.U. J. SCI. & TECH. L. 25 (2007).

29. *See infra* notes 63–81 and accompanying text.

30. *See infra* notes 84–90 and accompanying text.

31. *See* Siegel, *supra* note 7, at 9.

times to claim the prize. In hindsight, the Board of Longitude, which was constituted under the 1714 Longitude Act for the purpose of adjudicating the prize, fell victim to numerous administrative pathologies.[32] However, none of these issues are explored in the policy literature on prizes. Neither this historical event nor other more recent prizes have been used to understand how to move from the simple application of an economic formula to a technological problem, to the messy matters of governance and administration.

In this Article, we seek answers to the largely unasked "why" and "how" questions about prizes as they actually are implemented. We argue that prizes are justifiable as policy tools because they offer a particular institutional arrangement for governing the uncertainty and asymmetric information that plagues most technological innovation. Further, we argue that prize competitions can only be effective when implemented with appropriate attention to governance — the process of establishing and implementing rules and procedures — a set of choices that pose far more significant challenges than most legal and economic analyses suggest.[33]

Our analysis proceeds in four steps. In Part I, we argue that the existing literature fails to justify COMPETES Act-style innovation prizes. The economic literature has focused mostly on the wrong kind of prize, favoring a set of theoretical constructs while ignoring the prizes that the government offers in reality. To the extent it has anything at all to say about COMPETES Act prizes, it suggests that they are not justified under the prevailing framework used to assess the social welfare value of prizes and patents. Moreover, the policy literature that grew up around the COMPETES Act and the (limited) empirical analysis of prizes also fails to offer a satisfying account of why the government might choose innovation prizes over other incentive mechanisms and how they ought best to be structured and governed.

To begin filling these gaps, we turn in Part III to a detailed case study of the $10 million Auto X Prize, awarded in 2010. The Auto X Prize is a useful illustrative case study because its structure has come to be conventional. Indeed, it closely resembles, and was a model for, the prizes contemplated under the COMPETES Act.[34] Our case study involved in-depth field interviews with prize participants, organizers,

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32. *See id.* at 27–28.

33. A few words to clarify our use of the term "governance" may be helpful. We use "governance" to refer generically to the range of operations that prize-giving authorities — both public and private — must undertake in order to complete the goal of the program. *See infra* Part III (delineating governance challenges). This is consistent with the distinction sometimes drawn in the legal literature between "governance" and "regulation," where the former is meant to "signif[y] the range of activities, functions, and exercise of control by both public and private actors in the promotion of social, political, and economic ends." 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).

34. *See infra* notes 17–23 and accompanying text.

and funders carried out during and after the competition, and we use it to describe in detail the governance mechanisms that the prize developed to organize innovative activity toward a technological goal. We identify three central challenges that prize organizers faced: (1) making the rules; (2) changing the rules when the path of technological development proved unpredictable; and (3) implementing the rules fairly across diverse competitors and approaches. We explain these challenges as reflections of two pervasive characteristics of innovation: continuous uncertainty and information asymmetries.

In Part IV, we draw lessons from the case study to develop a theoretical model of prize governance, and then situate that model in the context of public administration. We suggest that in order to manage the uncertainty and information asymmetries of a prize competition while maintaining legitimacy for the participants, such competitions need a governance approach that is collaborative and transparent, is iterative, and utilizes tiered decision-making. But the model of prize governance that we develop, which bears some similarities to experiments in "collaborative" and "new" administrative governance models that were undertaken in the late 1990s and early 2000s, fits only uncomfortably within the administrative state. At the very least, heavy reliance on prizes is likely to incur administrative costs more complex than those that the existing literature has recognized.

Finally, in Part V, we apply these insights to the question of institutional choice. Having demonstrated through our case study that prizes may offer organizational solutions to the problems of uncertainty and asymmetric information in technological development, and then shown that these solutions are not without cost, particularly in public settings, we propose that the choice among prizes, grants, and patents depends in part on the tradeoff between efficacy and sustainability of each mechanism. In our new framework, the efficacy of prizes, patents, and grants is a function of two aspects of the innovation "problem" to be solved: the extent to which the problem can be identified and described (i.e., uncertainty), and the extent to which persons or entities with the capability to solve the problem can be identified (i.e., information asymmetry). We compare prizes with patents and grants along these dimensions and then balance the efficacy of each potential mechanism against the likelihood that it can be implemented at a scale commensurate with the problem. While we cannot provide a uniform answer to the question of when one mechanism should be preferred over another, we articulate a richer set of analyses than those offered by either the theoretical or policy literatures.

Of course, there are limits to the lessons that a single case study can teach. Although we have good reason to believe that the challenges the Auto X Prize faced will be typical of most private and public

"grand innovation prizes,"[35] every prize will ultimately be different. We use our case study to make three contributions: (1) to explain as an empirical matter how prizes operate in practice; (2) to justify prizes as institutional mechanisms to achieve innovation policy goals; and (3) to use that shift in perspective to derive a new set of considerations for policymakers choosing among innovation incentives.

II. ACTUAL VERSUS THEORETICAL INNOVATION PRIZES

Modern innovation prizes, as typically implemented, are a scholarly mystery. Three literatures speak to such prizes — economic, policy, and empirical — and yet none adequately justifies the use of innovation prizes in practice, explains when they should be chosen over other mechanisms, or explains whether or why they work. As a result, prizes remain little understood as an empirical matter and poorly justified as a theoretical matter.

The economics literature has little to say about COMPETES Act- and Longitude-style prizes; to the extent that it does offer theoretical insights into actual innovation prizes, it suggests that such prizes are difficult to justify and implement. Given that the government nevertheless continues to use them, indeed, at an increasing pace,[36] one might think that the policy literature provides a robust justification for the expanded use of prizes, but that literature is surprisingly thin. Lastly, the emerging empirical literature demonstrates that prizes can usefully incentivize innovation, but sheds little light on their operation and governance. We review each of these literatures in turn.

Economists have long understood that, left alone, competitive markets will tend to under-supply innovation.[37] Innovation is risky and often expensive, but its product — information — is cheap and easy to copy. More precisely, information is non-rivalrous and non-excludable.[38] These characteristics suggest that the private return on production of new information will rarely match the social value of that information; the private production of information therefore tends

35. *See* Murray et al., *supra* note 6, at 1779.

36. *See supra* notes 78–84 and accompanying text.

37. *See* Kenneth Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 616–19 (1962); Richard R. Nelson, *The Simple Economics of Basic Scientific Research*, 67 J. POL. ECON. 297, 302–04 (1959). For a review of the economic literature, see Peter S. Menell & Suzanne Scotchmer, *Intellectual Property Law*, *in* 2 HANDBOOK OF LAW AND ECONOMICS 1473, 1476–78 (A. Mitchell Polinsky & Steven Shavell eds., 2007).

38. *See* SCOTCHMER, *supra* note 6, at 31; Arrow, *supra* note 37, at 615, 616–17. Excludability refers more specifically to the cost of exclusion. Often this is high, but it need not always be so. *See* RICHARD CORNES & TODD SANDLER, THE THEORY OF EXTERNALITIES, PUBLIC GOODS, AND CLUB GOODS 3–6 (2d ed. 1996); Michael J. Burstein, *Exchanging Information Without Intellectual Property*, 91 TEX. L. REV. 227, 248–55 (2012).

to be suboptimal.[39] As Kenneth Arrow notes, "any information obtained, say a new method of production, should, from the welfare point of view, be available free of charge (apart from the cost of transmitting information). This [e]nsures optimal utilization of the information but of course provides no incentive for investment in research."[40]

Government intervention is therefore necessary to provide incentives for innovation beyond those offered by unfettered competitive markets. But this analysis says nothing about *how* the government ought to intervene. Arrow's preferred method was public funding.[41] The two most commonly discussed alternatives for incentivizing private research and development ("R&D") are patents and prizes,[42] and a tremendous literature has explored the choice between them.[43]

Patents solve the incentive problem by granting an inventor the exclusive right to make, use, or sell her invention.[44] This allows an inventor to place a non-zero price on her invention. If the invention is successful, the inventor can then recoup her investment. From the ex ante perspective, patents are therefore thought to offer an incentive to engage in risky innovative activity.[45] Indeed, that has come to be their primary justification.[46] As Arrow recognized, however, intellectual property is socially costly.[47] Because patents allow the price of the

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39. *See* STEVEN SHAVELL, FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW 138–40 (2004); Menell & Scotchmer, *supra* note 37, at 1476; Arrow, *supra* note 37, at 619. The classic economic analysis of innovation incentives assumes that individuals act to maximize their economic gain. More sophisticated analyses of innovation paint a significantly more varied picture of human motivation. *See, e.g.*, YOCHAI BENKLER, THE WEALTH OF NETWORKS 59–90 (2006). For the purpose of this section, we put aside alternative non-market forms of production. It is important to note, however, that the ultimate institutional choice of innovation structure will include these alternatives.

40. Arrow, *supra* note 37 at 616–17.

41. *See id.* at 623 ("The previous discussion leads to the conclusion that for optimal allocation to invention it would be necessary for the government or some other agency not governed by profit-and-loss criteria to finance research and invention.").

42. These are not the only alternatives. Tax credits for R&D make up a large but understudied portion of government support for innovation. *See* Hemel & Ouellette, *supra* note 1, at 321–26. And there are a variety of other institutional choices that the government can make to help promote innovation and commercialization. *See generally* Brett Frischmann, *Innovation and Institutions: Rethinking the Economics of U.S. Science and Technology Policy*, 24 VT. L. REV. 347, 353 (2000).

43. For a comprehensive summary of the existing literatures in economics, law, political philosophy, and public health, and their application to specific problems like pharmaceutical innovation and climate change, see Roin, *supra* note 1, at 1003–06 & nn.14–21.

44. *See* 35 U.S.C. § 271(a) (2012).

45. *See, e.g.*, SCOTCHMER, *supra* note 6, at 38; Menell & Scotchmer, *supra* note 37, at 1477–78.

46. *See, e.g.*, William Fisher, *Theories of Intellectual Property*, *in* NEW ESSAYS IN THE LEGAL AND POLITICAL THEORY OF PROPERTY 168, 169 (Stephen R. Munzer ed., 2001); Mark A. Lemley, *Property, Intellectual Property, and Free Riding*, 83 TEX. L. REV. 1031, 1053–55 (2005).

47. *See* Arrow, *supra* note 37, at 615. Lemley summarizes the costs of intellectual property well: "First, intellectual property rights distort markets away from the competitive norm, and therefore create static inefficiencies in the form of deadweight losses. Second,

invention to be set at greater than marginal cost (zero or close to it for information), there exist users who would purchase the good at or above the competitive price but who now will be unwilling (or unable) to purchase it at the monopoly price.[48] The loss in social welfare from transactions that would otherwise be completed is called deadweight loss.[49] Further social welfare loss results when, because information is an input into further R&D, exclusive rights limit the ability of follow-on innovators to create new works.[50]

An ideal prize system, by contrast, can avoid those inefficiencies. As it is usually modeled in the economic literature, a prize is awarded from the public purse to an inventor as compensation for placing her invention in the public domain.[51] That makes the invention available to users — including follow-on innovators — at a competitive price while still providing the inventor with a return. So long as the amount of the prize is sufficient, this system can in theory provide the same amount of incentive as a patent, but without the deadweight loss that accompanies exclusive rights.[52] This gives rise to what some have called the "unifying theme"[53] of the patents versus prizes literature: so long as the amount of the prize reflects the value of the innovation, prizes should be preferred to patents.[54]

Within this comparative framework, the economic analysis of innovation incentives does not generate determinate answers about when to prefer patents to prizes or to grants. Instead, it enumerates a long list of factors that may influence the choice. As Amy Kapczynski summarizes:

> [T]he . . . economics literature has proliferated a series of parameters that influence the comparative ef-

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intellectual property rights interfere with the ability of other creators to work, and therefore create dynamic inefficiencies. Third, the prospect of intellectual property rights encourages rent-seeking behavior that is socially wasteful. Fourth, enforcement of intellectual property rights imposes administrative costs. Finally, overinvestment in research and development is itself distortionary." Lemley, *supra* note 46, at 1058–59.

48. *See* SCOTCHMER, *supra* note 6, at 36–37.

49. *Id.* at 36.

50. *See* Menell & Scotchmer, *supra* note 37, at 1498–1501.

51. *See, e.g.*, Nancy Gallini & Suzanne Scotchmer, *Intellectual Property: When Is It the Best Incentive System?*, *in* 2 INNOVATION POLICY AND THE ECONOMY 51, 53–54 (Adam B. Jaffe et al. eds., 2002); Julien Penin, *Patents Versus Ex Post Rewards: A New Look*, 34 RES. POL'Y 641, 642 (2005).

52. That is not to say that there is no social cost. The funds for a prize system of this sort must come from taxation, which has its own associated deadweight losses. That said, conventional wisdom among economists is that the deadweight loss from general taxation is less than the deadweight loss from monopoly pricing associated with intellectual property, for a number of reasons. *See* Gallini & Scotchmer, *supra* note 51, at 54–55.

53. Menell & Scotchmer, *supra* note 37, at 1531; Roin, *supra* note 1, at 1038–39.

54. *See, e.g.*, Brian D. Wright, *The Economics of Invention Incentives: Patents, Prizes, and Research Contracts*, 73 AM. ECON. REV. 691, 691–95 (1983); Shavell & van Ypersele, *supra* note 24, at 530–31; Gallini & Scotchmer, *supra* note 51, at 54–55.

> ficiency of these different systems, including, most importantly, the competitiveness of the research environment; the cost of research as compared to the value of the reward; the riskiness of research or creativity; the importance of private information about the cost or value of creation; the costs of overseeing effort in the context of contracts; and the comparative costs of rent seeking, uncertainty, and the administration of each system. The information economics literature thus offers no general endorsement of any mechanism.[55]

Unfortunately for the policymaker, prizes that the economic theory literature describes are quite different from the actual innovation prizes that governments implement. In the economic literature, prizes are determined ex post, that is, after the invention is developed and in an amount that is supposed to estimate the social value of the invention. Actual prizes, by contrast, are offered ex ante, before the invention, and in amounts that are stated up front. They are monetary rewards offered for the development of particular technologies that are specified in advance.[56] Theoretical prizes are mandatory.[57] The system as modeled generally does not allow inventors to choose whether to participate in the prize system.[58] Actual innovation prizes are voluntary.[59] As such, while theoretical prizes are *substitutes* for intellectual property, actual prizes usually are complements or supplements to intellectual property.[60] Indeed, the COMPETES Act expressly provides that competitors will retain the ability to secure patents alongside their prizes.[61]

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55. Amy Kapczynski, *The Cost of Price: Why and How to Get Beyond Intellectual Property Internalism*, 59 UCLA L. REV. 970, 988 (2012); *see also* Heidi Williams, *Innovation Inducement Prizes: Connecting Research to Policy*, 31 J. POL'Y ANALYSIS & MGMT. 752, 767–78 (2012) (lamenting the absence of good empirical data to evaluate cost effectiveness).

