Beyond the Patents–Prizes Debate

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Intellectual property scholars have vigorously debated the merits of patents versus prizes for encouraging innovation, with occasional consideration of government grants. But these are not the only options. Perhaps most significantly, the patents-versus-prizes (or patents-versus-prizes-versus-grants) debate has largely neglected the role of tax incentives in innovation policy, despite the tens of billions of dollars spent globally on tax breaks for R&D activities each year. How should R&D-related tax incentives figure into this debate, and what criteria are relevant for policymakers selecting among the various tools?

In this Article, we develop a new taxonomy of innovation policies that allows direct comparisons among patents, prizes, grants, and tax incentives. This taxonomy highlights the overlooked efficiency benefits of tax credits: like patents, they elicit privately held information about the expected value of R&D projects; like grants, they reduce the social-welfare costs of frictions in imperfect capital markets. Our taxonomy also sheds new light on nonefficiency dimensions of R&D policy. Grants, tax credits, and prizes generally require all taxpayers to subsidize R&D regardless of whether they use the resulting products, whereas the patent system imposes R&D costs primarily upon the consumers who purchase patented products. In some contexts (e.g., life-saving drugs), the user-pays aspect of the patent system is difficult to defend on distributive justice grounds. In other contexts (e.g., luxury goods), the user-pays aspect of the patent system may make patents normatively preferable in comparison to alternative incentive mechanisms.

Ultimately, optimal innovation policy will depend on a range of factors that are likely to vary across contexts. For example, grants may be optimal where the government has a comparative advantage in evaluating potential projects, while tax credits may be optimal where potential innovators have private information about project prospects and limited access to outside capital. We argue for a pluralistic approach to innovation policy that

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incorporates each of the four main incentive mechanisms, and we provide examples of this pluralistic approach in practice.

Introduction

Lawyers and economists have long recognized that the patent system is not the only possible mechanism for incentivizing the production of new knowledge: government-awarded prizes and grants can perform similar functions.[1] Indeed, the patents-versus-prizes (or patents-versus-prizes-versus-grants) debate dates back at least as far as the nineteenth century.[2] In recent years, articles comparing the relative merits of patents, prizes, and grants have consumed thousands of pages in law reviews and economics journals.[3] And—outside of academic journals—Nobel laureates,[4] newspaper editorialists,[5] and presidential candidates[6] are taking sides in the debate.

1. *See, e.g.*, Nancy Gallini & Suzanne Scotchmer, *Intellectual Property: When Is It the Best Incentive System?*, *in* 2 INNOVATION POLICY AND THE ECONOMY 51, 51 (Adam B. Jaffe et al. eds., 2002) (noting that prizes and contract research are common alternatives to intellectual property in rewarding R&D); Joseph E. Stiglitz, *Economic Foundations of Intellectual Property Rights*, 57 DUKE L.J. 1693, 1719–24 (2008) (evaluating prizes and government-supported research as alternatives to the patent system); Brian D. Wright, *The Economics of Invention Incentives: Patents, Prizes, and Research Contracts*, 73 AM. ECON. REV. 691, 691 (1983) (comparing patents, prizes, and direct contracting as research incentives).

2. *See* Fritz Machlup & Edith Penrose, *The Patent Controversy in the Nineteenth Century*, 10 J. ECON. HIST. 1, 19 (1950) (noting that in the mid-nineteenth century, the *Economist*—under the editorship of James Wilson and later Walter Bagehot—championed the position that cash prizes could serve as effective substitutes for patents). *See generally* Steven Shavell & Tanguy van Ypersele, *Rewards Versus Intellectual Property Rights*, 44 J.L. & ECON. 525, 526–27 (2001) (reviewing this history).

3. For a review of the literature, see Peter S. Menell & Suzanne Scotchmer, *Intellectual Property Law*, *in* 2 HANDBOOK OF LAW AND ECONOMICS 1473, 1530–34 (A. Mitchell Polinsky & Steven Shavell eds., 2007).

4. *See* Joseph E. Stiglitz, *Prizes, Not Patents*, PROJECT SYNDICATE (Mar. 6, 2007), http://www.project-syndicate.org/commentary/prizes—not-patents; *see also* Eric S. Maskin, Letter to the Editor, *Patents on Software: A Nobel Laureate's View*, N.Y. TIMES, Oct. 14, 2012, http://www.nytimes.com/2012/10/15/opinion/patents-on-software-a-nobel-laureates-view.html ("[I]n an industry with highly sequential innovation, it may be better for society to scrap patents altogether than try to tighten them."); Gary Becker, *On Reforming the Patent System–Becker*, THE BECKER-POSNER BLOG (July 21, 2013, 2:38 PM), http://www.becker-posner-blog.com/2013/07/on-reforming-the-patent-system-becker.html (calling for the elimination of patents on software and DNA, among "[o]ther categories of innovations," and noting that "prizes and awards, like the Fields Medal and Nobel prizes," have served to "offset" the effect of excluding "basic scientific knowledge" from patent protection).

5. *E.g.*, Catherine Rampell, *Invent a Drug, Win $1 Million*, SLATE (Jan. 23, 2008), http://www.slate.com/articles/health_and_science/science/2008/01/invent_a_drug_win_1_million.html (arguing that "we don't need to punt the whole patent system to promote research for neglected diseases or other worthy causes," but that "a few reputable charities . . . should offer attractive prizes for solutions to carefully chosen problems"); Tina Rosenberg, *Prizes with an Eye Toward the Future*, OPINIONATOR, N.Y. TIMES (Feb. 29, 2012), http://opinionator.blogs.nytimes.com/2012/02/29/prizes-with-an-eye-toward-the-future (making the case for prizes); Matthew Yglesias, *My Five-Point Plan for Fixing Everything*, SLATE (Oct. 23, 2013), http://www.slate.com/blogs/moneybox/2013/10/23/how_to_fix_everything.html (arguing that we should "innovate with prizes, not monopolies").

6. *See* James Love, *John Edwards: Prizes, Not Patent Monopolies*, HUFFINGTON POST (June 15, 2007, 11:05 AM), http://www.huffingtonpost.com/james-love/john-edwards-prizes-not-p_b_52323.html (discussing John Edwards's support for prizes); Bradford Plumer, *Time To Socialize Drug Research?*, POLITICAL MOJO, MOTHER JONES (Oct. 18, 2005, 3:44 PM) (discussing a proposal by Dennis Kucinich, a candidate in the 2004 and 2008 Democratic

Meanwhile, the United States and other industrialized economies dole out tens of billions of dollars' worth of tax credits each year for research and development (R&D).[7] These tax credits are designed (albeit perhaps poorly)[8] to achieve the same objective as patents, prizes, and grants: to encourage the production of new knowledge. In the United States, the statutes that establish credits and deductions for R&D are among the most complex provisions in the Internal Revenue Code.[9] And while amendments to the Patent Act are few and far between, R&D-related tax laws in the United States are fast changing, with considerable congressional attention devoted toward these provisions each year.[10]

One might think that intellectual property scholars—who devote their professional careers to the study of the legal institutions that promote knowledge production—would take a keen interest in R&D tax incentives. After all, tax laws related to R&D—like patent laws—affect the allocation of the costs and benefits of knowledge production. And yet discussion of R&D tax incentives is largely left to tax law academics, practitioners, and nonlawyers.[11] Robert Merges summed up the general attitude among intellectual property scholars when he wrote recently that "[t]axation is, *of course*, external to IP law."[12] Most introductory courses in patent law make no reference to R&D tax incentives.[13] Even highly sophisticated analyses

presidential primaries, "to get rid of drug patents and steer about $25 billion in taxpayer money . . . to government-backed research organizations").

7. *See infra* notes 113–14 and accompanying text.

8. *See infra* notes 154–62 and accompanying text (discussing how federal tax incentives currently provide little encouragement to start-ups); *see also* David L. Cameron, *Research Tax Credit: Statutory Construction, Regulatory Interpretation and Policy Incoherence*, 9 COMPUTER L. REV. & TECH. J. 63, 65–70 (2004) (suggesting other problems).

9. *See infra* section I(B)(4) (describing the complexity of these provisions).

10. *See, e.g.*, H.R. 905, 113th Cong. (2013); S. 310, 113th Cong. (2013); S. 193, 113th Cong. (2013); H.R. 120, 113th Cong. (2013).

11. *See, e.g.*, Nick Bloom et al., *Do R&D Tax Credits Work? Evidence from a Panel of Countries, 1979–1997*, 85 J. PUB. ECON. 1 (2002); Bronwyn Hall & John Van Reenen, *How Effective Are Fiscal Incentives for R&D? A Review of the Evidence*, 29 RES. POL'Y 449 (2000). An important exception is Brett Frischmann, who compares tax credits with patents, grants, and contracts (but not prizes). *See* Brett Frischmann, *Innovation and Institutions: Rethinking the Economics of U.S. Science and Technology Policy*, 24 VT. L. REV. 347 (2000). On tax incentives versus grants (with no discussion of prizes and only passing mention of patents), see Paul A. David et al., *Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence*, 29 RES. POL'Y 497 (2000). An additional forthcoming analysis of the role of R&D tax incentives in spurring innovation can be found in Shaun P. Mahaffy, Note, *The Case for Tax: A Comparative Approach to Innovation Policy*, 123 YALE L.J. (forthcoming 2014).

12. ROBERT P. MERGES, JUSTIFYING INTELLECTUAL PROPERTY 132 (2011) (emphasis added).

13. *See, e.g.*, ROBERT P. MERGES ET AL., INTELLECTUAL PROPERTY IN THE NEW TECHNOLOGICAL AGE 1101 (5th ed. 2010) (indexing the subjects discussed in the casebook and not mentioning taxes); *id.* at 1092 (listing the statutes cited in the casebook and not mentioning the Internal Revenue Code).

of innovation policy levers omit any mention of tax law amid discussions of patents, prizes, and grants.[14]

The result is that the study of innovation policy remains a bifurcated field. We have yet to find an academic work that adequately answers the following questions: When should society use patents, prizes, and grants to incentivize knowledge production and allocate the corresponding costs? When should society use tax law to perform these functions instead? And when will the optimal innovation policy involve a mix of multiple incentive mechanisms utilized in combination? Indeed, not only do these questions go unanswered, but—with few exceptions—they go unasked.

In this Article, we present a new framework for approaching these questions—one that, we hope, will facilitate further research at the intersection of intellectual property and tax law. We begin in Part I with a simple economic model of the four main policy tools for promoting R&D: patents, prizes, government grants, and R&D tax incentives. We demonstrate that under various (stylized) assumptions, each mechanism leads to the same set of research projects being pursued at the same social cost. We also provide a brief overview of how each mechanism is implemented in U.S. policy.

Part II introduces our framework for comparing these different tools. We argue that any system for incentivizing knowledge production must explicitly or implicitly answer three distinct questions. First, *who decides* the size of the reward that innovators will receive? For grants and fixed prizes, the government tailors the reward on a project-by-project or discovery-by-discovery basis. For tax incentives and patents, the government simply establishes general ground rules for the reward system without making tailored, technology-specific judgments. This lets private parties decide which projects to pursue, and it allows decentralized decision makers and market actors to determine how large the reward will be. Participants in the patents-versus-prizes debate have recognized that patents may be preferable to prizes when the government is unable to accurately value projects.[15] But the same participants have failed to appreciate that tax

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14. *See, e.g.*, Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575, 1586–87 (2003) (discussing incentives such as prestige, prizes, the desire to do good, and *ex ante* subsidies by agencies and universities).

15. *See, e.g.*, Richard A. Posner, *Intellectual Property: The Law and Economics Approach*, 19 J. ECON. PERSP. 57, 58–59 (2005) (noting the difficulty of calculating optimal rewards for prizes). As Posner points out, the government may fail to assign accurate valuations not only because of insufficient information, but also because a government-run reward system stands at risk of being politicized. *Id.*

incentives—like patents—leverage the value of information held by private parties.[16]

Second, a system for rewarding innovators must answer the question of *when* the reward will be provided. Grants and tax credits provide rewards *ex ante*, before the results of R&D are known. By contrast, prizes and patents provide rewards *ex post*, after an R&D project has produced a novel discovery. The importance of reward timing is neglected in the patents-versus-prizes debate because both involve *ex post* rewards. It is often assumed that *ex post* rewards will provide strong motivation for researchers to expend their full effort in producing new knowledge. However, the incentive value of patents and prizes may be dulled because *ex post* rewards are both delayed and speculative. Due to capital constraints and risk aversion, innovators may be less willing to pursue new projects when rewards are allocated *ex post* than when society provides early, certain funding. *Ex ante* rewards may also be less costly to society because the social discount rate is lower than the private discount rate—i.e., society today values a future dollar more than an individual or firm does. Thus, society may get less "bang for its buck" when it seeks to incentivize innovation through the promise of future rewards than when it does so through present-period payments.

The third question that a system of allocating rewards for innovation must answer is *who will pay* the corresponding cost? Of the principal innovation policy mechanisms, patents currently are unique in that the primary payors are purchasers of patented products (i.e., the very people who benefit most from the underlying innovation). By contrast, for rewards funded through general tax revenues, users who do not consume particular technologies cross-subsidize those who do. Commentators often characterize the user-pays aspect of the patent system as a drawback.[17] From an efficiency perspective, spreading the costs of R&D across a broad base will reduce the corresponding deadweight loss. From a distributive-justice perspective, forcing sick people to pay for life-saving drugs or forcing starving people to pay for drought-resistant plant varieties may seem heartless. But we argue that for some innovations (in particular, luxury goods), the user-pays aspect of patents may be a normatively attractive feature. In theory, the user-pays principle can be incorporated into prize, grant, and R&D credit systems as well (although as we explain below, this is not always possible in practice).

With respect to each of these dimensions (*who decides*, *when* does the transfer occur, and *who pays*), innovation incentives fall onto a spectrum

16. *See, e.g.*, *id.* (implying that the alternative incentive system that addresses the valuation problem is a property-rights approach); sources cited *supra* note 1.

17. *See, e.g.*, *infra* notes 197–98 and accompanying text.

rather than into discrete boxes. And under some circumstances, policymakers can make changes with respect to one dimension while holding others constant. For example, the patent system is one in which the market rather than the government sets the size of the reward, transfers to innovators occur *ex post* (after the patented product is brought to market), and costs are borne primarily by product users. However, one can imagine a market-set, *ex post* reward system in which costs are spread across a broader base. Indeed, many European countries have adopted such a system through the addition of "patent boxes" to their tax codes (allowing patent income to be taxed at a lower rate).[18] Likewise, grants involve government decision making and *ex ante* transfers, with costs spread across society (cross-subsidization). However, one can imagine a government-set, *ex ante* reward system that adheres to the user-pays principle (e.g., if products made by grant recipients were subject to a sales tax to offset the cost of the grants). We show how our three-dimensional framework points toward space for more creative policymaking with respect to innovation incentives.

We conclude Part II by noting several further implications of the choice among innovation policies. For instance, how do patents, prizes, grants, and tax credits influence innovators who are primarily motivated by nonmonetary considerations? How can innovation incentives be structured so as to encourage individuals and firms to disclose technical information rather than keeping that knowledge secret? How can incentives be designed to discourage wasteful "races" among multiple innovators (or should racing be considered a feature rather than a bug)? And how can innovation regimes minimize administrative and compliance costs? The paradigmatic policies for incentivizing innovation—patents, prizes, grants, and tax credits—all address these considerations differently; no single tool strictly dominates the others; and each of the four will be optimal in specific contexts. Thus, when innovation debates truncate the menu of policy options to only two or three of these tools, we run the risk that the best option has been left off the table.

Part III illustrates some of the policy implications of our three-dimensional framework. First, we discuss various obstacles facing innovation policy reform efforts, and we suggest some ways in which these obstacles might be overcome. For example, while most countries are constrained in their ability to redesign their patent system by international trade agreements,[19] we argue that they can still significantly reduce their reliance on patent incentives without violating their international legal obligations. Meanwhile, domestic politicians may be biased in favor of the

18. *See, e.g.*, *infra* note 137 and accompanying text.
19. *See infra* notes 67, 291 and accompanying text.

patent system because the patent system's costs are hidden, while the costs of alternative incentive mechanisms are more transparent. However, we argue that mounting evidence of the patent system's considerable costs may make politicians more receptive to reform now than in the past. We then identify specific circumstances in which each of the four primary policy levers presents the optimal solution to a particular innovation-related problem. Finally, we argue that the either–or nature of the patents-versus-prizes debate has led scholars to overlook the benefits of innovation policy pluralism, and we suggest ways in which innovation policy levers can be fruitfully combined.[20]

I. Current Approaches to Encouraging Innovation

A. In Theory

Imagine that a small pharmaceutical company is deciding whether to pursue a project to develop a specific drug. If the project is successful, it will yield a cure for a rare disease. Let's say that the social cost of the disease is $1,000; the estimated cost of the project is $50; and the probability that the project will generate a cure for the disease is 1/10.[21]

For the time being, imagine that the company is considering the drug development project in a world where patents do not exist. This is not to say that there are zero private benefits from being the first to invent: if the project is successful, the company will enjoy a first-mover advantage over its competitors, and even when competing companies learn how to replicate the drug, the company may still be able to reap some profits based on its status as the brand-name maker of the drug.[22] Let's say that the pharma company will be able to appropriate one-quarter of the social benefit of the drug ($250) through first-mover advantage and brand-name status. But if the project is unsuccessful, the company's profits based on its first-mover advantage and brand-name status will be zero.