56. *See, e.g.*, Roin, *supra* note 1, at 1002 n.8 (drawing distinction between ex post and ex ante prizes).

57. *See* Shavell & van Ypersele, *supra* note 24, at 539–40.

58. *But see id.* at 539–45 (arguing that an optional prize system may generate pricing information closer to social optimum).

59. *See* Michael Kremer & Heidi Williams, *Incentivizing Innovation: Adding to the Toolkit*, *in* 10 INNOVATION POLICY AND THE ECONOMY 1, 10–11 (Josh Lerner & Scott Stern eds., 2010) (describing voluntary prize systems and arguing that such systems be deployed as experiments without disrupting settled expectations of IP-based appropriation of the gains from R&D).

60. *See* Roin, *supra* note 1, at 1022 ("[T]he vast majority of . . . prizes are not conditioned on innovators giving up their intellectual property rights."). *But see id.* at 1022 n.96 (describing historical examples of prizes as substitutes for patents).

61. 15 U.S.C. § 3719(j)(1) (2012) ("The Federal Government may not gain an interest in intellectual property developed by a participant in a competition without the written consent of the participant.").

The economic literature therefore does not address the far different features of actual innovation prizes. There are three insights from the economic literature, however, that suggest that such prizes are either unjustifiable in economic terms, or so costly to implement that their use will rarely be justified: (1) prize value; (2) prize commitment; and (3) administrative costs.

First, theoretical innovation prizes are justified only to the extent that the prize-giving authority has enough information accurately to assign value to the prizes ex post. In an influential critique of Arrow's call for government funding, Harold Demsetz argued that intellectual property was superior because it harnessed market signals to provide innovators with information about the most socially valuable rate and direction of invention.[62] Government funding, by contrast, would require the government to make those choices on the basis of — he presumed — far more limited information about costs and benefits than that generated by the operation of the market.[63] Brian Wright subsequently formalized this insight and applied it to prizes, modeling the effects of asymmetric information on the choice between prizes and patents. He concluded that if costs and benefits are known both to innovators and the government, then prizes (or grants) should be preferred to patents, but if there is asymmetric information about costs and benefits between the innovators and the government, and the prize terms must be specified before the asymmetry is resolved, then patents are likely to be superior.[64] This insight has been widely accepted.[65] As a result, much economic analysis of theoretical innovation prizes has pursued mechanisms by which prize systems can better estimate the social value of inventions, thereby reducing patents' advantage.[66]

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62. *See* Harold Demsetz, *Information and Efficiency: Another Viewpoint*, 12 J.L. & ECON. 1, 11–14 (1969).

63. *See id.* at 9–12. For more recent articulations of this idea, see, e.g., F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697, 705–17 (2001); Menell & Scotchmer, *supra* note 37, at 1477 ("Probably the most important obstacle to effective public procurement is in finding the ideas for invention that are widely distributed among firms and inventors. The lure of intellectual property protection does that automatically.").

64. *See* Wright, *supra* note 54, at 691–92, 704.

65. *See, e.g.*, Gallini & Scotchmer, *supra* note 51, at 60–61 (reviewing the literature); Penin, *supra* note 51, at 645 ("[I]n a world where information is scarce and costly, and therefore, where the central planner does not know exactly the value of the innovations, the conclusion that rewards are socially more desirable than patents does not hold any more."); Shavell & van Ypersele, *supra* note 24, at 530.

66. One proposal, for example, is to structure the prize as a government buyout of previously issued patents through an auction that would reveal private information about the value of the inventions. *See* Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137, 1144–46 (1998). *See generally* Hugo Hopenhayn, Gerard Llobet & Matthew Mitchell, *Rewarding Sequential Innovators: Prizes, Patents, and Buyouts*, 114 J. POL. ECON. 1041 (2006) (extending the analysis to include cumulative innovation). Alternatively, the government could rely upon actual sales or consumption data to

Any difficulties that theoretical prizes encounter in setting the appropriate amount of the prize are likely to be compounded for actual prizes. If it is difficult to estimate the value of an invention ex post — after the invention has come into being and there are objective indicators of value such as price signals available — then it is near-impossible to predict the value of an invention ex ante, before any information about its costs and benefits is available in concrete form.[67]

Second, as Peter Menell and Suzanne Scotchmer note, "[p]rizes can only work if the prize giver can commit not to renege."[68] This is a kind of moral hazard problem on the part of the prize giver. Because competitors must make fixed investments before the prize is awarded, they are particularly vulnerable to expropriation once those investments have been made.[69] This expropriation can take a couple of forms. The government could underpay or otherwise change the terms of the prize ex post.[70] Or it could apply necessarily flexible or unclear rules in such a way as to exclude competitors from claiming the prize.[71] As Nancy Gallini and Suzanne Scotchmer write, it is difficult "to ensure that the prizes are actually given, when it is easy to manufacture reasons to withhold them."[72] Indeed, this is the primary lesson that many draw from the story of the British longitude prize — ambiguities in the prize rules, coupled with a conflicted administrative body, made it very difficult for the winner of the prize to actually

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estimate social value. *See* Shavell & van Ypersele, *supra* note 24, at 541; *see generally* V.V. Chari, Mikhail Golosov & Aleh Tsyvinski, *Prizes and Patents: Using Market Signals to Provide Incentives for Innovations*, 147 J. ECON. THEORY 781 (2012) (analyzing effect of innovators' cost of manipulating market signals). For particular applications of this proposal, see generally WILLIAM W. FISHER III, PROMISES TO KEEP: TECHNOLOGY, LAW, AND THE FUTURE OF ENTERTAINMENT 202 (2004) (discussing music); James Love & Tim Hubbard, *Prizes for Innovation in New Medicines and Vaccines*, 18 ANNALS HEALTH L. 155 (2009) (discussing pharmaceuticals). For criticism of these and other such proposals, see generally, e.g., Michael Abramowicz, *Perfecting Patent Prizes*, 56 VAND. L. REV. 115 (2003).

67. *See* Roin, *supra* note 1, at 1002 n.8. Our case study illustrates this point. Organizers offered a $10 million prize before knowing how valuable the winning technology would ultimately be. *See infra* note 157 and accompanying text.

68. Menell & Scotchmer, *supra* note 37, at 1532.

69. *See* Roin, *supra* note 1, at 1067–68 ("[I]nnovators are particularly vulnerable to expropriation under a prize system because the government determines their prize payout after innovators have invested in [R&D] and disclosed their inventions to the government.").

70. *See* Wright, *supra* note 54, at 703–04 ("There is an additional moral hazard problem from the viewpoint of researchers, in that the government may understate its *ex post* evaluation if it wishes to minimize expenditures, and is not greatly concerned with the effects of such action on the reputation of future governments."); Kremer, *supra* note 66, at 1143 ("[T]he authority awarding prizes might be tempted to expropriate inventors by offering inadequate prizes.").

71. *See, e.g.*, Kremer, *supra* note 66, at 1143 (noting that expropriation "may be a problem even for prizes ostensibly specified ex ante, if the rules governing prize awards are not clear").

72. Gallini & Scotchmer, *supra* note 51, at 56.

claim his award.[73] Again, ex post prizes seem even more susceptible to this particular pathology than ex ante prizes. Because ex post prizes set their rules in a predictive fashion, and because parties rely upon those rules in the course of the competition, it becomes especially important to be able to assure commitment.[74]

The existing literature does not really assess the likelihood of, or conditions for, credible commitment becoming a problem. Nor does it offer much in the way of solutions. It suggests legal mechanisms to constrain prize givers' discretion, either in the form of administrative or legislative constraints,[75] or through the use of private arrangements, such as contracts or trusts, that can be enforced through judicial process, but offers little reason to believe these solutions will work.[76] More work is needed to understand the dynamics of credible commitment.

Third, the literature identifies administrative costs as an important factor in the choice among incentive mechanisms. But it generally does not explore them in any detail either in the cost-benefit calculus, or to figure out how prizes can best be implemented. Instead, the literature simply notes that there are administrative costs in implementing a prize mechanism — the cost of establishing the relevant agency or decision-maker and enabling that entity to carry out the various tasks associated with developing and awarding prizes.[77] Of course, as Kapczynski notes, "IP, prizes, and government contracts all have costs of implementation, so the matter is really one of comparative cost."[78] On its face, the administration of a prize seems more complex than the administration of a patent system, especially in view of the information problems described above.[79] But although the costs of patent administration have been studied in exhaustive detail,[80] there have been no serious attempts to study the costs of a prize system.

In short, the theoretical prize literature suggests that actual prizes cannot be justified as an economic matter. Far from attempting to match the reward to the social value of the invention, as theoretical

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73. *See supra* notes 31–32 and accompanying text.

74. *See infra* notes 169–183 and accompanying text.

75. *See* Abramowicz, *supra* note 66, at 125 (suggesting a requirement that all funds allocated to prizes be spent to avoid underpayment); *id.* at 206 (suggesting that prize givers be vested with limited discretion to cut down administrative costs).

76. *See* Menell & Scotchmer, *supra* note 37, at 1532.

77. *See* Kapczynski, *supra* note 55, at 987–88.

78. *Id.* at 987.

79. *See* Shavell & van Ypersele, *supra* note 24, at 543–44 ("Under a reward system, administrative costs would be incurred by the government in deciding upon rewards, and these costs presumably would exceed those associated with deciding on the granting of patents."); Gallini & Scotchmer, *supra* note 51, at 56 ("Prizes can be organized so that worthy projects need not be identified in advance, but administering the prize then becomes particularly burdensome.").

80. *See, e.g.*, JAMES BESSEN & MICHAEL J. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS, AND LAWYERS PUT INNOVATORS AT RISK 120–47 (2009).

prizes do, actual prizes seek to maximize prize-related activity.[81] And even if an ex ante prize organizer tried to set an economically optimal prize amount, it would almost certainly fail to do so in the face of asymmetric information. Although the literature suggests that actual innovation prizes are likely to be rife with credible commitment problems and administrative costs, it sheds little light on the nature of those problems and costs, and therefore offers no guidance about how they may be minimized or overcome.

Surprisingly, the policy literature that developed in the lead up to the COMPETES Act does not do much better at explaining and justifying prizes than does the economic literature. If the economic literature, with its laser focus on optimal incentives, leads to overdetermined results, the policy literature suffers from the opposite problem. It provides only rules of thumb for determining when and how to use prizes. The basic rule appears to be that prizes are most useful when the goal is clear but the path to achieving it is not.[82] Beyond that, prize proponents offer a wide range of goals somewhat tangential to the core purpose of incentivizing innovation. The White House, for example, articulates the following goals for prizes:

> Establish an important goal without having to choose the approach or the team that is most likely to succeed; Pay only for results; Highlight excellence in a particular domain of human endeavor to motivate, inspire, and guide others; Increase the number and diversity of the individuals, organizations, and teams that are addressing a particular problem or challenge of national or international significance; Improve the skills of the participants in the competition; Stimulate private sector investment that is many times greater than the cash value of the prize; Further a Federal agency's mission by attracting more interest and attention to a defined program, activity, or issue

81. *See* Murray et al., *supra* note 6, at 1783.

82. MCKINSEY & CO., *supra* note 9, at 51; *see also* Thomas Kalil, *Prizes for Technological Innovation*, THE HAMILTON PROJECT 6 (Dec. 2006), http://www.hamiltonproject.org/assets/legacy/files/downloads_and_links/Prizes_for_Technological_Innovation.pdf [https://perma.cc/K8UJ-YZWH]. ("Prizes are especially suitable when the goal can be defined in concrete terms but the means of achieving that goal are too speculative to be reasonable for a traditional research program or procurement."); NATIONAL ECON. COUNCIL ET AL., A STRATEGY FOR AMERICAN INNOVATION 12 box 2 (2011) [hereinafter *2011 Innovation Strategy*] ("Prizes allow the sponsor to set an ambitious goal without selecting the team or approach that is most likely to succeed."). We follow Murray et al., *supra* note 6, at 1779, in drawing a distinction between these prizes and many of the competitions sponsored by platforms such an InnoCentive or TopCoder that involve significantly less uncertainty and more limited goals. *See generally, e.g.*, Kevin J. Boudreau, Nicola Lacetera & Karim R. Lakhani, *Incentives and Problem Uncertainty in Innovation Contests: An Empirical Analysis*, 57 MGMT. SCI. 843 (2011).

> of concern; and Capture the public imagination and change the public's perception of what is possible.[83]

One line of literature suggests that prizes are useful in industries that are particularly susceptible to under-production of innovation because private actors lack a viable market. At best, the value of a patent — and therefore the financial incentive it offers — represents only the appropriable private value to the inventor rather than the full social value of the invention.[84] Patents may therefore perform particularly poorly as incentives in industries where the social value of innovation greatly exceeds the private value accessible in a market.[85] Consider, for example, the market for pharmaceuticals targeting diseases endemic to the developing world, where ability to pay does not correlate with need, or the market for technology to address climate change where social value far exceeds private value. Unsurprisingly, these are two areas in which prizes have most frequently been proposed.[86] But this literature too provides little more than a rule of thumb.

Finally, the policy literature — and, indeed, the enacted policies themselves — is mostly silent about *how* to implement prize competitions effectively. The policy documents leading up to the enactment of the COMPETES Act treated such issues only at a high level of generality.[87] The statute itself says nothing about governance, setting forth only the most basic parameters of agencies' authority.[88] Agencies im-

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83. Memorandum from Jeffrey D. Zients, Deputy Dir. for Mgmt., Office of Mgmt. and Budget, Exec. Office of the President, to The Heads of Exec. Dep'ts. and Agencies (Mar. 8, 2010), https://www.whitehouse.gov/sites/default/files/omb/assets/memoranda_2010/m10-11.pdf [https://perma.cc/QZ79-QA9C].

84. *See* Brett M. Frischmann & Mark A. Lemley, *Spillovers*, 107 COLUM. L. REV. 257, 258–61 (2007).

85. *See* Kapczynski, *supra* note 55, at 989–90; Joseph E. Stiglitz, *Economic Foundations of Intellectual Property Rights*, 57 DUKE L.J. 1693, 1706–09 (2008); Roin, *supra* note 1, at 1030–31.

86. *See, e.g.*, Love & Hubbard, *supra* note 66; Roin, *supra* note 1, at 1005 n.19 (citing sources); Jonathan H. Adler, *Eyes on a Climate Prize: Rewarding Energy Innovation to Achieve Climate Stabilization*, 35 HARV. ENVTL. L. REV. 1, 12–19 (2011); Joshua D. Sarnoff, *Government Choices in Innovation Funding (With Reference to Climate Change)*, 62 EMORY L.J. 1087, 1119 (2013).

87. *See, e.g.*, COMMITTEE ON THE DESIGN OF AN NSF INNOVATION PRIZE, NAT'L RES. COUNCIL OF THE NAT'L ACAD., INNOVATION INDUCEMENT PRIZES AT THE NATIONAL SCIENCE FOUNDATION 5–6 (1991) ("Contests should be designed around objectively measurable outcomes to give clear guidance to contestants and minimize the role of subjective judgments and controversy about outcomes. . . . The determination of winners should be made by the [National Science Foundation] director, whose decision on technical grounds should be final."); Kalil, *supra* note 82, at 20 (warning against vague standards that could "lead to litigation about the final outcome").

88. *See, e.g.*, 15 U.S.C. § 3719(d) (2012) ("In selecting topics for prize competitions, the head of an agency shall consult widely both within and outside the Federal Government, and may empanel advisory committees."); 15 U.S.C. § 3719(k) (2012) (specifying rules for avoiding conflicts of interest in judging).

plementing the authority have sometimes promulgated guidance on specific topics,[89] but there has been no systematic attempt to coordinate inter-agency best practices or the like. The National Aeronautics and Space Administration maintains a clearinghouse of information for other agencies,[90] but this information is directed primarily toward prize selection and design.

Meanwhile, a small literature has developed that seeks to evaluate the effectiveness of innovation prizes empirically. Some of these studies are historical in nature, utilizing data from past innovation prizes to identify the effects of such prizes on competitive entry and subsequent patenting.[91] Some are experimental. Karim Lakhani and his collaborators have been using large-scale data sets drawn from prize platform TopCoder to examine how innovation prizes affect competitiveness, quality of solutions, and collaboration.[92] Luciano Kay studied the Ansari X Prize and the Northrup Grumman Lunar Lander Challenge, but focused primarily on "the motivation of prize entrants, the characteristics of their research and development (R&D) activities, and the overall effect of prizes on innovation."[93] But this literature, too, elides the complex role that governance plays.

In short, more theoretically grounded, but empirically informed studies of the operation of innovation prizes are needed. In particular, we need to expand our understanding of prize governance.[94]

III. A CASE STUDY OF INNOVATION PRIZE GOVERNANCE

The shortcomings of the literature described above suggest the need for a new approach. Rather than starting with theory and deriving an optimal prize system, our approach is to examine a prize that sponsors actually offered to gauge its effectiveness and governance, and in doing so, to glean insights for further policy. In this Part, we describe our case study of the Auto X Prize, with a focus on governance — the process of making, changing, and implementing the rules.

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89. *See, e.g.*, *HHS Competes - The HHS IDEA Lab*, U.S. DEP'T OF HEALTH AND HUMAN SERVS., http://www.hhs.gov/idealab/what-we-do/hhs-competes/ [https://perma.cc/MSD3-7X6K].

90. *See NASA Center of Excellence for Collaborative Innovation*, NAT'L AERO. AND SPACE ADMIN., http://www.nasa.gov/offices/COECI/index.html [https://perma.cc/G5CK-TPE9].

91. *See generally* Liam Brunt, Josh Lerner & Tom Nicholas, *Inducement Prizes and Innovation*, 60 J. INDUS. ECON. 657 (2012); Petra Moser & Tom Nicholas, *Prizes, Publicity and Patents: Non-Monetary Awards as a Mechanism to Encourage Innovation*, 61 J. INDUS. ECON. 763 (2013).

92. *See generally* Boudreau et al., *supra* note 82.

93. Luciano Kay, *The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrup Grumman Lunar Lander Challenge*, 41 R&D MGMT. 360, 360 (2011).

94. *See* Williams, *supra* note 55, at 767–72.

The discussion that follows is structured to be illustrative and illuminating rather than comprehensive and conclusive.

There are several reasons to believe that the Auto X Prize is a good representative illustration with which to begin the study of governance. For one thing, "the approach developed by the X PRIZE Foundation is emerging as a canonical design and prizes in the X PRIZE 'tradition' seem to be increasingly common."[95] In particular, the X PRIZE competitions formed much of the inspiration for the COMPETES Act. Although the statute contemplates a number of different prize types,[96] its implementation has all of the markings of the X PRIZE model. Indeed, the President's updated 2011 National Innovation Strategy specifically cites the Auto X Prize as an example of what the statute is trying to accomplish,[97] and the Office of Science and Technology Policy, which was charged with implementing the statute, hired a former X PRIZE official, Cristin Dorgelo, as the Assistant Director of Grand Challenges.[98] The Auto X Prize had mostly the same structure as many of the prizes carried out to date under COMPETES authority.[99] It posited a well-defined problem without a clear path to a solution;[100] it incentivized its participants not only with the lure of the prize itself but also with the opportunity to keep their intellectual property;[101] and the prize was structured with a view toward not only the development of a particular new technology, but also to publicizing the results and engaging the broader public with the problem to be solved.[102] The Auto X Prize is among the more sophisticated of the X PRIZE competitions.[103] Unlike, say, the X PRIZE Foundation's previous spaceflight competition, in which the criteria for awarding the prize were simple — "[t]he plane goes up, the plane comes down"[104] — the Auto X Prize, by virtue of its emphasis on

95. Murray et al., *supra* note 6, at 1782.

96. *See, e.g.*, 15 U.S.C. § 3719(c) (2012) (establishing (1) "[a] point solution prize that rewards and spurs the development of solutions for a particular, well-defined problem;" (2) "[a]n exposition prize that helps identify and promote a broad range of ideas and practices that may not otherwise attract attention;" and (3) "[p]articipation prizes that create value during and after the competition by encouraging contestants to change their behavior or develop new skills").

97. *See 2011 Innovation Strategy*, *supra* note 82, at 12 box 2.

98. *See* Daniel Terdiman, *How the White House is Aiming the X Prize Model at Big Problems*, CNET (June 12, 2012), http://www.cnet.com/news/how-the-white-house-is-aiming-the-x-prize-model-at-big-problems [https://perma.cc/X2SX-6DUV].

99. *See infra* notes 17–23 and accompanying text.

100. *Cf.* 15 U.S.C. § 3719(c)(1) ("A point solution prize that rewards and spurs the development of solutions for a particular, well-defined problem.").

101. *See* Auto X Prize Master Team Agreement art. IX (Aug. 20, 2009) (on file with author); 15 U.S.C. § 3719(j)(1) (2012).

102. *See infra* notes 116–117 (publicity), 160–161 (engaging the public) and accompanying text; KALIL, *supra* note 82, at 23 (engaging the public).

103. *See* JASON FAGONE, INGENIOUS: A TRUE STORY OF INVENTION, AUTOMOTIVE DARING, AND THE RACE TO REVIVE AMERICA 199 (2013).

104. *Id.*

production capability and the need to compare fuel efficiency across a range of designs and power plants, evolved a larger number of rules and evaluative criteria.[105] This complexity is probably more representative of the COMPETES Act prizes and, in all events, makes it easier to study governance issues because they are more starkly presented.

We utilized a mixed methodology approach that included documentary analysis, qualitative data based on interviews and direct observation, and survey data.[106] With the permission of the X PRIZE Foundation, we conducted interviews from November 2009 through January 2011, which included the period of active competition and its aftermath. The interviews were semi-structured, focusing on a variety of issues. We interviewed participants and organizers for one to two hours each, recorded the interviews with permission, and transcribed them. We then coded the interviews for different aspects of prize governance. In addition, we collected documentary evidence from the prize organizers including various iterations of the relevant contracts, guidelines, and rules.

A. Overview of the Auto X Prize

The X PRIZE Foundation is a nonprofit organization that sponsors "Grand Innovation Prizes,"[107] with the goal of "bring[ing] about radical breakthroughs for the benefit of humanity, thereby inspiring the formation of new industries and the revitalization of markets."[108] The X PRIZE Foundation launched the Auto X Prize in 2006, and Progressive Insurance signed on as the sponsor of the $10 million prize in 2008.[109] The basic goal of the prize was articulated simply: "A ten million dollar cash purse will be awarded to the teams that win a long-distance stage race for clean, production-capable vehicles that exceed 100 miles-per-gallon energy equivalent."[110] By "production-

105. *See infra* Part III.A.

106. This study is part of a broader project that seeks to examine the nature of the prize organization, the incentives provided by the prize and experienced by the participants, and the governance of the prize throughout its implementation. The broader methodology is described in Murray et al., *supra* note 6, at 1782–83. It is in the spirit of previous mixed method studies of innovation such as Alan MacCormack et al., *Developing Products on "Internet Time": The Anatomy of a Flexible Development Process*, 47 MGMT. SCI. 133 (2001).

107. Murray et al., *supra* note 6, at 1779.

108. *See Who We Are*, X PRIZE FOUND. (Jan. 16, 2013), http://www.xprize.org/about/who-we-are [https://perma.cc/9TDU-YG4U].

109. *X PRIZE Foundation & Progressive Insurance Join Forces to Officially Announce the $10 Million Progressive Automotive X Prize*, X PRIZE FOUND. (Mar. 20, 2008), http://auto.xprize.org/press-release/x-prize-foundation-progressive-insurance-join-forces-to-officially-announce-the-1 [https://perma.cc/P4UQ-38QF].

110. X PRIZE FOUND., PROGRESSIVE INSURANCE AUTOMOTIVE X PRIZE COMPETITION GUIDELINES VERSION 1.3, at 7 (Dec. 21, 2009), http://www.xprize.org/sites/default/files/piaxp_guidelines_v_1.3.pdf [https://perma.cc/L3V5-UUVY] [hereinafter GUIDELINES V1.3].

capable," the organizers meant that the cars had to be "designed to reach the market,"[111] rather than merely serve as "concept cars."[112] As a practical matter, this translated into a wide range of requirements. Entrants had to demonstrate compliance with the major Federal Motor Vehicle Safety Standards.[113] They had to demonstrate that their vehicles could be manufactured at scale, in quantities of at least 10,000 per year, and in accordance with a sustainable business plan.[114] Finally, the vehicles had to appeal to consumers, incorporating all of the usual features of modern cars — standard controls, seatbelts, exterior features, etc. — so that an average person without special knowledge could drive the car.[115]

Consistent with the X PRIZE Foundation's broader mission, the Auto X Prize had goals beyond the development of new automotive technologies. The Department of Energy contributed $3.5 million to fund an education program for primary and secondary school students that coincided with the various stages of the competition.[116] The prize organizers also sought publicity for the prize with the intention of using it as a way to start a broader national conversation about energy efficiency and to create an industry for fuel-efficient vehicles.[117] Regarding the competitors themselves, the prize organizers expressly recognized that the prospect of the prize would not be the sole motivation. Thus, the organizers sought to "[p]rovide many opportunities for recognition so that it's worthwhile to compete, and not just for first place," and to "[m]ake heroes out of the competitors and winner(s) through widespread exposure, media coverage and a significant cash reward."[118]

The prize attracted a wide range of competitors. Some were auto industry professionals working for startup companies with venture capital financing; others were hobbyists who self-financed their entries, students from universities and a high school in West Philadelphia, or engineers from other industries who wanted to take a swing at

111. *Id.* at 8.
112. *Id.* at 7.
113. *See id.* at 49–56.
114. *See id.* at 8.
115. *See id.* at 8; X PRIZE FOUND., PROGRESSIVE INSURANCE AUTOMOTIVE X PRIZE SUPPLEMENTAL REGULATIONS FOR KNOCKOUT AND FINALS STAGES: AMENDMENT AND ADDENDUM V2.2 TO COMPETITION GUIDELINES VERSION 1.3, at 25–35 (June 7, 2010), http://www.xprize.org/sites/default/files/piaxp_guidelines_addendum_supplemental_regulations_v2.2_20100607.pdf [https://perma.cc/ELK2-G8TL] [hereinafter GUIDELINES ADDENDUM].
116. *See Education*, X PRIZE FOUND. (July 6, 2014), http://www.progressive-autoxprize.org/education [https://perma.cc/A5BL-3BPH].
117. *See* GUIDELINES V1.3, *supra* note 110, at 6.
118. *Id.*

building a car.[119] The entrants brought a range of technical expertise to the competition, including not only mechanical engineering, but also electrical engineering, computer science, materials science, and aerospace engineering.[120]

The purse was divided between two different classes of vehicles. The "mainstream" class, the winner of which could claim half the prize purse, comprised "typical existing small, 5-passenger economy mixed-use vehicles."[121] Entrants in that class "were required to seat at least four passengers, have four wheels, and have a minimum 200 mile range."[122] Two "alternative" classes, with "tandem" and "side-by-side" seating, each worth $2.5 million, focused on 2-passenger, non-standard designs.[123] The cars in all classes could — and did — rely on a variety of fuel sources, including gasoline, batteries, ethanol, biodiesel, and compressed natural gas.[124]

To award the prize, the organizers conducted the competition in a series of stages, each stage designed to winnow the field. Registration was easy. A team provided an application with basic technical information about the vehicle, paid a $5,000 entry fee, and signed the Master Team Agreement.[125] The X PRIZE administrators applied a light screen to registrations, weeding out only those applicants that were "clearly unqualified."[126] By the February 2009 deadline, 111 teams registered a total of 136 vehicles for judging in the next stage.[127]

The registered teams then competed in a "design judging" stage, in which they provided detailed data submissions to demonstrate that their vehicles were production-capable. The Auto X Prize provided contestants with broad outlines of the minimal design requirements,[128] and then convened panels of experts with broad discretion to determine which cars would qualify for the on-track events. These expert panels — judging submissions on safety and emissions, manufacturability and cost, features, and business plan — met and considered submissions over the course of several days.[129] Forty-three teams representing fifty-six vehicles passed the design judging stage in October

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119. *See* X PRIZE FOUND., REGISTERED COMPETITORS (May 8, 2009) (on file with author); MIT X PRIZE Lab Survey Data (on file with author); FAGONE, *supra* note 103, at 38–41.