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20. While this Article focuses on the patent system and alternative innovation incentives, our framework likewise applies to other areas of IP. For example, prizes, grants, and tax credits can potentially replicate the incentive effect of copyright for creative works. On alternatives to copyright, see generally WILLIAM W. FISHER III, PROMISES TO KEEP: TECHNOLOGY, LAW, AND THE FUTURE OF ENTERTAINMENT 8–10, 173–258 (2004) and Stephen Breyer, *The Uneasy Case for Copyright: A Study of Copyright in Books, Photocopies, and Computer Programs*, 84 HARV. L. REV. 281, 287 & n.28 (1970). Considerably less academic attention has been devoted to trademark alternatives, although we believe that this area is fertile ground for future work.

21. Our argument does not depend on the numbers chosen. *See infra* note 26.

22. *See* Henry G. Grabowski & John M. Vernon, *Brand Loyalty, Entry, and Price Competition in Pharmaceuticals After the 1984 Drug Act*, 35 J.L. & ECON. 331, 340 (1992) (finding that two years after generic entry, brand-name drugs retain about half of their market share despite being on average three times the price of generics).

If the pharma company is purely profit-motivated, then it will not develop the drug under these circumstances: a 1-in-10 chance of a $250 reward is not worth the $50 cost. From society's perspective, this result is lamentable: the expected value of the social benefit from the project is one-tenth of $1,000 (i.e., $100), which is double the project's cost. So the government, realizing that profit-motivated enterprises are forgoing projects with potentially large social benefits, may decide to step in.

Government interventions to incentivize innovation may take one of four basic forms. First, the government might increase the reward for successful innovators by offering a prize to the first person who discovers a drug that cures the rare disease. Let's say that the government announces a prize of $250. Now, if the pharma company pursues the project, it has a 1-in-10 chance of a $250 profit (from first-mover advantage and brand-name status) *plus* a 1-in-10 chance of winning a $250 prize.[23] The expected value of the project (1/10 × $500) is now sufficient to offset the $50 cost.

Second, the government might announce that the first person who discovers a drug that cures the rare disease will acquire an exclusive right to sell or license the drug for a limited time (i.e., a patent). Depending on the scope and duration of the patent right, this second option may produce the same effect as the prize: if the company expects to reap profits of $250 from its patent (over and above the $250 it reaps on account of first-mover advantage and brand-name status), then the company faces the same 1-in-10 chance of a $500 profit—again, enough to justify the $50 cost.

Alternatively, the government might encourage innovation not by increasing the rewards for success, but by decreasing the costs of R&D. Thus, a third option would be to offer grants for efforts to cure rare diseases. For example, the government could offer the pharma company a $25 grant for drug development, with sufficient strings attached to make sure that the company actually allocates funds to the project in question. With a $25 grant, the expected value of pursuing the project is still only $25 (a 1-in-10 chance of a $250 profit from first-mover advantage and brand-name status), but the net cost is only $25 as well ($50 minus the $25 government grant). As with prizes and patents, government intervention via grants could convince the pharma company to pursue the project.

A fourth option—and the one most often neglected by IP scholars—is a refundable tax credit for R&D. The tax credit could take the form of a 50-cent refund for every dollar the taxpayer spends on R&D. If the government made such a credit available for R&D projects focused on finding cures for rare diseases, then the credit would have the same effect as

23. The prize is just large enough to induce one entrant; if a second company with similar costs also pursued the project, the expected value would not offset its costs. For more on the problem of rent dissipation if the reward is set too high, see *infra* section II(D)(3).

the grant: the pharma company would calculate that the pre-tax cost of pursuing the project ($50), minus the refund from the tax credit ($25), is commensurate with the rewards from success (a 1-in-10 chance of a $250 profit).

Thus, in this stylized example, the four options available to the government—prizes, patents, grants, and refundable tax credits—have the same effect on the pharma company's incentives.[24] Importantly, three of the four options also have equivalent expected effects on the government's budget. A prize would require the government to make a $250 payment if the company discovers a drug that cures the rare disease. There is only a 1-in-10 chance that the company will actually find a cure, however, so a prize carries an expected cost to the government of only $25. A grant would require the government to pay the pharma company regardless of whether the project proves to be successful, but since the grant is only $25, the expected cost to the government is the same as under the prize regime. A tax credit effectively imposes this same $25 cost on the government, as the credit reduces tax revenues by that amount.

Patents—unlike prizes, grants, and tax credits—don't necessarily impose a budgetary cost on the government (apart from the costs of administering the patent system, which we will set aside for the moment). But if the patent allows the pharma company to reap $250 of additional profits, those profits have to come from *somewhere*—and presumably, that *somewhere* is from consumers who pay higher prices for the drug. From the consumers' perspective, there is little difference between the patent option and a sales tax imposed exclusively on rare-disease-curing drugs (assuming that the sales tax is calibrated so that it raises $250 in total revenue and setting aside concerns about deadweight loss for the moment). Patents are, in substance, a sales tax combined with a prize: the sales tax is imposed on users of the patented product, and the prize is reaped by the patentee in the form of supracompetitive profits. The sales tax only kicks in if the pharma company's drug development efforts are successful, so the expected cost to consumers is $1/10 \times \$250$—the same $25 social cost that arises with respect to prizes, grants, and credits. We can think of the higher price of patented products as a "shadow" tax and the patent system as a "shadow" government expenditure: while it does not show up in annual appropriations or deficit calculations,[25] it is a cost ultimately borne by consumers (and thus by taxpayers).

24. We have only considered a single potential innovator. Additional entrants reduce the probability that any given firm will capture the rewards from innovation, yet a new entrant does not necessarily internalize the effect of entry on other potential innovators' payoff structure. We discuss this "common-pool" problem in section II(D)(3).

25. The shadow tax imposed by the patent system *does* appear on budgets when the government is the purchaser of patented products. For example, Medicare Part D is estimated to

The claim that prizes, patents, grants, and tax credits all have the same effect on innovation incentives at the same budgetary (or shadow budgetary) cost does not depend on the specific numbers we chose.[26] But this claim must be accompanied by numerous caveats. We explore these caveats in detail in Part II; here we simply mention three examples. First, we have assumed that potential innovators respond in the same way to a guaranteed $25 as to a 1-in-10 chance of $250. Yet potential innovators may be risk averse and thus more responsive to a certain $25 grant or tax credit than to a riskier 1-in-10 chance of a $250 patent or prize.

Second, we have assumed that potential innovators face no capital constraints: if they don't have $50 to spend out-of-pocket today, they can borrow against the expectation of future profits. But for cash-strapped innovators without access to outside funding, grants (which provide funds immediately) and refundable tax credits (which provide funds within a short timeframe) may be more desirable than prizes and patents (for which the potential rewards are long-delayed).

Third, we have assumed that the government recognized the potential of this project and could perfectly tailor each reward. But the government typically has imperfect information. According to the conventional wisdom, patents are superior to prizes and grants when the government is at an informational disadvantage relative to market actors.[27] Yet arguably, when the government cannot accurately evaluate potential projects *ex ante* or assess their benefits *ex post*, rewards based on tax credits may be most

account for approximately a quarter of U.S. prescription drug spending in 2013. *See* OFFICE OF THE ACTUARY, CTS. FOR MEDICARE & MEDICAID SERVS., NATIONAL HEALTH EXPENDITURE PROJECTIONS 2012-2022 tbl.2 (2013), *available at* http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/Proj2012.pdf (projecting $262.3 billion will be spent on prescription drugs in 2013); *The Medicare Prescription Drug Benefit Fact Sheet*, HENRY J. KAISER FAMILY FOUND. (Nov. 19, 2012), http://kff.org/medicare/fact-sheet/the-medicare-prescription-drug-benefit-fact-sheet/ (noting the Congressional Budget Office estimates that Part D spending will total $60 billion in 2013).

26. More generally, if p is the probability of success (1/10 in our example), B is the social benefit ($1,000), F is the first-mover advantage ($250), and C is the cost of development ($50), welfare-enhancing projects for which C falls in the range $pF < C < pB$ (which is true in our example: $25 < $50 < $100) will not be pursued absent an additional innovation incentive of magnitude $C – pF$. Grants and tax credits can provide this reward directly, or prizes and patents can provide $(C – pF)/p$ with probability p, for an equivalent total cost of $C – pF$ (so in our example, grants and tax credits provide a direct reward of $25, and prizes and patents provide a reward of $250 with probability 1/10). It is irrelevant whether the size of F changes in response to the reward; for example, if a patent right mostly supplants the first-mover advantage, so that F_{patent} = $50 (rather than $250) and the patent reward is $C – pF_{\text{patent}}$ = $450, the *total* cost to society is still $500; we are paying the shadow sales tax whether exclusivity arises due to first-mover advantage or to patent rights. The social benefit B is only relevant for determining whether a project enhances welfare; doubling B creates additional surplus but does not require a larger reward to the inventor. In fact, a larger reward may be inefficient if it is simply dissipated through duplicative research, known as "racing." *See infra* section II(D)(3).