120. MIT X PRIZE Lab Survey Data, *supra* note 119.

121. GUIDELINES V1.3, *supra* note 110, at 9.

122. *Overview*, X PRIZE FOUND., http://www.progressiveautoxprize.org/prize-details [https://perma.cc/W5M4-S3DD].

123. GUIDELINES V1.3, *supra* note 110, at 11.

124. *See* GUIDELINES V1.3, *supra* note 110, at 27–28.

125. *Id.* at 15.

126. *Id.*

127. *See* Murray et al., *supra* note 6, at 1783 tbl.2 (descriptive statistics).

128. *See* X PRIZE FOUND., PROGRESSIVE INSURANCE AUTOMOTIVE X PRIZE COMPETITION GUIDELINES VERSION 1.2, at 16–20, 23–25 (Jan. 10, 2009) (on file with author) [hereinafter GUIDELINES V1.2].

129. *See id.* at 54–55.

2009 and were qualified for the on-track race events held from April 2010 through August 2010 at the Michigan International Speedway.[130] In the weeks between qualification and the start of the on-track events, the prize organizers provided the competitors with additional technical details and requirements, and performed inspections and safety tests, while the teams continued to hone their vehicles.[131] Not all teams made it through this process; only thirty-three vehicles eventually entered the on-track race events.[132]

The on-track events were conducted in stages. The first stage was a "shakedown" event that took place from April 26 to May 7, 2010.[133] In that phase, the teams put their vehicles through a number of long-distance practice races and a rigorous safety inspection to "shake out any problems, make final adjustments, and verify competition readiness."[134]

Following the "shakedown" phase, twenty-eight vehicles entered the "knockout" stage,[135] which was the first of the competitive races, held from June 16 to 30, 2010.[136] To move on from the knockout stage to the final race stage, vehicles had to successfully complete a number of performance and safety tests to "confirm compliance with [the] minimum specifications" for things such as acceleration and braking speeds, noise, and speed maintenance on a grade.[137] These were standard automobile performance tests, such as the ability to accelerate from 0 to 60 mph in 15 seconds, the ability to stop from 60 mph within 180 feet, and the infamous Consumer Reports "moose test," in which a car must swerve across two lanes and back without crossing a set of cones.[138] The teams also had to complete a first set of range and efficiency runs. Cars in the mainstream class had to achieve an average fuel efficiency of 67 miles-per-gallon-equivalent ("MPGe") over a range of conditions simulating city and highway driving, and a 134 mile range.[139] Thirteen teams qualified for the finals, and nine teams ultimately competed in the finals.[140]

The final races were held from July 19 to 30, 2010.[141] The marquee race was a combined performance and efficiency test over a 200

130. *See* Murray et al., *supra* note 6, at 1783 tbl.2.
131. *Id.* at 1783 tbl.1.
132. *Id.* at 1783 tbl.2.
133. *Schedule*, X PRIZE FOUND., http://auto.xprize.org/about/schedule [https://perma.cc/CP8E-WPZU].
134. GUIDELINES V1.3, *supra* note 110, at 37.
135. *See* Murray et al., *supra* note 6, at 1783 tbl.2.
136. *Schedule*, *supra* note 133.
137. GUIDELINES V1.3, *supra* note 110, at 37–38.
138. *See* GUIDELINES ADDENDUM, *supra* note 115, at 56–57; FAGONE, *supra* note 103, at 159.
139. GUIDELINES V1.3, *supra* note 110, at 10, 37.
140. *See* Murray et al., *supra* note 6, at 1783 tbl.2.
141. *Schedule*, *supra* note 133.

mile course.[142] The vehicles were then subjected to validation testing at Argonne National Laboratory.[143] The winning vehicle in each class would be the vehicle that achieved the fastest race time in the final stages while still achieving 100 MPGe and meeting all other safety and technical requirements.[144] On September 16, 2010, the X PRIZE Foundation announced the winners of the Auto X Prize.[145] The mainstream class winner was a team called Edison2, a group of automobile engineers from Charlottesville, VA, whose gasoline powered car was significantly lighter than any car on the market.[146]

B. Governance Challenges in the Auto X Prize

The Auto X Prize was structured and governed using a series of interlocking contracts between the organizers and participants. Each participating team and the prize organizers were parties to a "Master Team Agreement."[147] That agreement set forth what might be called the "constitutional" rules of the competition: a set of rules that defined the basic goals of the competition and obligations of the parties toward one another and that were not subject to change.[148] The "Master Team Agreement" governed the relationship between the prize organizers and the teams on such topics as indemnification and insurance, sponsorship and advertising, media rights, intellectual property, and the like.[149]

Importantly, the Master Team Agreement incorporated by reference a set of further guidelines and rules that were subject to change and amendment at the will of the prize organizers. Teams agreed in advance to comply with subsequently-issued Competition Guidelines and Technical Specifications, plus revisions and other competition-related documents.[150] Pursuant to the authority granted in the Agreement, the Auto X Prize organizers promulgated a series of documents throughout the course of the prize that elaborated upon the rules and requirements. The "Competition Guidelines" laid out most of the rules of the competition — the various stages and the requirements for teams to move from one stage to the next. These Guidelines reminded

142. GUIDELINES V1.3, *supra* note 110, at 38.

143. *Id.* at 41.

144. *See generally* GUIDELINES V1.3, *supra* note 110.

145. *See Three Teams Awarded Share of $10 Million Purse in Progressive Insurance Automotive X Prize for Super Fuel-Efficient Vehicles*, X PRIZE FOUND. (Sept. 16, 2010), http://www.progressiveautoxprize.org/news-events/press-releases [https://perma.cc/WR9M-CZG7].

146. *See Edison2*, X PRIZE FOUND., http://www.progressiveautoxprize.org/teams/edison2?carId=144 [https://perma.cc/7T7Y-W4P5].

147. *See* Progressive Insurance Automotive X Prize Master Team Agreement (Aug. 20, 2009) (on file with author).

148. *See id.*

149. *See id.*

150. *Id.* at art. V.

participants that they "[we]re binding as referenced in the overall Master Team Agreement."[151] But the Guidelines were subject both to change and elaboration. Regarding change, the Guidelines stated: "There may also be unanticipated issues that arise and require modifications to these Guidelines; thus, we reserve the right to revise as appropriate."[152] Regarding elaboration, in addition to the Competition Guidelines, the organizers articulated more precise rules and technical requirements in a periodic series of bulletins that they issued to participants and in a series of in-person briefings at the start of the on-track race events.[153]

Given this structure, the organizers relied heavily on concepts of good faith borrowed from commercial law. The Guidelines expressly stated, for example, that the Auto X Prize "organizers and sponsors are entering into this competition in good faith. We expect and require the same attitude from all competitors and participants, so that together we can provide the most favorable experience for all."[154]

Several features therefore emerge at the outset: the initial contracting was incomplete; it delegated authority to the organizers to fill in the gaps as the competition progressed; and even then it relied on the good faith of the participants to help overcome necessary incompleteness. This highly contingent structure led to three central governance challenges, which we consider in turn: making the rules, changing the rules, and implementing the rules. These challenges arose from the interaction of the basic structure described above and the technological characteristics and complexity of the project.

1. Making the Rules

The first challenge was establishing a process for the development of the rules of the competition. As others have noted, the rules for prize competitions are a complex balancing act.[155] They must set goals that are at once technologically ambitious but not impossible. They must be clear enough to implement without too much subjectivity and litigation, but flexible enough to accommodate the demands of fast-developing technology.

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151. GUIDELINES V1.3, *supra* note 110, at 5.

152. *Id.*

153. *See Technical Information*, X PRIZE, http://auto.xprize.org/about/technical-information [https://perma.cc/26MU-MX9M]. These technical specifications were themselves subject to revision. *See* GUIDELINES ADDENDUM, *supra* note 115, at 11 ("The Progressive Insurance Automotive X Prize expects to publish revisions of these Technical Specifications, to provide more information and to include additional specifications whose need becomes apparent as the Competition evolves.").

154. GUIDELINES V1.3, *supra* note 110, at 7; *cf.* U.C.C. § 1-304 (AM. LAW INST. & UNIF. LAW COMM'N 2014) ("Every contract or duty within [the Uniform Commercial Code] imposes an obligation of good faith in its performance and enforcement.").

155. *See* Kalil, *supra* note 82, at 20.

Take, for example, the development of the basic fuel efficiency goal of the competition. Because the Auto X Prize wanted to remain technologically neutral, it needed to compare fuel efficiency across divergent technologies, some of which already existed, and some of which may not have. The standard measure of automobile fuel efficiency — the number of miles the car can go on a gallon of gasoline — is an obviously poor fit for an electric car that does not utilize any "gallons" of any fuel, or a car that uses, say, gaseous rather than liquid fuels. The Auto X Prize solved this problem by creating a new measure: MPGe. This new measure tracked energy consumption from any source and then compared that consumption with the energy content of a standard gallon of gasoline.[156]

Sometimes, making the rules involved guesswork. Once the organizers settled on a fuel efficiency measure, they still needed to set a goal using that measure, but the limits of the technology were untested. One journalistic account of the Auto X Prize describes the process of settling on the 100 MPGe goal — the fundamental goal of the competition: "Instead of a target of 250 or 500 MPGe," which the organizers had originally considered, the organizers "settled on 100 MPGe — hard, but doable. 'Five hundred would have been impossible,' Shore recalls. 'And one hundred is a lovely nice round number.'"[157]

To develop and implement the necessary goals and standards, the Auto X Prize put into place several mechanisms. First, they sought input from a wide variety of sources:

> [W]e went to a range of advisors . . . [and had] to sort out what was bias and what were actual facts when it came to establishing core metrics of competitions. . . . [We] wanted to make sure our matrix was objective not subjective . . . . [W]e knew they had to be clear and easily explained to consumers and the public.[158]

To this end, the Auto X Prize appointed a "Prize Development Advisory Board" made up of representatives from the government, the au-

156. *See* GUIDELINES V1.3, *supra* note 110, at 29 ("MPGe is an attractive figure of merit because it is a direct measure of overall pump-to-wheels efficiency, because it is technology-neutral, and because it relates nicely to consumer intuition — i.e., it reduces to the familiar MPG if the fuel is in fact gasoline. MPGe is also attractive because it applies to any combination of fuels (including ones we may [not] be thinking about yet)."); *id.* at 31 (describing calculation); FAGONE, *supra* note 103, at 36.

157. FAGONE, *supra* note 103, at 37.

158. Interview with Organizer. Beginning here and throughout the remainder of Part III.B, we include quotations from interviews we conducted with Auto X Prize organizers and participants. Because we promised our interview subjects anonymity, we have not provided identifying information in the footnotes.

tomotive industry, environmental groups, academia, and finance.[159] When this board completed a draft of the guidelines for the prize, the organizers released these guidelines for public comment: "The first time we showed the public in detail what we were aiming for was when we published the draft guidelines. . . . [W]e [got] 1,000 comments or so."[160] They sought opinions not only on the technical specifications that would be most appropriate, but also on the prize's media and public relations attractiveness. For example, "[o]ne of the versions . . . was a sales race. . . . It is a proxy for is there a market . . . but we abandoned it . . . one reason the media advisors said it was boring."[161] This was particularly important to the prize organizers because, as described above, publicity was a key part of building awareness of the need for efficient vehicles and a further non-monetary inducement for participation.[162]

Second, the organizers engaged in an iterative process of rule development:

> Developing the criteria was one of the early things that we did . . . . [W]e realized we needed to take a step back and have some meta criteria . . . . Then we went through an iterative process of developing draft guidelines . . . .We went through five different versions before we honed in on the one that became the automotive X PRIZE.[163]

This iteration took place within a smaller group of experts on the Prize Development Advisory Board and then again after receiving public comments.

Finally, the prize organizers sought to build consensus among various stakeholders: "We held [a] series of working groups . . . auto industry reps, regulatory agencies and more helping us to compare fairly those various fuel sources."[164] These working groups were organized by topic area: energy and emissions, race structure and course design, and production capability.[165] Each was staffed with represent-

159. *See Prize Administration Advisory Board*, X PRIZE FOUND., http://static.progressiveautoxprize.org/about/advisors [https://perma.cc/KX3R-QL5H].

160. Interview with Organizer. *See also* GUIDELINES V1.3, *supra* note 110, at 47 ("We solicited input and feedback directly, and we also published Draft Guidelines for public comment. We received well over 1000 comments from the general public, and a number of substantial changes included in these Guidelines are the result of the public's input.").

161. Interview with Organizer.

162. *See supra* notes 118–119 and accompanying text.

163. Interview with Organizer.

164. Interview with Organizer.

165. *See* X PRIZE FOUND., AUTO X PRIZE DRAFT COMPETITION GUIDELINES VERSION 6.0, at 33–35 (Apr. 2, 2007) (on file with author).

atives from government, academia, and the private sector, and each was charged with achieving consensus before moving forward.[166]

Taken together, these methods appear to have been successful in lending credibility to the guidelines and securing buy-in from most of the parties. Nevertheless, the development process was not free of problems. The prize organizers acknowledged that members of the development team included potential competitors:

> We recognize that some of those advising on [Auto X Prize] Guidelines may end up competing, but that is an unavoidable result of engaging with so many experts who have real-world knowledge of the automotive industry. We believe that the Guidelines published here are balanced and credible, and that this would not have been possible without seeking as much feedback as possible from diverse parties, without regard for future possible conflicts. Had we only sought input from those unlikely to have a future interest in the [Auto X Prize], the result would have been poor Guidelines. Our process is open and we do not hide our involvement with any party.[167]

At least one team angrily withdrew from the competition, in part because "in our opinion, a problematic conflict of interest occurred when X PRIZE allowed one of the accepted letter of intent contenders to be part of the rule setting and ultimate team evaluation processes."[168]

2. Changing the Rules

One problem with establishing rules for an innovation prize competition is that they may be made obsolete by the development of the technology. The original rules may prove to be technologically infeasible or inappropriate in a way that is hard to predict. One team, for example, developed a technology for machining extremely light parts to reduce the weight of its car. This made it very difficult to comply with technical specifications that were written assuming normally-

166. *Id.*

167. *Id.* at 25.

168. Sebastian Blanco, *HP2G Acrimoniously Drops Out of Auto X Prize*, AUTOBLOGGREEN (June 5, 2009), http://green.autoblog.com/2009/06/05/hp2g-acrimoniously-drops-out-of-auto-x-prize [https://perma.cc/8MN5-X3NA]. The Auto X Prize organizers disputed this team's characterization of the process, noting that competitors could be involved in rule development but not in any actual evaluation of one another. *See id.*

weighted systems.[169] Another team entered a vehicle that was essentially a motorcycle — it sat two people front-to-back and had two main wheels. To comply with the Prize's drivability requirement, which presumed knowledge of how to drive a car rather than a motorcycle, "a set of training wheels flick[ed] out to each side, balancing the vehicle" when it came to a stop.[170] To some competitors, this seemed to violate the spirit, if not the letter, of the rules.[171]

The Auto X Prize organizers expressly acknowledged the possibility that the rules would have to be flexible, providing in the Guidelines that: "There may also be unanticipated issues that arise and require modifications to these Guidelines; thus, we reserve the right to revise as appropriate. In all cases, we will endeavor to remain true to the spirit of these Guidelines."[172] The Auto X Prize organizers used this express flexibility to adapt to changing circumstances. Commenting, for example, on a change in the format of the race events from street to closed track, one organizer said: "It has been a very natural evolution given the external circumstances — ranging from economic crisis and what is facing cities . . . . Most teams understand the change of format."[173] Similarly, another organizer emphasized the importance of being able to define milestones as the competition progressed: "A lot of milestones were not defined at the beginning but certain things had been decided, e.g. basic structure."[174]

Changes were made both to the overall structure of the competition and to the detailed technical requirements. In late 2009, for example, entrants in the alternative class complained that the vehicles being entered were too diverse to be compared using the same technical specifications. Following consultation with experts and teams, the Auto X Prize organizers decided to split the alternative class into two separate classes: one for cars with side-by-side seating, and one for cars with tandem seating.[175] The $5 million purse was similarly split in half; the winner in each class would take home $2.5 million.[176] Other changes were more technical in nature. For example, between the first and second iterations of the Guidelines, the prize organizers eliminated the top speed requirement rule, replacing it with a more flexible "highway-capable" standard, reduced acceleration specifications, and reduced the amount of space that had to be allocated to the back seat in the mainstream class.[177]

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169. *See* FAGONE, *supra* note 103, at 146–48.
170. *Id.* at 155.
171. *See id.* at 156.
172. GUIDELINES V1.3, *supra* note 110, at 5.
173. Interview with Organizer.
174. Interview with Organizer.
175. *See* GUIDELINES V1.2, *supra* note 118, at 6.
176. *Id.*
177. *See id.* at 5.

The organizers tried to keep the changes reasonable: "Most teams . . . look at [the changes from a cross country race] as reasonable changes and in many cases they have benefited our teams . . . . [It is less] expensive for teams in terms of time required of them."[178] But they nevertheless received mixed reviews from participants. Some were understanding of the need:

> I think as those rules get solidified and more things are written down than verbally, I think it will be run a little better. I think they're doing a good job. I think they are feeling their way trying not to knock anybody out because of a rule that was written a year ago when it turns out maybe nobody can pass that. So things are in a state of [flux].[179]

But a more commonly voiced sentiment was frustration with what seemed to be a moving target. One participant complained that "the rules for the events have been changing all [the] time."[180] Similarly, another explained that:

> [We are] competing for real money in real events. But you don't know what they are until you get there. . . . There has to be a goal. And the goal here is really fuzzy. You have to go [on] trust. And be willing to gamble. Because you just don't know. The truth is, you don't. [T]he rules have changed many times.[181]

Participant complaints seemed most directed at the lack of an established process for making these changes. As one team described:

> Quite often we'll get either a rule change or a schedule change or something a week before we are leaving. I think . . . we got a 60 page document that was what our technical spectrum was going . . . to be and there were a lot of differences between that and the original rules, so that last week before we had to leave was like triage . . . . [T]hese are like large

178. Interview with Organizer.
179. Interview with Participant.
180. Interview with Participant; *see also* FAGONE, *supra* note 103, at 130.
181. Interview with Participant.

> changes to the car . . . . [I]t's like "oh, by the way . . ."[182]

This lack of process also created problems with respect to the teams' reliance interests in the stability of the rules. Because engineering automobiles is a difficult process, teams that come to rely upon the old rules may find themselves facing significant hardship in re-engineering their cars to meet the new rules. The costs of changes at a late stage, once many design and technical choices became irreversible, were high. One team explained:

> I was around [to] comment on the rules before they were final. . . . [I'm] jaded because [changes were] stuff that affected me directly but I know why they made the decision. The problem is some of the decisions they didn't make soon enough so once it was welded in steel in our car we couldn't change it. . . . I had to bite my tongue. . . . [T]here have been some critical [rules] that have changed or they have allowed leniency on but it hurt us, too.[183]

3. Implementing the Rules

Finally, the implementation of the stated rules during the course of the competition proved to be contentious. There were two potential sources of trouble. One was that broadly written, flexible rules gave judges significant discretion in implementation. As one organizer explained, "In a perfect world things could have been more black and white. It . . . just wasn't, there were shades of gray."[184] Given the conflict of interest issues that the Auto X Prize encountered during the period of rule development,[185] the organizers implemented a "strict no-conflict policy" once the competition was underway.[186] They disbanded the Prize Development Advisory Board, and replaced it with "a conflict-free Prize Administration Advisory Board."[187] For the design judging phase, which appears to have been the most discretionary, the prize organizers put into place a set of procedures designed to incorporate as many viewpoints as possible and to achieve consensus

182. Interview with Participant.

183. Interview with Participant; *see also* FAGONE, *supra* note 103, at 130 ("Sometimes the officials made some minor-seeming change that turned out to be not so minor in the implementation, or suddenly clarified a requirement that had been vague, and either way it meant more work for [the team].").

184. Interview with Organizer.

185. *See supra* notes 167–168 and accompanying text.

186. GUIDELINES V1.3, *supra* note 110, at 47.

187. *Id.*

among the judges where possible.[188] The judging criteria stated that members of judging panels "may not have a direct conflict of interest,"[189] but it was unclear what constitutes "direct" or "indirect," leaving the possibility of bias intact.

The second problem was that even where the rules were stated with clarity and in such a way that discretion was not lodged in the judges, they were not applied uniformly across the competitors. This was partly a matter of design. As one of the organizers explained, in the early "shake down" round, there was a "much more understanding sort of appeal process because it . . . wasn't ultimately out there to get rid of everybody."[190] And several competitors noticed that the rules were sometimes "lenient."[191] This flexibility had its advantages, particularly in the early stages in which the organizers emphasized feedback and technical support to ensure that less experienced teams were still able to compete.

But, predictably, this flexibility led to efforts to "work[] the refs."[192] One account describes a team "blitzing Prize officials with e-mails and phone calls," to "plead[] for leniency on a range of yet-to-be-decided issues" such as ballast, the appropriate measure of weight penalties, and the time of day that was best for running the on-track events.[193]

Equally predictably, the organizers' position generated complaints that the rules were not applied fairly: "The rules are fair, the enforcement of those rules, not fair."[194] Another team complained: "[I]t depends on the team. So this team gets this sort of waiver, and this team over here gets this as a waiver, but this guy doesn't get that guy's waiver. So as soon as they do it, they should say okay . . . you can all do this, all do that."[195] And another: "Actually, I think there's been quite a bit slipping in the rules for some things. I don't know why. But it seems to me that their rules aren't that strict. You can go under the fence somewhere."[196]

These charges of unfairness or bias were compounded by a lack of transparency. One team believed that there were secret agreements in place between certain competitors and the organizers: "There was a super secret probation which some of the other teams were on [but we were not]."[197] In one particular instance of opaque decision-making, a high profile team that missed a performance target was not immedi-

188. *See id.* at 57–59.
189. *Id.* at 58.
190. Interview with Organizer.
191. Interview with Participants.
192. FAGONE, *supra* note 103, at 222.
193. *See id*. at 221–22.
194. Interview with Participant.
195. Interview with Participant.
196. Interview with Participant.
197. Interview with Participant.

ately sent home, and the organizers delayed making an announcement about the teams' status.[198] This gave rise to angry discussion board comments: "IS THIS A JOKE? So who's righting [sic] the rules at X Prize? Why can't they enforce the very rules they write? . . . [If] this contest [is] rigged what's the point of this [w]hole thing"?[199] Eventually, the organizers explained the reason for the deviation from the rules. It was "complicated and technical, but it boil[ed] down to fairness."[200]

Here again, there seems to be a balancing. On the one hand, the organizers, in light of the overall goals of the prize competition, could reasonably choose to be inclusive and help teams to achieve the goal. On the other hand, to the extent that such help was doled out unfairly or without any process, it called into question the legitimacy of the prize. These difficulties highlight the importance of a mechanism by which teams can surface issues in the implementation of the rules and bring them to a fair resolution. Later in the competition, the organizers implemented an appeals process aimed at "provid[ing] Teams an opportunity to have actions of other Teams reviewed and to have administrative and competition decisions of the organizers reconsidered."[201] The process involved two stages of review: the first before X PRIZE officials, and the second before a panel of "expert inspectors/judges who are not employees of the X PRIZE Foundation."[202] The appeals process was invoked several times during the competition and provides one of several examples of the administrative team for the prize recognizing, working with, and attempting to solve the various governance challenges that they confronted.[203]

C. Foundations of Prize Governance Challenges

The problems the prize organizers confronted in making the rules, changing the rules, and implementing the rules arose out of the uncertainty and information asymmetries that pervade the innovation process.

1. Uncertainty

Innovation is an inherently uncertain activity.[204] Most basically, an innovator experiences uncertainty when she cannot determine

198. *See* FAGONE, *supra* note 103, at 282.
199. *Id.*
200. *Id.* at 283.
201. GUIDELINES ADDENDUM, *supra* note 115, at 16.
202. *Id.* at 17.
203. *See* FAGONE, *supra* note 103, at 281.
204. *See* Nathan Rosenberg, *Uncertainty and Technological Change*, *in* THE MOSAIC OF ECONOMIC GROWTH 334, 334 (Ralph Landau et al. eds., 1996). Following Knight, we dis-

ahead of time whether — or how — her innovative activities will succeed in solving a particular problem. "Producers have to make a decision on inputs at the present moment, but the outputs are not completely predictable from the inputs."[205] From the perspective of a social planner, the uncertainties associated with innovation proliferate. As Richard Nelson writes, "It is very easy to make choices which, ex-post, turn out to be the wrong ones."[206] At the outset of a project, it is easy enough to state a goal: curing cancer, say, or landing a man on the moon. But from an ex ante perspective, the technological path that will accomplish that goal is uncertain. So too is the time it will take and, of course, the cost.[207] No one hearing President Kennedy's 1961 speech setting a national goal of landing a man on the moon could have predicted the mix of technologies that would ultimately achieve that goal — the Saturn V rocket, the Apollo spacecraft, and so forth.[208] Instead, those technologies emerged from a process of development; the ultimate outcome was entirely path dependent.

Uncertainty plagued the Auto X Prize from the very start. Recall that the prize organizers knew they wanted to create a prize that would lead to the development of cars that could achieve much greater fuel efficiency than presently available.[209] But because it was impossible to predict ex ante the course of technological development they were incentivizing, they could not set a target through anything other than guesswork.[210] The rules they settled on as an initial matter — the 100 MPGe target as well as a large number of safety and performance specifications — were based only on unquantifiable extrapolations from the state of technology at the time the decisions were made.[211]

Of course, during the process of technological development, it is possible for some uncertainties to be resolved. Information gleaned through experimentation can help to refine estimates about the plausi-

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tinguish here between uncertainty and risk; the latter is quantifiable, while the former is not. *See* FRANK H. KNIGHT, RISK, UNCERTAINTY AND PROFIT 233 (1921); *cf.* Ronald J. Gilson, Charles F. Sabel & Robert E. Scott, *Contracting for Innovation: Vertical Disintegration and Interfirm Collaboration*, 109 COLUM. L. REV. 431, 433 n.2 (2009) (drawing a similar distinction in the context of supply chain contracting).

205. Arrow, *supra* note 37, at 610.

206. Richard R. Nelson, *Uncertainty, Learning, and the Economics of Parallel Research and Development Efforts*, 43 REV. ECON. & STAT. 351, 352 (1961). Nelson advocates for parallel research efforts to overcome the uncertainty of technological development. *See id.* at 361–62.

207. *See id.* at 353 ("[A]t the start of a development program, estimates of the cost, time, and performance of a proposed [project] are subject to great uncertainty.").

208. Indeed, Kennedy himself acknowledged this uncertainty in his speech. *See* John F. Kennedy, President of the United States, Address Before a Joint Session of Congress (May 25, 1961) ("We propose to develop alternate liquid and solid fuel boosters[,] much larger than any now being developed, *until certain which is superior*." (emphasis added)).

209. *See* FAGONE, *supra* note 103, at 34–35.

210. *See supra* note 157 and accompanying text.