27. *See infra* notes 123–24 and accompanying text.

desirable, as these only require the government to be able to value a project's inputs rather than its outputs.[28]

We explore these and other caveats at further length in Part II. For now, we emphasize that at least *in theory*, the four tools for incentivizing innovation—prizes, patents, grants, and refundable tax credits—can potentially generate the same effect on innovation incentives at the same budgetary (or shadow budgetary) cost.

This is not to say that the four tools are equivalent in terms of allocative efficiency. What we called the shadow tax of the patent system—monopolistic price minus marginal cost—excludes the deadweight loss associated with monopoly.[29] And the budgetary costs of grants, prizes, and credits exclude the deadweight loss associated with taxation.[30] In theory, the government may be able to raise revenue to finance public goods through a lump sum tax without generating any deadweight loss.[31] But we have yet to encounter an economist who believes that in practice, tax financing for public goods in the United States (or any other country) actually *is* accomplished with no deadweight loss. Thus, innovation policies inevitably entail some deadweight loss. The choice between patents, on the one hand, and tax-financed innovation incentives, on the other, involves a tradeoff between the deadweight loss of monopoly and the deadweight loss of taxation.

One might expect the deadweight loss of monopoly to be greater than the deadweight loss of taxation, assuming that taxes are imposed on a broad base. As Steven Shavell and Tanguy van Ypersele write:

> [I]ncome taxation is equivalent to a uniform tax on all goods, whereas intellectual property rights involve[] concentrated taxes in the form of monopoly prices on just a subset of goods; and raising a

28. The ease of determining the cost of research is only *relative* to the complexity of determining the social benefit of a new innovation. Taxpayers and IRS agents devote considerable time to drawing the line between expenses that are eligible for federal R&D tax incentives and expenses that are not. *See infra* section II(D)(4).

29. *See* N. GREGORY MANKIW, PRINCIPLES OF ECONOMICS 311–13 (6th ed. 2011) (illustrating this inefficiency). The current patent system could be modified to provide similar innovation incentives while reducing deadweight loss. *See* Ian Ayres & Paul Klemperer, *Limiting Patentees' Market Power Without Reducing Innovation Incentives: The Perverse Benefits of Uncertainty and Non-Injunctive Remedies*, 97 MICH. L. REV. 985 (1999) (arguing that uncertainty and delay in patent enforcement may constrain a patentee's market power and reduce deadweight loss).

30. *See* MANKIW, *supra* note 29, at 156–67 (explaining how taxation creates deadweight loss).

31. *Id.* at 246. Note that in models with endogenous fertility (i.e., where taxation affects the number of children that parents decide to have), a per capita lump sum tax is distortionary. Marc Nerlove et al., *Some Welfare Theoretic Implications of Endogenous Fertility*, 27 INT'L ECON. REV. 3, 3, 18 (1986).

given amount through a uniform tax on all goods generally involves less deadweight loss than through a tax on a subset of goods.[32]

Note, though, that the equivalence between a labor income tax and a uniform tax on goods is purely theoretical: in reality, numerous deductions and exclusions (e.g., for houses[33] or health care[34]) upset this equivalence and increase the distortionary effect of income taxation.[35] When the tax code is sufficiently deduction-ridden, the marginal distortion due to additional revenue-raising for credits, grants, and prizes could conceivably exceed the marginal distortion due to stronger patent rights.[36]

As we will explain in Part II, this issue is not unique to patents: prizes, grants, and R&D tax credits can be financed either though general taxation or by taxing only a subset of goods. For the purposes of this Article, we bracket the question of whether distortions due to the current tax code exceed distortions due to taxing a subset of goods, which will depend in part on the structure of the tax system. We do, however, identify nonefficiency reasons that policymakers might favor one financing mechanism over the other.

B. In Practice

The previous subpart showed how prizes, patents, grants, and R&D tax incentives could potentially provide equivalent incentives in theory; here we consider how they operate in practice. It is important to note that

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32. Steven Shavell & Tanguy van Ypersele, *Rewards Versus Intellectual Property Rights* 25 (Nat'l Bureau of Econ. Research, Working Paper No. 6956, 1999), *available at* http://www.nber.org/papers/w6956; *see* Gallini & Scotchmer, *supra* note 1, at 54 ("Monopoly pricing is equivalent to taxing a single market, which is generally thought to impose greater deadweight loss than the broad-based taxation that generates general revenue."); Douglas Gary Lichtman, *Pricing Prozac: Why the Government Should Subsidize the Purchase of Patented Pharmaceuticals*, 11 HARV. J.L. & TECH. 123, 129–30 (1997) (arguing that a subsidy scheme funded by mandatory tax contributions can be sufficiently inexpensive to improve market efficiency by eliminating the deadweight loss of monopoly pricing). *See generally* Michael Abramowicz, *Perfecting Patent Prizes*, 56 VAND. L. REV. 115, 200–07 (2003) (examining the distortionary effects of taxation); Michael Kremer, *Patent Buyouts: A Mechanism for Encouraging Innovation*, 113 Q.J. ECON. 1137, 1146–48 (1998) (suggesting an auction mechanism for patent buyouts to eliminate monopoly pricing distortions). To clarify, a *wage* income tax is equivalent to a uniform commodity tax (assuming a constant rate of return on investment). A.B. Atkinson & J.E. Stiglitz, *The Design of Tax Structure: Direct Versus Indirect Taxation*, 6 J. PUB. ECON. 55, 64 (1976). This equivalence disappears when capital income is also taxed.

33. *E.g.*, I.R.C. § 121 (2006).

34. *E.g.*, *id.*

35. We bracket the question of whether the inclusion of capital income in the tax base is also distortionary. *See generally* JANE G. GRAVELLE, THE ECONOMIC EFFECTS OF TAXING CAPITAL INCOME (1994).

36. John F. Duffy, *The Marginal Cost Controversy in Intellectual Property*, 71 U. CHI. L. REV. 37, 42, 55–56 (2004).

innovation does not always require government intervention: non-IP-based appropriation mechanisms such as first-mover advantage, secrecy, and norms (such as anti-copying norms in a small community) may provide sufficient monetary incentives for many projects,[37] and other innovation is driven by nonmonetary incentives such as intrinsic motivation or prestige.[38] But societies have long recognized that absent incentive mechanisms, information will be underproduced.[39] The U.S. federal government currently uses prizes, patents, grants, and tax credits to incentivize the invention and commercialization of new technologies;[40] this subpart reviews the legal framework for each of these mechanisms.

While most commentary evaluates innovation policy options as *alternatives* (e.g., patents *versus* prizes),[41] U.S. policy typically uses patents as a *complement*, so that innovators may be rewarded through patents *and* prizes,[42] grants,[43] or tax incentives. Other funding mechanisms, however,

37. *See* Wesley M. Cohen et al., *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)* 32 tbl.1 (Nat'l Bureau of Econ. Research, Working Paper No. 7552, 2000), *available at* http://www.nber.org/papers/w7552 (reporting that R&D managers generally view secrecy and lead time as more effective appropriation mechanisms than patents); Edwin Mansfield, *Patents and Innovation: An Empirical Study*, 32 MGMT. SCI. 173, 174 (1986) (reporting that U.S. manufacturing firms often did not view patents as essential for developing inventions); *see also* Abramowicz, *supra* note 32, at 129 n.43 (citing sources on first-mover advantages); Rochelle Cooper Dreyfuss, *Does IP Need IP? Accommodating Intellectual Production Outside the Intellectual Property Paradigm*, 31 CARDOZO L. REV. 1437, 1446 (2010) (reviewing the literature on norms that promote innovation in the absence of IP, such as reputational and employment sanctions). *See generally* KAL RAUSTIALA & CHRISTOPHER SPRIGMAN, THE KNOCKOFF ECONOMY: HOW IMITATION SPARKS INNOVATION (2012) (examining how innovation can thrive without IP in industries such as fashion and the culinary arts).

38. *See infra* section II(D)(1).

39. *See generally* SUZANNE SCOTCHMER, INNOVATION AND INCENTIVES 1–27 (2004) (reviewing the history of innovation incentives).

40. These are the policies that most directly transfer financial rewards to researchers; other innovation policy tools include regulations, e.g., 49 U.S.C. §§ 32901–32916 (2006 & Supp. V 2012) (mandating fuel economy standards), and subsidies for consumers of innovative products, e.g., CAL. VEH. CODE §§ 5205.5, 21655.9 (West 2013) (allowing single-occupant electric vehicles in carpool lanes). While these indirect rewards could also be placed within our framework, for simplicity we focus on monetary transfers. For a review of many other policies that indirectly affect innovation (including immigration, tort law, and land use), see generally THE KAUFFMAN TASK FORCE ON LAW, INNOVATION, AND GROWTH, RULES FOR GROWTH: PROMOTING INNOVATION AND GROWTH THROUGH LEGAL REFORM (2011).

41. *See, e.g.*, Gallini & Scotchmer, *supra* note 1; Wright, *supra* note 1.

42. *See* 15 U.S.C. § 3719(j)(1) (2012) (prohibiting agencies from acquiring an intellectual property interest in prize technologies without written consent); Heidi Williams, *Innovation Inducement Prizes: Connecting Research to Policy*, 31 J. POL'Y ANALYSIS & MGMT. 752, 753 (2012) ("[C]urrent policy discussions are essentially exclusive in their focus on using innovation prizes as a complement to the patent system, not as a replacement for it.").

43. 35 U.S.C. § 202(a) (2006). Grant recipients must disclose patentable inventions to the federal government. *Id.* §§ 201(d)–(e), 202(c)(1). If the grant recipient does not patent, the government may. *Id.* § 202(c)(2)–(3).

cannot always be combined: for example, the federal R&D tax credit is not available for research funded by a government or private grant.[44]

1. Prizes.—Technology inducement prizes[45] were frequently used to spur innovation in the eighteenth and nineteenth centuries; famous examples include the British Longitude Prize and Napoleon's prize for food preservation.[46] Prizes fell out of favor for most of the twentieth century, but recent private competitions have generated renewed interest. Most notably, in 1996 the X Prize Foundation offered $10 million to the first nongovernment organization to launch a spacecraft capable of carrying three people to 100 kilometers above the earth's surface twice within two weeks; the prize was awarded in 2004.[47] Privately sponsored prizes that have not been awarded or fully awarded include $30 million for an efficient refrigerator[48] and $25 million for removing greenhouse gases from the atmosphere.[49] In 2009, McKinsey estimated the size of the global prize sector, including recognition prizes, to be "as much as $1 to $2 billion."[50]

A 1999 report from the National Academy of Engineering urged the U.S. government to make greater use of technology inducement prizes,[51] and the United States has since begun to do so on a limited scale. As of

44. I.R.C. § 41(d)(4)(H) (2006).

45. "Inducement prizes" for a specified goal should be distinguished from "recognition prizes" such as the Nobel Prize. *See* NAT'L ACAD. OF ENG'G, CONCERNING FEDERALLY SPONSORED INDUCEMENT PRIZES IN ENGINEERING AND SCIENCE app. A at 1–2 (1999) (defining each term).

46. SCOTCHMER, *supra* note 39, at 32–34, 43–44; Jonathan H. Adler, *Eyes on a Climate Prize: Rewarding Energy Innovation to Achieve Climate Stabilization*, 35 HARV. ENVTL. L. REV. 1, 19–22 (2011); *see also* Liam Brunt et al., *Inducement Prizes and Innovation*, 60 J. INDUS. ECON. 657, 658 (2012) (concluding that prizes offered by the Royal Agricultural Society of England from 1839 to 1939 boosted innovation).

47. *Ansari X Prize*, X PRIZE FOUND., http://space.xprize.org/ansari-x-prize. The X Prize Foundation has also awarded $1.4 million for oil cleanup and $10 million for fuel-efficient vehicles (with $3.5 million of government support). *Energy and Environment Prize Group*, X PRIZE FOUND., http://www.xprize.org/prize-development/energy-and-environment; DEBORAH D. STINE, CONG. RESEARCH SERV., FEDERALLY FUNDED INNOVATION INDUCEMENT PRIZES 12–13 (2009). The Foundation is currently offering prizes for genome sequencing, medical diagnostics, and sending a robot to the moon. *Exploration Prize Group*, X PRIZE FOUND., http://www.xprize.org/prize-development/exploration; *Life Sciences Prize Group*, X PRIZE FOUND., http://www.xprize.org/prize-development/life-sciences.

48. *See* NAT'L ACAD. OF ENG'G, *supra* note 45, at app. A at 5–6 (noting that the prize was distributed incrementally based on product's units of sale); PAUL BREST & HAL HARVEY, MONEY WELL SPENT 177 (2008) (indicating that the winner, Whirlpool, reportedly sold 30 to 35 percent below the number of units needed to pocket the full prize).

49. *See* James Kanter, *Cash Prize for Environmental Help Goes Unawarded*, N.Y. TIMES, Nov. 21, 2010, http://www.nytimes.com/2010/11/22/business/energy-environment/22green.html.

50. MCKINSEY & CO., "AND THE WINNER IS . . .": CAPTURING THE PROMISE OF PHILANTHROPIC PRIZES 16 (2009).

51. NAT'L ACAD. OF ENG'G, *supra* note 45, at 1.

2009, the Department of Defense, Department of Energy, and NASA had offered or awarded over $35 million in prizes, ranging from $250,000 for an astronaut glove to $10 million for a 60W equivalent LED light bulb.[52] Congress has made clear that other funding agencies have the authority to offer prizes as well,[53] and President Obama has asked agencies to increase their use of prizes.[54] Agencies are heeding this call: between September 2010 and September 2013, fifty-eight different federal agencies administered a total of 288 "challenge competitions,"[55] ranging from the Department of Energy's $10 million "L Prize" for the development of a replacement for the sixty-watt incandescent lamp[56] to the U.S. Forest Service's prize for photos of urban and community forests, which offered $200 worth of outdoor gear to the winner.[57]

Most prize rewards have been fixed by the prize administrator and distributed to one or more winners based on the contest rules.[58] Recently, however, commentators have proposed market-based or performance-based prizes.[59] Specific proposals for performance-based prizes have focused on

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52. *See* STINE, *supra* note 47, at 3–5 tbl.1 (cataloging federally funded innovation prizes totaling over $35 million); Peter Whoriskey, *Government-Subsidized Green Light Bulb Carries Costly Price Tag*, WASH. POST, Mar. 8, 2012, http://articles.washingtonpost.com/2012-03-08/business/35450148_1_light-bulbs-expensive-bulb-traditional-60-watt (describing the outcome of the light bulb prize); *see also* Adler, *supra* note 46, at 25–28 (reviewing the federal government's interest in prizes following the 1999 National Academy of Engineering report).

53. *See* America COMPETES Reauthorization Act of 2010, Pub. L. No. 111-358, § 105, 124 Stat. 3982, 3989–93 (codified at 15 U.S.C. § 3719) (authorizing agencies to "carry out a program to award prizes competitively to stimulate innovation that has the potential to advance the mission of [each] respective agency"); *see also* Science, State, Justice, Commerce, and Related Agencies Appropriations Act, 2006, Pub. L. No. 109-108, 119 Stat. 2290, 2318 (specifying that National Science Foundation (NSF) appropriations "may be available for innovation inducement prizes"); NAT'L RESEARCH COUNCIL, INNOVATION INDUCEMENT PRIZES AT THE NATIONAL SCIENCE FOUNDATION 2 (2007) (urging the NSF to use this authority); Michael Price, *Will NIH Embrace Biomedical Research Prizes?*, SCI. INSIDER (July 19, 2011), http://news.sciencemag.org/scienceinsider/2011/07/will-nih-embrace-biomedical-research.html ("NIH has so far sat on the sidelines of the prize game, but . . . that may soon change.").

54. NAT'L ECON. COUNCIL ET AL., A STRATEGY FOR AMERICAN INNOVATION: SECURING OUR ECONOMIC GROWTH AND PROSPERITY 12 (2011).

55. *About Challenge.gov*, CHALLENGE.GOV, https://challenge.gov/p/about.

56. *L Prize Competition Overview*, L PRIZE, U.S. DEP'T OF ENERGY, http://www.lightingprize.org/overview.stm (last updated Nov. 7, 2012).

57. *My Neighborhood Forest Photo Contest*, CHALLENGEPOST, http://urbanforest.challengepost.com.

58. *See, e.g.*, sources cited *supra* note 48. *See generally* MCKINSEY & CO., *supra* note 50 (examining the prize sector). Prizes need not be limited to a single winner; an award could be split between the best three entries, or between all entries to meet a specified goal by a certain date.

59. *See, e.g.*, Abramowicz, *supra* note 32, at 176–77 (discussing the advantages of basing rewards on sales); Lichtman, *supra* note 32, at 124–25 (proposing a system that provides subsidies to consumers willing to pay more than the market price but less than the monopoly price); Shavell & van Ypersele, *supra* note 2, at 541 (suggesting that the government could implement a reward

health technologies; for example, pharmaceutical companies that registered products with the proposed Health Impact Fund would receive payments based on the "assessed global health impact."[60] A smaller-scale performance-based prize was launched in 2009 in the form of a $1.5-billion Advance Market Commitment (AMC) for pneumococcal vaccines, which guarantees suppliers a subsidy per vaccine dose sold.[61] Experimentation with AMCs could help inform the design of broader performance-based prize systems.[62]

2. Patents.—Patents have long had a much more prominent role in U.S. innovation policy than prizes.[63] Current U.S. patent law allows inventors to receive twenty-year patents on all novel, nonobvious, useful, and adequately disclosed inventions,[64] without discrimination as to the field of technology,[65] with the limited exception of "laws of nature, physical phenomena, and abstract ideas."[66] The international TRIPS agreement imposes similar patent law requirements on most countries.[67] Patents are the only innovation policy tool that states are precluded from using, due to

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system for patents that is based on sales data). An early example of the market-based prize approach seems to be the private prize for a super-efficient refrigerator mentioned earlier, which conditioned some of the prize on market sales. *See supra* note 48 and accompanying text.