211. *Cf.* KNIGHT, *supra* note 204, at 237–38.

ble technological approach (or approaches), its characteristics, and its costs.[212] But the process itself involves what Ronald Gilson and his co-authors call "continuous uncertainty."[213] Technological development is ongoing and dynamic. The resolution of one particular aspect of uncertainty often raises others. Imagine, for example, a binary choice between two technologies to accomplish a single problem at the outset of development. Choosing one or the other likely results in two different subsequent technological choices. That second-order decision then yields a third set of choices. And so on. As Gilson et al. explain, "operational decisions must be continually updated and refined" in light of decisions made during development.[214]

We observed this process throughout the course of the Auto X Prize. The prize sponsors had a clear enough technological goal: the production of a car capable of achieving 100 MPGe fuel efficiency. But the technological path to that goal was highly uncertain at the outset. As the competition went on, information about which technologies were likely to be more successful than others emerged. But in the meantime, decisions had to be made about the rules of the competition amidst this uncertainty, hence the need to change the rules midstream. As described above, in one case the prize organizers initially set a staging goal — a criterion that had to be met for a team to move from one stage of the competition to the next — too high. [215] Although the goal may have seemed reasonable ex ante, it turned out to be technologically too difficult for any team to meet. Thus the rules set under conditions of uncertainty needed to be revisited when at least one aspect of that uncertainty — whether a technological threshold was reasonable — was resolved. Similarly, the Auto X Prize changed its structure when two different technological paths toward the 100 MPGe car proved to be non-comparable.[216] Although the competition organizers initially envisioned a singular "alternative class" for unusual vehicle designs, the divergence of the designs from one another — which could not have been predicted ex ante — necessitated splitting the class in two. Uncertainty also explains the need to implement the rules more flexibly than some of the participants might have preferred. Even if wholesale change of a rule was unwarranted, the imperfect fit between the rules as written, and the technologies as developed and implemented, required some creativity as the competition progressed.[217]

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212. *See* Nelson, *supra* note 206, at 352 ("[E]stimates of cost, performance, and development time tend to improve as development proceeds and information accumulates.").

213. *See* Gilson et al., *supra* note 204, at 448.

214. *Id.* at 449.

215. *See supra* note 177 and accompanying text.

216. *See supra* notes 174–177 and accompanying text.

217. *See supra* notes 198–200 and accompanying text.

The need to change the rules can therefore be seen as a direct consequence of the continuous uncertainty of the technological innovation. Uncertainty makes it impossible to specify ex ante the precise rules of the game. A prize sponsor can make an educated guess based on presently available information.[218] But that guess may turn out to be wrong in any number of ways. When new facts make the old rules obsolete, a change is necessary. The fact that the Auto X Prize had to change the rules and, indeed, had to do so throughout the competition, should be unsurprising in light of the uncertainty of the technology.[219]

2. Information Asymmetry

Organizing innovation also requires aggregating technological information that might be highly dispersed among different parties. As described above, Demsetz observed that it was difficult for any single actor — such as the government — to "produce information on the desired directions of investment and on the quantities of resources that should be committed to invention."[220] As a result, he and his successors have argued that because the government cannot adequately amass enough information to determine the costs and benefits of any particular research program, it is better to let the market determine the social value of R&D through a patent system.[221]

Gallini and Scotchmer model more precisely the difficulty a central authority might have in aggregating highly dispersed technological information.[222] Their central insight is that different inventors pursuing a similar goal may have different cost or value signals that are unobservable to others engaged in the activity.[223] This makes the firms' individual investment choices inefficient, but also makes it difficult for a central authority to determine the appropriate rate and direction of investment.[224] That said, the fact that aggregating information may be difficult and imperfect does not suggest that *some* aggregation of information is impossible in all circumstances: "[t]here

218. To the extent that information can even be gleaned in the first place. *See infra* Part III.C.2.

219. In a similar vein, most accounts of the British longitude prize suggest that the difficulty Harrison had in claiming the prize was due in no small part to the fact that the rules of the competition were not adapted to the unexpected success of his chronometer. Instead, the prize sponsors believed that an astronomical solution would be most likely and built the competition around that ultimately erroneous presumption. *See* SOBEL, *supra* note 7, at 8–10; Siegel, *supra* note 7, at 12–14, 17–32.

220. *See* Demsetz, *supra* note 62, at 12.

221. *See id.* at 12–14.

222. *See* Gallini & Scotchmer, *supra* note 51, at 56–58.

223. *See id.*

224. *Cf. id.*

are ways, of course," for a system to produce information about the optimal allocation of inventive resources.[225]

The Auto X Prize implemented several such mechanisms. In order for the Auto X Prize to make, change, and implement the rules, the organizers needed to access, aggregate, and analyze information held by a large number of parties. The prize organizers made use of several mechanisms throughout the competition. First, as described above, they used a process akin to administrative notice-and-comment rulemaking to gather information sufficient to set the overall goal of the prize and the initial set of rules. The process was iterative, with a widening circle of participants. The organizers began by seeking information from a small number of trusted sources, then moved on to a private advisory board, before seeking wider public comment.[226] Once the competition was underway, different mechanisms came into use. One was the staging process. At each stage of the competition, participants were required to make disclosures to the organizers either through the submission of documents, as in the design judging and shakedown phases,[227] or implicitly through observation of their vehicles' performance on the track. The prize organizers were in the position of trusted intermediary. The teams would disclose to the organizers the confidential information that they would not disclose to competitors. The transitions from one stage of the competition to the next functioned as organizing events in which information asymmetries would be at least partially resolved and, if necessary, the rules would then be changed. Finally, the appeals process put in place for the knockout and final rounds also served as a device to draw information from parties that were best in a position to reveal it.[228] That process incentivized participants to monitor their competitors and bring relevant information to the prize organizers.[229]

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225. Demsetz, *supra* note 63, at 12.

226. *See* FAGONE, *supra* note 103, at 35 (describing Peter Diamandis's initial conversations with Larry Page, Elon Musk, et al.); *supra* notes 158–164 and accompanying text.

227. *See* GUIDELINES V1.3, *supra* note 110, at 57–60.

228. By way of analogy, many aspects of litigation have been analyzed as mechanisms that incentivize efficient information disclosure, that is, disclosure by the least cost information revealer. *See, e.g.*, Alex Reinert, *Pleading as Information-Forcing*, 75 LAW & CONTEMP. PROBS. 1, 32–35 (2012); Ronald J. Allen, *Presumptions in Civil Actions Reconsidered*, 66 IOWA L. REV. 843, 860–63 (1981). This literature draws on the classic theory of information revelation through contract rules. *See, e.g.*, Ian Ayres & Robert Gertner, *Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules*, 99 YALE L.J. 87, 95–100 (1989).

229. *See* GUIDELINES ADDENDUM, *supra* note 115, at 16–18 (requiring complaining parties to file a written dispute).

IV. INNOVATION PRIZES IN THE ADMINISTRATIVE STATE

Part III identified the central challenge innovation prize competitions face: how to navigate uncertainty and information asymmetry in an efficient manner while maintaining the legitimacy of the prize competition necessary to attract and retain participants. Indeed, these dual goals lie at the core of the governance issues that beset innovation prizes.

In this Part we place this challenge in more general terms, recognizing that prize organizers will likely face significant challenges as they attempt to be flexible in the face of uncertainty and to aggregate information from all of the relevant parties in the face of information asymmetry. While changing the rules mid-stream and implementing them flexibly are critical given the underlying nature of the innovation process, they also lead to significant complaints about fairness, transparency, and legitimacy. Similarly, allowing competitors to help develop the rules could lead to charges of bias. These problems are, however, the familiar stuff of administrative law, much of which is concerned with balancing efficacy and legitimacy in modern governance.

Innovation prizes can productively be thought of as institutional settings in which to meet these governance challenges. We therefore evaluate more systemically innovation prizes' institutional potential. Situating innovation prizes in the modern administrative state, we observe that our proposed model for prize governance resembles the new governance or experimentalist paradigm for regulation. We then extend that literature to innovation, arguing that prizes are subject both to similar normative justifications, and to similar critiques, as collaborative governance. While some have called for wholesale revision of administrative law to accommodate governance experiments,[230] we argue more modestly that some simple approaches to prize governance will significantly lower the administrative costs (or at least reduce the administrative noise) of innovation prizes. At the same time, however, we recognize that the administrative costs of prizes likely make them difficult to scale in any simple fashion.

A. Toward a Model of Innovation Prize Governance

The experience of the Auto X Prize may not resemble the experiences of all prizes in all circumstances. Nevertheless, as we argued above, most inducement prizes that have a similar structure will confront the same basic governance challenges. Extrapolating from the

230. *See generally* Robin Kundis Craig & J.B. Rhul, *Designing Administrative Law for Adaptive Management*, 67 VAND. L. REV. 1 (2014) (proposing a "Model Adaptive Management Procedure Act").

Auto X Prize's successes and failures, we believe there are three key features of effective innovation prize governance: (1) transparency and collaboration; (2) iteration; and (3) nested decision-making structures.

1. Transparency and Collaboration

At the most basic level, this is necessary to enable information flow from competitors to organizers. The organizers serve as a clearinghouse for data, aggregating information about the state of the art that might otherwise be highly dispersed among the various competitors. Resolving information asymmetries, in turn, enables the organizers to resolve uncertainty as the competition progresses. The more information the organizers have at their disposal, the more able they will be to adapt the rules of the competition to the course of technological development. Because, as described above, that course cannot be determined ex ante, continuous information gathering is critical.

But transparency is not a one-way street. It is not only the participants who must reveal their technological developments to the organizers, but also the organizers who must reveal the reasoning behind their changes to the participants. This is so because transparency and collaboration also are mechanisms for building trust in organizations.[231] In inducement prize competitions in particular, the organizers and participants confront a variation of what Robert Cooter has called the "double trust dilemma" in linking ideas and capital.[232] Innovators must often disclose their ideas to secure capital, but such disclosure is risky because the information can be misappropriated. Similarly, investors must trust innovators with their capital well before the innovator can bring a product to market. In short, "the innovator must trust the investor not to steal his idea, and the investor must trust the innovator not to steal his capital."[233] These fears are easy to understand in the context of innovation prizes. Competitors may worry that their trade secrets or valuable information may be used to benefit others — either the organizers themselves or, by intentional or inadvertent further disclosure, other competitors. Similarly, the prize organizers need to trust that their investment in the competition will bear fruit, that the participants will not privately appropriate all of the gains from the collaboration by leaving the competition before the organizers reap the full benefits of wide participation.

231. This is well-documented in the organization literature. *See, e.g.*, Gilson et al., *supra* note 204, at 447–48.

232. *See* ROBERT D. COOTER & HANS-BERND SCHÄFER, SOLOMON'S KNOT: HOW LAW CAN END THE POVERTY OF NATIONS 27–28 (2012).

233. *See* COOTER & SCHÄFER, *supra* note 232, at 27–29.

Collaboration is a mechanism for building trust that can overcome this dilemma.[234] In a collaborative environment in which *both* sides make disclosures at risk, the parties engage in a process of learning about one another that can lead them safely to make further disclosures.[235] In the Auto X Prize, the organizers did a reasonable job of aggregating information but often failed to be sufficiently transparent to reap the maximal amount of trust from their participants. It is of course impossible to know if the outcome of the prize would have been different with added transparency about the organizers' decision-making processes. But it is clear that there was room for improvement. The complaints described above suggest that participants did not always trust the organizers to manage the competition fairly.[236]

2. Iteration

The second feature of innovation prize governance that is likely to be of especial importance is iteration — a process for routinely and systematically revisiting and revising previous decisions. Continuous uncertainty requires that parties frequently revisit past decisions in light of new information. As described above, uncertainty often requires that initial policy decisions be made as "best guesses." Although uncertainty in the Knightian sense,[237] by definition, precludes much ex ante prediction, it does not preclude the ability to refine those initial guesses as some aspects of uncertainty are resolved. Rational policymaking in conditions of continuous uncertainty therefore should be responsive to the development of new information. In the context of innovation prizes, this requires prize organizers and participants to continually revisit previous decisions in light of new information. Consistently evaluating decision criteria and the rules of prize competitions, for example, allows for frequent incorporation of new data that emerges as the competition progresses. Iteration is thus a key institutional feature of innovation prizes. Iteration also functions to reinforce the trust-building necessary to sustain collaboration.[238]

The most prominent example of iteration in the Auto X Prize was the initial notice-and-comment process to set the prize goals and structure.[239] Later in the competition, however, the prize organizers did not appear to iterate their rule changes. This may have been due in part to the exigencies of changing the rules in the midst of a competition that was supposed to adhere to deadlines, but adding mechanisms for iteration might have helped stave off some complaints.

234. *See id*.
235. *See* Gilson et al., *supra* note 204, at 476–81.
236. *See supra* notes 194–199 and accompanying text.
237. *See supra* note 204 and accompanying text.
238. *See* Gilson et al., *supra* note 204, at 481–89.
239. *See supra* note 160 and accompanying text.

3. Nested Decision-Making Structures

Finally, decision-making should take place through a tiered structure. The iteration described above would result in chaos if all of the rules of the game were equally susceptible to change and revision. One way to avoid that result is to nest decision-making at different hierarchical levels. In such a structure, the most fundamental rules are the most difficult to change. The more detailed the rule, the more susceptible it is to revision. Yet lessons learned at one tier ought to be communicated to the tiers above it so that change remains possible. While it may be difficult to change a fundamental rule, such as the makeup of the divisions of the Auto X Prize competition, such change should still be possible and facilitated by learning that takes place at lower tiers.

Putting these three attributes together results in the model depicted below in Figure 1:

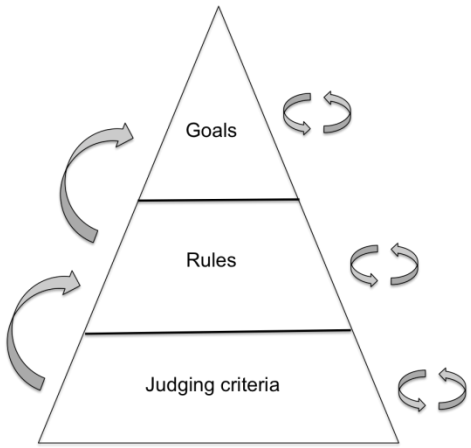

Figure 1: Model Innovation Prize Governance Structure

In this model, collaboration, transparency, and iteration take place at each stage of the decision-making process. As the prize competition proceeds, feedback is incorporated at each stage of the decision-making pyramid but also is fed to levels above and below it, so that each type of decision is fully informed by the experience of the prize competition.