60. AIDAN HOLLIS & THOMAS POGGE, INCENTIVES FOR GLOBAL HEALTH, THE HEALTH IMPACT FUND: MAKING NEW MEDICINES ACCESSIBLE FOR ALL 109 (2008). Senator Bernie Sanders has proposed similar health-impact-based prize schemes, but he would use these to replace, not complement, the patent system. *See, e.g.*, Prize Fund for HIV/AIDS Act, S. 1138, 112th Cong. § 5 (2011) (proposing to eliminate exclusive rights to HIV/AIDS treatments); Medical Innovation Prize Fund Act, S. 1137, 112th Cong. § 5 (2011) (proposing to eliminate exclusive rights to market drugs and biological products). For a proposal in which health-impact-based rewards are provided through variable-length market exclusivity, see Shamnad Basheer, *The Invention of an Investment Incentive for Pharmaceutical Innovation*, 15 J. WORLD INTELL. PROP. 305 (2012).

61. *See* Tania Cernuschi et al., *Advance Market Commitment for Pneumococcal Vaccines: Putting Theory into Practice*, 89 BULL. WORLD HEALTH ORG. 913, 913–14 (2011) (describing the pilot AMC).

62. *See* Williams, *supra* note 42, at 768–70 (describing the use of counterfactual analysis to analyze whether an AMC is successful).

63. *See* SCOTCHMER, *supra* note 39, at 11–14, 25.

64. 35 U.S.C. §§ 101–103, 112, 154(a)(2) (2006 & Supp. V 2012).

65. Congress has, however, allowed additional market exclusivity in the drug context. *See, e.g.*, 21 U.S.C. §§ 355(c)(3)(E)(ii)–(iii), (j)(5)(F)(ii)–(iv), 360cc (2012) (granting three, five, or seven years of "data exclusivity" for certain drugs); *id.* § 355(j)(5)(B)(iv) (granting the first-filing generic 180 days of exclusivity as the only generic); 35 U.S.C. § 156 (2006 & Supp. V 2012) (allowing a five-year extension for one patent per new drug).

66. Bilski v. Kappos, 130 S. Ct. 3218, 3225 (2010) (internal quotation marks omitted).

67. *See* Agreement on Trade-Related Aspects of Intellectual Property Rights arts. 27–33, Apr. 15, 1994, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, 1869 U.N.T.S. 299 [hereinafter TRIPS] (requiring twenty-year patents on "any inventions" (with limited exceptions) "without discrimination as to . . . the field of technology").

federal preemption.[68]

A patent conveys the "right to exclude" others from practicing the invention,[69] which may enable the inventor to charge supracompetitive prices, either by practicing the invention herself or by licensing the patent to others. The size of the patentee's reward is thus determined by demand for the claimed invention. Estimating the size of this reward is difficult. Patent and Trademark Office (PTO) economists recently estimated that "patent-intensive" industries accounted for $763 billion in value added to U.S. GDP in 2010,[70] but much of this value is not directly attributable to patents.[71] One attempt to separate the value of patents from the value of the underlying technology estimated that the rents attributable to patents held by U.S. public firms in 1999 (when there were fewer patents than today) totaled $18.4 billion in 1992 dollars, equivalent to $30.67 billion today.[72]

3. Government Grants.—The third innovation mechanism we consider is government grants—a category that includes direct spending on government research laboratories and grants to nongovernment researchers.[73] Both types of expenditures ballooned in the early years of the

68. *See* Bonito Boats, Inc. v. Thunder Craft Boats, Inc., 489 U.S. 141, 152 (1989) ("[S]tate regulation of intellectual property must yield to the extent that it clashes with the balance struck by Congress in our patent laws."). *But see* Camilla A. Hrdy, *State Patents as a Solution to Underinvestment in Innovation*, 62 U. KAN. L. REV. (forthcoming 2013) (arguing that states can and should offer patents).

69. 35 U.S.C. § 154(a)(1).

70. ECON. & STATISTICS ADMIN. & U.S. PATENT & TRADEMARK OFFICE, U.S. DEP'T OF COMMERCE, INTELLECTUAL PROPERTY AND THE U.S. ECONOMY: INDUSTRIES IN FOCUS 45 (2012). The twenty-six patent-intensive industries were defined as those with above average patent-per-job ratios. *Id.* at 7, 36–38 tbl.10.

71. For example, some patent-intensive firms have reported that they would develop most of their inventions without patents and that they seek patents for reasons other than appropriating the returns from R&D. *See* FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY, ch. 3, 30–56 (2003) (reporting on the mixed role of patents and alternative means of fostering innovation in the hardware, semiconductor, software, and Internet industries); Cohen et al., *supra* note 37, at 1–19, figs.5, 6, 7 & 8 (presenting results from a 1994 survey examining the effectiveness of different appropriability mechanisms); Stuart J.H. Graham et al., *High-Technology Entrepreneurs and the Patent System: Results of the 2008 Berkeley Patent Survey*, 24 BERKELEY TECH. L.J. 1255, 1325–27 (2010) (finding a variety of reasons that entrepreneurs use the patent system and differences between industries); Mansfield, *supra* note 37, at 176 (finding firms derived benefits from patent protection beyond royalties such as delay to prospective imitators and using patents as bargaining chips).

72. *See* JAMES BESSEN & MICHAEL J. MEURER, PATENT FAILURE: HOW JUDGES, BUREAUCRATS, AND LAWYERS PUT INNOVATORS AT RISK 114 (2008); *CPI Inflation Calculator*, BUREAU LABOR STAT., http://www.bls.gov/data/inflation_calculator.htm (estimating present dollars as of Oct. 15, 2013); *see also infra* notes 310–11 and accompanying text (noting additional estimates).

73. Our analysis of government grants applies to all instances in which the federal government provides direct financial support for a particular project, regardless of whether the

Cold War: federal spending on nondefense R&D increased more than thirty-fold between 1949 and 1967.[74] Today, direct federal R&D spending (which includes the very small amount currently spent on prizes) is about $130–$140 billion per year—slightly more than half of which is defense-related.[75] Many states also provide direct R&D support: in fiscal year 2009, states spent $3.6 billion on support for R&D at state universities and another $1.3 billion on other grants and facilities for in-state research.[76]

In some cases, lawmakers themselves decide which projects are worthy of financing; in other cases, they allocate money to agencies with broad research goals but delegate to agency officials the decisions about which projects to fund.[77] In both cases, the decision about which projects are funded and how much funding they receive is made by central planners, not individual researchers or market actors.

4. R&D Tax Incentives.—Finally, R&D-related tax incentives are

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arrangement is structured as a "procurement contract" under 31 U.S.C. § 6303, a "grant agreement" under § 6304, or a "cooperative agreement" under § 6305. On the differences among these arrangements, see generally Danielle Conway-Jones, *Research and Development Deliverables Under Government Contracts, Grants, Cooperative Agreements and CRADAs: University Roles, Government Responsibilities and Contractor Rights*, 9 COMPUTER L. REV. & TECH. J. 181 (2004).

74. *See* OFFICE OF MGMT. & BUDGET, HISTORICAL TABLES, BUDGET OF THE UNITED STATES GOVERNMENT, FISCAL YEAR 2014, at 202 tbl.9.7 (2013) (tracing the increase in nondefense R&D outlays in fiscal year 2005 dollars from $1.2 billion in 1949 to $37.6 billion in 1967).

75. *Id.* at 203 tbl.9.7; *see also* NAT'L SCI. FOUND., FEDERAL FUNDS FOR RESEARCH AND DEVELOPMENT: FISCAL YEARS 2009–11, at 9 tbl.1 (2012) (providing similar estimates of total R&D spending). As explained in section II(D)(4), these figures include administration costs for recipients but not for agencies.

76. NAT'L SCI. FOUND., ACADEMIC RESEARCH AND DEVELOPMENT EXPENDITURES: FISCAL YEAR 2009, at 7 tbl.1 (2011); NAT'L SCI. FOUND., STATE GOVERNMENT RESEARCH AND DEVELOPMENT: FISCAL YEAR 2009, at 3 tbl.1 (2012); *see also* Bo Zhao & Rosemarie Ziedonis, State Governments as Financiers of Technology Startups: Implications for Firm Performance (July 2012) (unpublished manuscript), *available at* http://ssrn.com/abstract=2060739 (examining state R&D awards in Michigan).