B. Evaluation of the Model

Balancing efficacy and legitimacy is one of the central problems of administrative law.[240] The basic tension between the two arises because politically accountable actors cannot themselves complete all of the tasks of modern governance. Instead, a vast administrative state has arisen in which most of the work of government is performed by agencies under delegation from the legislature with oversight from the executive. So the question is how best to ensure that agencies are able to perform the multitude of tasks they are assigned while simultaneously remaining accountable to the public.[241]

Over the years, policymakers and academics have converged upon, and then come to criticize, a number of different models of administrative governance that attempt to strike this balance. The New Deal-era expansion of the administrative state purported to balance effective administration with public legitimacy through the use of disinterested, technocratic expertise.[242] The "expertise" model gave way to an understanding that the administrative process was based on bargaining among competing interest groups.[243] Following this conception, procedures — especially notice-and-comment rulemaking — were made more robust for the purpose of ensuring that agencies heard and responded to all available viewpoints. Constraining agency discretion became of central concern in administrative law.[244] This model in turn was criticized as too focused on procedures, too slow, and too cumbersome to achieve efficacy in the modern regulatory environment. Complaints that the rulemaking process in particular had become "ossified" were legion.[245]

The search for alternatives has led some to a model variously called "collaborative governance,"[246] "new governance,"[247] and "ex-

240. For classic articulations of the tension between efficacy and legitimacy, see, e.g., Richard H. Pildes & Cass R. Sunstein, *Reinventing the Regulatory State*, 62 U. CHI. L. REV. 1, 8 (1995) ("The key task for those interested in regulatory performance is to find ways of simultaneously promoting economic and democratic goals."); Richard B. Stewart, *The Reformation of American Administrative Law*, 88 HARV. L. REV. 1667, 1669–70, 1805 (1975).

241. *See* Jody Freeman, *Collaborative Governance in the Administrative State*, 45 UCLA L. REV. 1, 4 n.5 (1997) ("The crisis of legitimacy in administrative law stems from the lack of constitutional status accorded to administrative agencies and the need for oversight from the three branches of government to ensure that agency decision making is accountable to the public.").

242. *See generally* JAMES M. LANDIS, THE ADMINISTRATIVE PROCESS (1938).

243. *See* Stewart, *supra* note 240, at 1810–13.

244. *See* Lisa Shultz Bressman, *Procedures as Politics in Administrative Law*, 107 COLUM. L. REV. 1749, 1761–63 (2007).

245. *See* Thomas O. McGarity, *Some Thoughts on "Deossifying" the Rulemaking Process*, 41 DUKE L.J. 1385, 1396–98 (1992).

246. Freeman, *supra* note 241, at 4.

247. *See, e.g.*, Gráinne de Búrca & Joanne Scott, *Introduction: New Governance, Law and Constitutionalism*, *in* LAW AND NEW GOVERNANCE IN THE EU AND THE US 1, 2–4

perimentalism."[248] This model upends many of the common assumptions of administrative law and posits that it is possible to "integrate [agency] discretion and stakeholder participation in a disciplined, accountable manner."[249] The unifying theme of the new governance literature is a move away from traditional command-and-control regulation,[250] toward "a model that views the administrative process as a problem-solving exercise in which parties share responsibility for all stages of the rule-making process, in which solutions are provisional, and in which the state plays an active, if varied, role."[251] The core of the idea is moving from a governance model marked by conflict, bargaining, adversarial relations, and the need to constrain discretion,[252] to one in which problem solving, participation, and flexibility are key.[253]

Although particular models of experimental governance vary in their particulars, usually "central institutions give autonomy to local ones to pursue generally declared goals. The center then monitors local performance, pools information in disciplined comparisons, and creates pressures and opportunities for continuous improvement at all levels."[254] This style of governance requires the articulation of "framework goals" which are then pursued by local units with "broad discretion."[255] But "as a condition of this autonomy, the local units must report regularly on their performance," and those reports are the basis for continuous revision of the "framework goals, performance measures, and decision-making procedures themselves . . . on the basis of alternatives reported and evaluated in peer reviews."[256] As Jody Freeman explains, "[t]his requires information sharing and deliberation among parties with the knowledge most relevant to devising and implementing creative solutions."[257]

(Gráinne de Búrca & Joanne Scott eds., 2006); Lobel, *supra* note 33, at 345–46 (cataloguing terms).

248. *See, e.g.*, Charles F. Sabel & William H. Simon, *Minimalism and Experimentalism in the Administrative State*, 100 GEO. L.J. 53, 55 (2011); Michael C. Dorf & Charles F. Sabel, *A Constitution of Democratic Experimentalism*, 98 COLUM. L. REV. 267, 288 (1998).

249. Sabel & Simon, *supra* note 248, at 56. The authors note this premise is "controversial." *Id.*

250. *See* de Búrca & Scott, *supra* note 247, at 2.

251. Freeman, *supra* note 241, at 6.

252. *See id.* at 18–19.

253. *See id.* at 22.

254. Sabel & Simon, *supra* note 248, at 55; *see also* Craig & Rhul, *supra* note 230, at 7 (describing experimental protocol that consists of "(1) definition of the problem, (2) determination of goals and objectives for management, (3) determination of the baseline, (4) development of conceptual models, (5) selection of future actions, (6) implementation and management actions, (7) monitoring, and (8) evaluation and return to step (1).").

255. Sabel & Simon, *supra* note 248, at 79.

256. *Id.*

257. Freeman, *supra* note 241, at 22.

Learning and adaptation are central to the model.[258] Indeed experimentalism is likely to be particularly successful where collaboration is necessary to resolve uncertainty. As Charles Sabel and William Simon write:

> [E]xperimentalist regimes are especially well suited for circumstances in which effective public intervention requires local variation and adaptation to changing circumstances. . . . In the realm of uncertainty, policy aims cannot be extensively defined in advance of implementation; they have to be discovered in the course of problem solving.[259]

Unsurprisingly, then, most of the successful examples of experimentalist governance have come in regulatory areas plagued by uncertainty, such as environmental regulation.[260]

Such experimentalism acquires and maintains legitimacy mostly because of the ways in which stakeholders participate. "Experimentalism emphasizes stakeholder participation to elicit and reconcile the diverse views and interests of people distinctively affected by and knowledgeable about the matters in issue."[261] That deep participation makes the parties "interdependent and accountable to each other."[262]

The model of prize governance that emerges from our case study resembles experimental approaches to regulation in several ways. The prize organizer operates as a central clearinghouse, aggregating information from the participants — the "local units" — over the course of the competition, and adjusting not only the judging criteria and rules, but also the goals of the competition itself, when necessary, in response to new information. This system is undergirded by strong norms of collaboration even amidst nominal competition, and it all depends on the kind of adaptation and learning that new governance proponents emphasize. To the extent that experimental approaches to governance are justified on the ground that they are effective means of

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258. *See* Sabel & Simon, *supra* note 248, at 78.

259. *Id.* at 56; *cf.* Craig & Ruhl, *supra* note 230, at 13 (explaining that experimentalist approaches are particularly *unsuited* to regulatory situations where "long-term stability of decisions is important," "decisions simply can't easily be adjusted once implemented," or "it is essential that an agency retain firm authority to say 'yes' or 'no' and leave it at that").

260. *See, e.g.*, Sabel & Simon, *supra* note 248, at 83, 89. *But see* David A. Super, *Laboratories of Destitution: Democratic Experimentalism and the Failure of Antipoverty Law*, 157 U. PA. L. REV. 541, 546 (2008) (criticizing experimental approach to social welfare administration).

261. Sabel & Simon, *supra* note 248, at 82.

262. Freeman, *supra* note 241, at 22; *see also id.* ("New arrangements, networks, institutions, or allocations of authority may replace or supplement traditional oversight mechanisms."); Craig & Ruhl, *supra* note 230, at 7 ("[P]ublic input is derived through an emphasis on more loosely defined processes for 'stakeholder involvement' and multiparty 'collaborative planning.'").

solving certain kinds of regulatory problems, those justifications extend to the provision of innovation incentives through prizes.

To be sure, the problem of legitimacy in innovation incentives is not entirely the same as it is in command-and-control regulation of primary behavior. That is because prize participants always have the option of exiting the competition.[263] This option is unavailable except at very high cost to participants in a regulated industry, such as polluters, and in some circumstances to social welfare beneficiaries who come reasonably to rely on the continued receipt of benefits.

Nevertheless, legitimacy is critical to innovation prizes to keep participants engaged. Assuming that an inventor is willing to invent, notwithstanding market uncertainty, she may still be unwilling to make the investment if she cannot be reasonably assured that she could obtain the offered incentive. The inventor may be willing to tolerate uncertainty in outcome (i.e. the value of the invention) if there is certainty as to the process of obtaining the innovation incentive. Uncertainty and information asymmetries persist throughout the innovation process, but a stable structure within which they can be managed provides innovators with enough security to prevent defection from the sphere of collective action. In this way, innovation prizes function much like experimentalist regimes. They rely on trust building over iterated collaborative interactions to keep participants motivated to pursue the technological goal within the prize structure. As such, innovation prizes can therefore be justified along the same lines as experimental governance more broadly. They are institutional mechanisms for balancing efficacy and legitimacy throughout a process rife with uncertainty and asymmetric information.

At the same time, however, experience with experimental governance models offers some cautions for prizes. In particular, experimentalism has been subject to two critiques that may just as easily be applied to prizes.

First, the conditions in which experimentation will work often are more limited than new governance proponents suggest. David Super, for example, identifies several key assumptions underlying new governance models: (1) "[A] general consensus about the existence and nature of a problem;" (2) "that all relevant players are inclined to act in a public-spirited way to correct that problem;" (3) "that reliable metrics exist, and can readily be agreed upon and implemented, for measuring policies' effectiveness;" (4) "that time does not constrain decision making;" (5) "the absence of factors that would necessitate national regulation;" and (6) "that transaction costs do not significantly deter political participation."[264] He argues that when any one of

263. *See generally* ALBERT O. HIRSCHMAN, EXIT, VOICE AND LOYALTY: RESPONSES TO DECLINE IN FIRMS, ORGANIZATIONS, AND STATES (1970).

264. Super, *supra* note 260, at 553–58.

these assumptions is missing, experimentalism may serve to entrench existing policies rather than to break out of the cycle of traditional regulation.[265] A similar critique by Martin Kurzweil notes that collaborative governance is difficult and expensive to undertake: "Because experimentalism requires close observation, critical self-evaluation, and constant revision, significant effort is expected of participants. It is a far more active and mentally taxing form of governance than bureaucracy. Experimentalism also requires this active engagement from more people than traditional bureaucracy."[266]

The X PRIZE Foundation itself witnessed the high profile failure of an innovation prize in part for some of the reasons that Super suggests. The $10 million Archon Genomics X Prize was offered for the development of the next generation of genome sequencing. Although the prize was announced in 2006, it struggled to attract competitors and had to be re-launched with a different goal and incentive structure in 2011. Even then, it attracted only two teams and was cancelled before the formal start of competition in 2013. Much of the difficulty with the prize arose because the technology was moving rapidly and the parties could not execute an agreement as to the relevant rules and guidelines before it would have become outmoded. Ultimately, the prize became irrelevant to the development of the technology.[267]

Second, and relatedly, prize models are likely to break down if much of modern administrative law applies with rigor.[268] A full assessment of the relationship between prizes and administrative law is beyond the scope of this article, but it suffices to say that experimentalist governance fits only uncomfortably within conventional administrative law. And prizes are no exception.[269] Consider just a few of the requirements of conventional administrative law that might interfere with the model of prize governance described above. The Federal Advisory Committee Act would subject information gathering at the beginning of the prize development process to a series of disclosure obligations.[270] Although there is an argument that the COMPETES Act notice requirement — that agencies publish basic rules in the Federal Register before conducting a prize competition[271] — supplants notice-and-comment rulemaking under the Administrative Pro-

265. *See id.* at 559–63.

266. Martin A. Kurzweil, *Disciplined Devolution and the New Education Federalism*, 103 CALIF. L. REV. 565, 585 (2015).

267. *See* Peter Diamandis, *Cancellation of the Archon Genomics XPRIZE: A Public Debate*, X PRIZE FOUND., http://genomics.xprize.org/news/blog/cancellation-of-archon-genomics-xprize-public-debate [https://perma.cc/DBS5-PYEB].

268. *See* Craig & Ruhl, *supra* note 230, at 27.

269. *See generally* Steven L. Schooner & Nathaniel E. Castellano, *Eyes on the Prize, Head in the Sand: Filling the Due Process Vacuum in Federally Administered Contests*, 24 FED. CIR. B.J. 391 (2014).

270. 5 U.S.C. app. §§ 1–16 (2012).

271. *See* 15 U.S.C. § 3719(f) (2012).

cedure Act ("APA"), that is not certain. And requiring such notice-and-comment rulemaking would prove to be cumbersome. Notwithstanding the Auto X Prize's success at using a similar mechanism, APA rulemakings can be exceedingly complex.[272]

More fundamentally, when agencies change their position on any given issue, they usually are expected to provide adequate notice and a reasoned explanation for the departure.[273] Even if prizes were to adopt the model of transparency we describe above,[274] the quick adaptation to changing circumstances required of the model would be almost impossible by the standards of reasoned decision-making in administrative law.

And, finally, basic notions of due process arguably may be implicated when disappointed prize contestants are not given full information about why they failed to achieve the prize. Already at least one such contestant has filed suit in the Court of Federal Claims seeking compensation for an agency's failure to award him a prize.[275] That case was brought on a breach of contract theory and the court ultimately held that the participation agreement barred the suit.[276] But a challenge to such an outcome under the APA is plausible.[277] The COMPETES Act is silent on the subject of judicial review, so the ordinary presumption of reviewability of agency actions should apply.[278] The theory of relief would be a straightforward application of § 706 of the APA, which authorizes courts to set aside arbitrary and capricious agency action.[279] Given the subjectivity and quick turnaround inevitable in prize judging, it is unlikely that any given decision will withstand hard look review if applied by a court.[280]

As a practical matter, the application of ordinary administrative law might pose a barrier to implementing prizes at significant scale. Absent a change in law, the sustainability of an innovation prize depends on the willingness of parties to go along with the model. This cannot be assured in all cases, and the likelihood of participation without defection necessarily limits the scale that a prize system can achieve.

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272. *See* McGarity, *supra* note 245, at 1398.

273. *See, e.g.*, FCC v. Fox Television Stations, Inc., 556 U.S. 502, 515–16 (2009).