77. *Compare, e.g.*, *The Human Genome Project Completion: Frequently Asked Questions*, NAT'L HUMAN GENOME RESEARCH INST., http://www.genome.gov/11006943 (last updated Oct. 30, 2010) (noting that the Institute and the Department of Energy received funds from Congress for the completion of the Human Genome Project), *with Cancer Research Funding*, NAT'L INST. OF HEALTH, http://www.cancer.gov/cancertopics/factsheet/NCI/research-funding (explaining that the NIH receives a budget from Congress to fund cancer research but the specific projects are of the agency's own choosing). Until 2010, Congress used "research earmarks" to allocate funds to particular projects. *See* OFFICE OF SCI. & TECH. POL'Y, EXEC. OFFICE OF THE PRESIDENT, RESEARCH EARMARKS: RESEARCH AND DEVELOPMENT FUNDING IN THE PRESIDENT'S 2009 BUDGET (2008), *available at* http://www.whitehouse.gov/files/documents/ostp/Budget09/ResearchEarmarks1pager.pdf (describing and criticizing the use of earmarks). Earmarks were banned in 2010. *See* Brendan Greeley, *Earmarks: The Reluctant Case for Ending the Ban*, BLOOMBERG BUSINESSWEEK (Jan. 10, 2013), http://www.businessweek.com/articles/2013-01-10/earmarks-the-reluctant-case-for-ending-the-ban.

provided through several provisions in the tax code.[78] We focus on the two largest R&D tax expenditures: the expensing of research and experimental expenditures (Section 174) and the credit for increasing research activities (Section 41).

a. Expensing of Research and Experimental Expenditures (Section 174).—As part of the 1954 overhaul of the Internal Revenue Code, Congress enacted a provision (now codified as Section 174) allowing taxpayers to "expense" certain R&D costs.[79] To understand this provision, it is helpful to begin with a situation in which it does not apply. Imagine that a railroad spends $1 million to excavate a new tunnel in 2013. Under the tax code, the recovery period for railroad tunnel bore is fifty years, and the "straight line method" of depreciation applies.[80] This means that the railroad will be able to claim a $20,000 deduction in 2013, another $20,000 deduction in 2014 (even though the tunnel was excavated the prior year), and so on until 2062, when the full $1 million will have been written off.

Section 174 allows taxpayers to use a different approach when deducting research or experimental expenditures. Let's say that rather than spending $1 million on a new tunnel, the railroad spends $1 million in 2013 to research more durable tunnels and safer excavation methods.[81] Instead of deducting this $1 million in $20,000 increments over a half-century, Section 174 allows the railroad to deduct the full $1 million in 2013.[82] This option will be attractive to the railroad because: (1) inflation is likely to make $1 in 2062 less valuable than $1 today;[83] (2) even in inflation-adjusted terms, firms generally value $1 in the future less than $1 today; and (3) the railroad knows that it might not exist in fifty years.[84] Of course, the same factors that make expensing attractive to taxpayers also make it costly for the government. The Joint Committee on Taxation estimates that in 2013, the federal government will lose $5.4 billion in tax revenue due to

78. *See generally* CONG. RESEARCH SERV., 112TH CONG., TAX EXPENDITURES: COMPENDIUM OF BACKGROUND MATERIAL ON INDIVIDUAL PROVISIONS 87–111 (Comm. Print 2012) (summarizing these policies).

79. Internal Revenue Code of 1954, ch. 736, 68A Stat. 66 (codified as amended at I.R.C. § 174 (2006)).

80. I.R.C. § 168(b)(3), (c).

81. On the dangers of railroad tunnels, see, for example, Pete Donohue et al., *Dad Fails in Desperate Bid To Save Son in Collapse, Concrete Crushes Sandhog Son in Tunnel*, N.Y. DAILY NEWS, Nov. 18, 2011, http://www.nydailynews.com/new-york/dad-fails-desperate-bid-save-son-collapse-concrete-crushes-sandhog-son-tunnel-article-1.979682.

82. I.R.C. § 174(a) (2006).

83. A dollar 49 years ago would be worth 13 cents in 2013. *See CPI Inflation Calculator*, *supra* note 72.

84. *See* Edward I. Altman, *Railroad Bankruptcy Propensity*, 26 J. FIN. 333 (1971) (analyzing how railroads fail).

expensing for R&D.[85] Meanwhile, the Treasury Department published proposed regulations in September 2013 that, if finalized, are likely to make it easier for firms to expense costs incurred in developing products that are later sold to customers.[86]

b. Credit for Increasing Research Activities (Section 41).—The corporate R&D tax credit (now known as the "credit for increasing research activities") was first enacted in 1981 as a temporary provision set to expire after four-and-a-half years.[87] Since then, Congress has extended the credit sixteen times—most recently as part of the New Year's 2013 "fiscal cliff" deal.[88] The credit applies only to "qualified research expenses," which include only a subset of the expenditures for which Section 174 expensing is available.[89] To qualify for the credit, expenses must:

(1) be undertaken for purposes that are "technological in nature";[90]

(2) be intended to yield applications that will "be useful in the development of a new or improved business component of the taxpayer";[91] and

(3) comprise activities "substantially all . . . of which constitute elements of a process of experimentation."[92]

Even if they meet these requirements, expenses are ineligible if they are related to adaptation or duplication of an existing business component, market research, quality-control testing, social science research, grant-funded research, or research conducted outside the United States.[93]

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85. *See* STAFF OF THE JOINT COMM. ON TAXATION, 113TH CONG., ESTIMATES OF FEDERAL TAX EXPENDITURES FOR FISCAL YEARS 2012–2017, at tbl.1 (Comm. Print 2013) (taking the sum of "[e]xpensing of research and experimental expenditures" for corporations and individuals in 2013).

86. *See* 78 Fed. Reg. 54,796 (Sept. 6, 2013) (providing guidance for the treatment of expenses "in connection with the development of tangible property"); *see also* Jaime Arora, *Research Deduction Regs Find Favor With Practitioners*, 140 TAX NOTES 1074 (2013) (discussing proposed regulations).

87. Economic Recovery Tax Act of 1981, Pub. L. No. 97-34, § 221(d), 95 Stat. 172, 247 (current version at I.R.C. § 41 (2006 & Supp. V 2012)).

88. *See* American Taxpayer Relief Act of 2012, Pub. L. No. 112-240, § 301(a)(1), 126 Stat. 2313, 2326 (2013) (to be codified at I.R.C. § 41) (providing the most recent extension); LAURA TYSON & GREG LINDEN, CTR. FOR AM. PROGRESS, THE CORPORATE R&D TAX CREDIT AND U.S. INNOVATION AND COMPETITIVENESS: GAUGING THE ECONOMIC AND FISCAL EFFECTIVENESS OF THE CREDIT 26 tbl.5 (2012), *available at* http://www.americanprogress.org/wp-content/uploads/issues/2012/01/pdf/corporate_r_and_d.pdf (cataloging fifteen prior extensions). The credit lapsed for one year (July 1995–July 1996) since its initial enactment. *Id.*

89. I.R.C. § 41(d).

90. *Id.* § 41(d)(1)(B)(i).

91. *Id.* § 41(d)(1)(B)(ii).

92. *Id.* § 41(d)(1)(C).

93. *Id.* § 41(d)(4)(B)–(H).

As the name suggests, Section 41 is designed to encourage businesses to *increase* R&D spending, not to reward businesses for R&D expenditures that they would have made irrespective of any credit. The general rule is that the credit is only available for qualified research expenses above a "base amount" determined from past research spending.[94] To continue with the railroad example, imagine that the railroad took in gross receipts of $10 million each year from 1984 through 1988 and that the railroad spent $500,000 on qualified research in each of those years. The railroad's "fixed-base percentage" would be 5%.[95] Now let's say that the railroad's gross receipts average $20 million a year from 2009 through 2012. The railroad's base amount for 2013 would be 5% (the fixed-base percentage) times $20 million (the average annual gross receipts for the past four years), or $1 million.[96] The railroad could claim the credit for qualified research expenses in excess of $1 million.

The credit equals 20% of qualified research expenses over the base amount.[97] To continue with the example above, if the railroad's base amount is $1 million and the railroad spends $1.5 million on qualified research in 2013, it can claim a credit equal to 20% times $500,000, or $100,000. Importantly, a credit reduces a taxpayer's tax liabilities dollar for dollar, whereas a deduction reduces a taxpayer's taxable income dollar for dollar. For a corporation facing a 35% marginal tax rate,[98] a $1 deduction is worth 35 cents, whereas a $1 credit is worth its full face value.

The example above is only the simplest application of Section 41. Calculating the fixed-base percentage for start-ups is considerably more complicated.[99] Section 41 also contains provisions to avoid penalizing firms with strong R&D records,[100] to prevent a windfall for firms that ramp up R&D spending after the base period,[101] and to allow firms to opt for an "alternative simplified credit."[102]

94. *Id.* § 41(a)(1), (c)(1)–(3).

95. *See id.* § 41(c)(3).

96. *See id.* § 41(c)(1).

97. *Id.* § 41(a)(1).

98. *See id.* § 11(b)(1)(D).

99. For the first five years in which a start-up company has qualified research expenses, its fixed-base percentage is 3%; after that, Section 41 provides for a gradual transition toward calculating the fixed-base percentage based on actual R&D. *Id.* § 41(c)(3)(B).

100. *Id.* § 41(c)(3)(C) (setting a maximum fixed-base percentage of 16%).