274. *See supra* notes 231–233 and accompanying text.

275. *See* Frankel v. United States, 122 Fed. Cl. 287, 288–89 (Fed. Cl. 2015).

276. *See id.* at 292.

277. *See* Schooner & Castellano, *supra* note 269, at 414–20. It is worth noting that there are several additional theories under which disappointed prize contestants can recover from the government. These theories sound in procurement law. *See id.* at 419–26. Again, the COMPETES Act is unclear about the framework for reviewability of competitions conducted under its authority.

278. *See* 5 U.S.C. § 702 (2012).

279. *See* 5 U.S.C. § 706(2)(A) (2012).

280. *See, e.g.*, Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 42–43 (1983).

In the skein of public administration, then, prizes offer some significant advantages but also some significant drawbacks. Like experimentalist governance more broadly, they offer a particular means to balance efficacy and legitimacy to solve a particular problem. But they may not always be an appropriate solution to the problem of innovation incentives, may present administrative pathologies of their own, and may not be compatible with some of the basic principles of administrative law beyond a small scale.

V. RETHINKING GOVERNMENT CHOICE OF INNOVATION INCENTIVES

In this Part, we place the benefits and costs of prize competitions, as described in Part IV, into comparative perspective in order to guide policymakers in their decision-making around when (rather than how) to make use of innovation prizes. Conventional analysis is, as we noted in Part I, guided by an economic approach that frames the mechanistic choice as being among prizes, patents, and grants. In this framework, the government's role is limited to providing the institutional support needed for the incentive mechanisms.[281] The rate and direction of inventive activity usually arises from the operation of the chosen mechanism. It is not established as a matter of government policy.

This model is too simplistic. There are many reasons why the government might choose among different innovation targets and policy goals. When the social value of a particular solution far exceeds its private value, government intervention is particularly necessary.[282] The market will fail to produce technologies whose value is not well-reflected in consumer prices, even with the intervention of patents or theoretical prizes. This occurs when ability to pay is not an accurate reflection of social value or where innovation is accompanied by large positive or negative externalities.[283] In these situations, the government makes a choice about what innovation goals it ought to pursue: Should it send a person to the moon or develop new treatments for rare diseases? The point here is simply that government innovation policy choices are often exogenous to the mechanism being used to implement those choices.

While a number of scholars have recently expanded the analysis of innovation institutions, they put the government's choice of technology direction to the side. Brett Frischmann, for example, argues that "[c]hoosing between institutions rests on subtle differences in the manner in which they target innovation market failures, rely on in-

281. *See generally* Wright, *supra* note 54.
282. *See* Stiglitz, *supra* note 85, at 1706–09.
283. *See* Roin, *supra* note 1, at 1029–31.

formation processing, and have dynamic effects on incentives and other institutions."[284] He considers a broad range of factors based on the precise market failure that the intervention seeks to remedy and the economic characteristics of the innovation good that is sought.[285]

Our framework for institutional choice is different. Taking our cue from the new governance literature described above, we posit an exogenously determined innovation goal for policymakers.[286] We then consider the institutional alternatives that are available for meeting that goal. Our analysis takes as its starting point a particular problem to be solved and focuses on the fit between that problem and the institutional mechanism for solving it. We measure that fit along two dimensions: efficacy and sustainability.

A. Efficacy

We have described the basic challenge of solving a technological problem as one of managing uncertainty and information asymmetries.[287] The extent of uncertainty and asymmetric information determines how effective one or another institutional mechanism for solving the technological problem will be.

Uncertainty affects both the goal and the path toward achieving that goal. Sometimes both can be articulated clearly at the outset of a project. For example, the government may decide that a live virus vaccine for a particular illness is highly socially desirable and the path to that end is well-specified. In contrast, sometimes a goal can be articulated but the path or paths toward it cannot be specified.[288] The Apollo space program is the canonical example of this context: the government chose to land a man on the moon within a particular time frame but could not determine ex ante how to do so (likewise with the desire for a fully sequenced human genome.) Other times, neither the goal nor the path can be very well articulated. For instance, the gov-

284. Frischmann, *supra* note 42, at 392.

285. *See id.* at 392–95. Hemel & Ouellette similarly conclude that "government grants are most effective when the government has a comparative advantage relative to the private sector in evaluating the costs and benefits of potential projects," "where market signals are poor proxies for the social benefits of new products, where potential innovators encounter significant capital constraints, and where cross-subsidization of product users by nonusers is desirable." Hemel & Ouellette, *supra* note 1, at 375. Government-sponsored prizes "may be most effective when government officials are capable of setting a clear goal and an appropriate prize size, but where government officials are at a disadvantage in identifying the most promising potential projects *ex ante*." *Id.* at 376. And patents "are most effective where potential innovators have ready access to the requisite financial capital and where the negative effects of risk aversion on innovators' incentives are limited." *Id.*

286. To be fair, part of the point of new governance, or experimentalism, is that the goal need not be specified with particularity; instead, goals are refined through the same process of iteration that produces policy action. *See, e.g.*, Sabel & Simon, *supra* note 248, at 56.

287. *See supra* Part III.C.

288. *See* Kalil, *supra* note 82, at 6.

ernment may choose to promote investment in nanotechnology research broadly without specific applications in mind.

The extent of information asymmetry is also a key characteristic of the problem to be solved. In other words, how dispersed is the relevant solution set likely to be amongst innovators? When only a few groups are likely to have the specialized knowledge and skills to solve a given problem, it is relatively easy to identify and access them. There are a limited number of aerospace contractors capable of building an advanced fighter jet, so allocating that task is simply a matter of choosing one, for example. But as the degree of information asymmetry increases, it becomes more difficult simply to choose because the policymaker cannot predict where good solutions may come from. At the extreme end, choice is impossible.

Putting these two factors together yields insights into how efficacious different institutions might be against different problems. Begin with two simple examples:

(1) When uncertainty and information asymmetry are both low, the solution resembles simple procurement. The government can specify in a contract what it wants and award the contract to the party best able to fulfill the mission. Grants are essentially a form of procurement and are likely to be a good solution in this circumstance.

(2) When uncertainty and information asymmetry are both high, patents are likely to be the better solution. That is because the patent system depends on market signals to aggregate the necessary information about the socially useful rate and direction of innovation.[289] It is distributed and undirected.

Prizes in this framework occupy a complex but important middle ground. Our case study shows that prizes can be useful when the degree of uncertainty is significant but not insurmountable, and when there is likely to be a number of identifiable parties who can provide a solution, but also room for unexpected or novel participation in the problem solving process. The Auto X Prize met these criteria, as did the Longitude prize, the Netflix Prize, and other now well-known prize competitions. The prize organizers could identify a goal but not necessarily a means to achieve it, and although some information holders were obvious — auto companies and their former employees — others, such as hobbyists, were not. Figure 2 depicts a simpli-

289. Recall that this is the canonical advantage of patents over other mechanisms. *See* Demsetz, *supra* note 63, at 11–12.

fied framework for determining the efficacy of an innovation institution.[290]

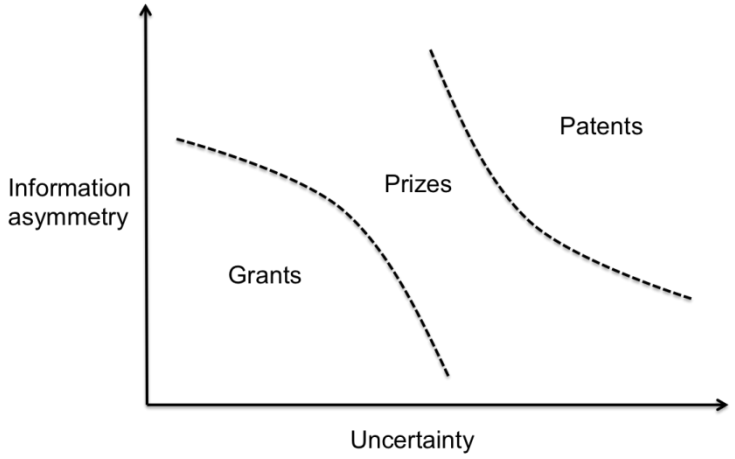

Figure 2: Efficacy

Of course, this framework is not as simple as it appears. Incentive mechanisms are better thought of as occupying ranges with fuzzy boundaries and overlaps. It may be that multiple mechanisms are efficacious for a given problem. Consider, for example, the problem of basic nanotechnology research. On one hand, the uncertainty associated with this research is likely to be high. The policymaker can articulate a broad area in which socially valuable research has yet to be undertaken, but it is hard to be more specific than that. On the other hand, there are usually a finite number of researchers working in cutting edge fields. So grants or prizes may be appropriate. In most cases, we suspect, the government will have a range of options available.

B. Sustainability

Choosing among institutional options for innovation depends not only on pure efficacy, but also on the sustainability of each option. We define sustainability as a combination of legitimacy and scalability (which, as described above in Part IV.B, is a function of administrative costs). Part IV assessed the sustainability of innovation prizes, explaining that innovation prizes achieve legitimacy through collabo-

290. For simplicity, we omit express discussion of some alternative innovation incentive mechanisms, such as R&D tax credits. *See* Hemel & Ouellette, *supra* note 1, at 321–26. Our framework is, however, equally applicable to this and other mechanisms.

rative problem solving based on transparency, iteration, and tiered decision-making. But it also suggested reasons to believe why this mechanism, effective though it may be in some settings, may not scale well. Large-scale projects put stress on those collective approaches that rely in large part on the development of shared norms and trust, and perhaps on the repeated execution of prizes by certain organizations that, over time, accumulate trust among communities of innovators.

Other innovation incentives achieve legitimacy in different ways and are scalable in different ways. The patent system achieves legitimacy through a highly regulated scheme of administrative and judicial review, undergirded by the constitutional value of due process. Patent applications are examined at the United States Patent and Trademark Office, and applicants have a right to administrative appeal of the denial of their applications.[291] If the denial is upheld on appeal, applicants have a further avenue of judicial review available to them. Throughout the process, the applicant has the opportunity to present evidence supporting her argument for patentability. Once the patent issues, it enjoys a presumption of validity.[292] Though it remains subject to challenge, such challenges must be proven by clear and convincing evidence in a fully litigated judicial setting in which the applicant may put on a robust defense.[293] This system is not without flaws.[294] Nonetheless, the system has for many years assured inventors that so long as they meet a set of criteria defined ex ante, they will get a patent. Then, *if* there is a market for their product, they will be able to take advantage of that market. Security in the former enables risk-taking in the latter.

Grant-making institutions manage the dual problems of uncertainty and asymmetric information through a mix of high-level policymaking and distributed peer review. Overall funding priorities — the decisions about what innovation policy goals to achieve — are set by politically accountable government officials in their relevant departments.[295] The task of choosing individual grant recipients is then typically carried out through peer review of prospective recipients' grant

291. *See* 35 U.S.C. § 134(a) (2012).

292. *See* 35 U.S.C. § 282(a) (2012).

293. *See* Microsoft Corp. v. i4i Ltd. P'ship, 131 S. Ct. 2238, 2251–52 (2011).

294. For example, some argue that various judicial doctrines make it too easy to challenge the validity of patents and therefore undermine the stability that we describe here. *See generally* Rochelle Cooper Dreyfuss & Lawrence S. Pope, *Dethroning* Lear*? Incentives to Innovate After* MedImmune, 24 BERKELEY TECH. L.J. 971 (2009).

295. For example, the Secretary of Health and Human Services, a political appointee, is authorized to support and fund stem cell research. *See, e.g.*, *2009 Guidelines on Stem Cell Research*, NAT'L INST. HEALTH, http://stemcells.nih.gov/policy/pages/2009guidelines.aspx [https://perma.cc/EX6J-FVET].

applications.[296] Peer review legitimizes these decisions in part because it is a long-accepted scientific norm and a historic part of the scientific community,[297] and in part because it is an instance of collective decision-making within the relevant scientific communities. Peer review operates well when it takes place at a scale that enables it to aggregate private information from the relevant community while maintaining legitimacy through effective decision-making and a sense of fairness. It is undermined when individuals feel that factors other than scientific merit are at work, although there is growing evidence that social networks and other factors are relevant to the peer review process.[298]

Although these sketches are necessarily brief, they should be enough to demonstrate that none of the three innovation incentives — patents, grants, and prizes — are amenable to treatment as black boxes. Each of these innovation incentives is an institution. Each is a system for organizing innovation and for managing uncertainty and information asymmetry in a particular way. And each is sustainable in different ways. The patent system works well at scale but is particularly expensive to administer, both from the perspective of the government and from the perspective of the participants who may have to engage in costly litigation to validate their rights. The system of peer-reviewed research grants generally scales to a given research community but is subject to a number of pathologies that arise from strategic behaviors that can emerge in those communities.

The fit between any given innovation problem and the set of institutions that may address that problem therefore depends on the tradeoff between efficacy and sustainability.

VI. CONCLUSION

Innovation prizes have great potential to help drive technological innovation in socially and economically useful directions. But too often the contemporary discourse about prizes has assumed this potential rather than proven or evaluated it. This Article presents a first step towards a deeper understanding of how innovation prizes work and when they should be used. But it is not the last step.

Our analysis justifies prizes as reasonable institutional solutions to exogenously defined innovation goals. And we suggest a new way to analyze the comparative effectiveness of prizes, patents, and grants at achieving those goals, namely, by comparing the efficacy and sustainability of their different approaches to managing and governing

296. *See, e.g.*, *Merit Review*, NAT'L SCI. FOUND., http://nsf.gov/bfa/dias/policy/merit_review/ [https://perma.cc/3334-5UUK].

297. *See* Katherine L. Gross & Gary G. Mittelbach, *What Maintains the Integrity of Science: An Essay for Nonscientists*, 58 EMORY L.J. 341, 349–52 (2008).

298. *See generally* Danielle Li & Leila Agha, *Big Names or Big Ideas: Do Peer-Review Panels Select the Best Science Proposals?*, 48 SCI. 434 (2015).

the uncertainty and information asymmetry that plague many areas of innovation.

Further empirical study of the operation of innovation prizes will yield further insights into whether and how they can be managed better. It will also provide critical data points for policymakers. In turning to comparative institutional analysis, we therefore not only put prizes on a firmer theoretical footing, but also hope to open the door to future research that can refine and expand upon the models we present here.