101. *Id.* § 41(c)(2) (setting a minimum base amount of 50% of qualified expenses).

102. *Id.* § 41(c)(5)(A) (2006 & Supp. V 2012) (setting the base amount to 50% of the company's average qualified research expenses over the previous three years, and the credit to 14%, or 12% for taxable years before 2009, of the amount by which current-year qualified research expenses exceed the three-year moving average).

According to the Joint Committee on Taxation, Section 41 will lead to $6.9 billion in lost revenue for the federal government in 2013.[103] As of this writing, the credit is scheduled to expire after December 31, 2013.[104] However, President Obama's budget for fiscal year 2014 includes a proposal to make the credit permanent.[105] In any event, if history is any guide, the credit is likely to be extended beyond this year.[106]

Although a taxpayer can claim the credit for increasing research activities while also taking advantage of the expensing provisions, the Internal Revenue Code limits a taxpayer's ability to "double-dip."[107] There are also other federal tax incentives for R&D that can be combined to some extent with these more general provisions: these include the credit for clinical testing expenses for rare diseases,[108] which is estimated to cost the federal government approximately $800 million a year,[109] and the qualifying therapeutic discovery project credit,[110] which is estimated to cost the federal government approximately $200 million per year.[111] Tax credits are also widely used by state governments to encourage in-state innovation; in 2006, thirty-two states offered a general R&D tax credit, with an average effective credit rate between 5% and 6%.[112] And although there is no international agreement governing R&D tax credits, this policy tool is widely used around the world; annual global spending on R&D tax

103. STAFF OF THE JOINT COMM. ON TAXATION, *supra* note 85 (taking the sum of "[c]redit for increasing research activities ([c]ode section 41)" for corporations and individuals in 2013).

104. I.R.C. § 41 (h)(1); American Taxpayer Relief Act of 2012, Pub. L. No. 112-240, § 301(a)(1), 126 Stat. 2313, 2326 (2013) (to be codified at I.R.C. § 41).

105. DEP'T OF THE TREASURY, GENERAL EXPLANATIONS OF THE ADMINISTRATION'S FISCAL YEAR 2014 REVENUE PROPOSALS 13 (2013).

106. *See supra* note 88 and accompanying text.

107. Taxpayers who claim the Section 41 credit must reduce their Section 174 deductions by the credit amount. I.R.C. § 280C(c)(1). Thus, if a railroad spends $1.5 million on qualified research and claims a $100,000 credit, then it must reduce its Section 174 deduction to $1.4 million. Alternatively, the railroad can deduct the full $1.5 million and then reduce its credit by the maximum statutory corporate tax rate (35%). *Id.* § 280C(c)(3). For a taxpayer facing a 35% corporate tax rate, the two options are financially equivalent, while a taxpayer facing a lower marginal tax rate will benefit by claiming the full credit. ALAN D. CAMPBELL ET AL., 2009 FEDERAL TAX COURSE ¶ 1107, at 458 (2008).

108. I.R.C. § 45C.

109. STAFF OF THE JOINT COMM. ON TAXATION, *supra* note 85 (listing expenditures for the orphan drug research credit).

110. I.R.C. § 48D (Supp. V 2012).

111. STAFF OF THE JOINT COMM. ON TAXATION, *supra* note 85 (taking the sum of "[t]herapeutic research credit[s]" for corporations and individuals in 2013).

112. Daniel J. Wilson, *Beggar Thy Neighbor? The In-State, Out-of-State, and Aggregate Effects of R&D Tax Credits*, 91 REV. ECON. & STAT. 431, 433 fig.1 (2009); *see also* JENNIFER WEINER, FED. RESERVE BANK OF BOS., STATE BUSINESS TAX INCENTIVES: EXAMINING EVIDENCE OF THEIR EFFECTIVENESS 40 tbl.3 (2009), *available at* http://www.bos.frb.org/economic/neppc/dp/2009/neppcdp0903.pdf (surveying R&D tax credits offered by New England states).

incentives totals tens of billions of dollars.[113] Indirect government funding of R&D in Japan through tax incentives totaled more than $5 billion in 2008; credits in Canada totaled nearly $3 billion; and credits in South Korea totaled approximately $2.5 billion.[114]

Estimates of the effectiveness of the R&D credit vary widely. Some studies suggest that state R&D tax credits have a "beggar-thy-neighbor" effect: credits encourage companies to shift the location of R&D activities rather than increasing aggregate expenditures.[115] On balance, the evidence suggests that country-level R&D tax credits raise R&D expenditures: one cross-country meta-analysis concludes that "a dollar in tax credit for R&D stimulates a dollar of additional R&D."[116] Yet from a policy perspective, the most important question is not whether tax credits increase R&D *inputs* (i.e., spending), but whether tax credits increase R&D *outputs* (i.e., innovation). Unfortunately, as one study recently concluded, "[e]valuations of output additionality of tax incentives are rather scarce," and "little is yet known about the welfare effects in the long run."[117]

II. Comparing Innovation Incentives

As described in Part I, U.S. innovation policy uses a diverse portfolio of tools to incentivize R&D. Yet we lack a unified analytical framework to help determine when any given innovation policy should be employed. In this Part, we present a new taxonomy of innovation policies. We argue that every government transfer to spur innovation embodies answers to three distinct questions: (1) *Who decides* the size of the transfer—a central planner (i.e., the government) or decentralized actors (i.e., the market)?[118]

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113. *See* ORG. FOR ECON. COOPERATION & DEV., TESTIMONY BEFORE THE U.S. SENATE COMM. ON FIN., THE INTERNATIONAL EXPERIENCE WITH R&D TAX INCENTIVES 4 fig.1 (2011), *available at* http://www.finance.senate.gov/imo/media/doc/OECD%20SFC%20Hearing%20testimony%209%2020%2011.pdf (listing the estimated costs of R&D tax incentives relative to GDP for selected OECD countries).

114. ORG. FOR ECON. COOPERATION & DEV., R&D TAX INCENTIVES: RATIONALE, DESIGN, EVALUATION 3 fig.2 (2010), *available at* http://www.oecd.org/innovation/policyplatform/48141363.pdf.

115. *See, e.g.*, Wilson, *supra* note 112, at 435 (noting the shifting of R&D activities between states).

116. Hall & Van Reenen, *supra* note 11, at 449; *see also* Bloom et al., *supra* note 11, at 1 (reaching a similar conclusion).

117. Christian Köhler et al., *The Impact and Effectiveness of Fiscal Incentives for R&D* 29 (Nat'l Endowment for Sci., Tech. & the Arts, Working Paper No. 12/01, 2012), *available at* http://www.nesta.org.uk/library/documents/wp12-01v2.pdf.

118. In one sense, rewards are always government-set insofar as the government establishes the rules of the game: patents—the quintessential market-set reward—only exist because governments have created patent systems. We note this without dwelling upon it: the degree of government involvement in determining reward size varies widely between, at one extreme, prize systems in which the government sets the size of the prize and, at the other extreme, patent systems in which the government establishes and enforces a framework of broadly applicable

(2) *When* is the reward transferred—before the outcome of a project is known or only after a project is successful? (3) *Who pays* for the reward—all taxpayers, or only users of any resulting products? In the remaining Parts of this Article, we show how this simple taxonomical scheme can yield new insights into innovation policy.

A. *The First Dimension: Government-Set Versus Market-Set Transfers*

The patents-versus-prizes debate has focused on the issue of *who decides* which projects to reward and how much to reward them.[119] Government-set rewards, such as grants and fixed prizes, rely on public officials to figure out how much a particular technology should be subsidized. For example, in the case of the British Longitude Prize, Parliament decided that it would be worth paying £20,000 for a method that could determine longitude within 30 nautical miles, and this reward was not linked to the number of marine chronometers ultimately sold.[120] Government-set rewards are inefficient when the government cannot foresee a potential invention or evaluate its costs and benefits; the government might vastly undervalue the invention (causing innovators to not pursue the project despite its social value) or overvalue the invention (diverting innovators' attention from more useful endeavors). Government-set rewards also raise the significant risks of politicization, rent-seeking, and mismanagement,[121] which may explain why the social rate of return on R&D funded through government grants has been estimated to be lower than on private R&D.[122]

In contrast, with the patent system, the government merely sets the ground rules (in terms of patentable subject matter, patent term, etc.), and the reward size is then based on the forces of supply and demand. Patents' ability to take advantage of private information is well recognized in the innovation-policy literature. For example, in a classic article comparing

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rules but allows market forces to drive the size of the rewards that individual innovators ultimately reap.

119. *See, e.g.*, sources cited *supra* note 1.

120. *See* SCOTCHMER, *supra* note 39, at 32–33 (explaining that the £20,000 award was offered in hopes of finding a "knowledge template" that would be a pure public good rather than a device to be marketed and sold). In fact, the Board of Longitude initially refused to award a prize to John Harrison for his solution (an accurate clock, or marine chronometer) because it had sought an astronomical solution that would not need to be distributed through markets, rather than a rivalrous and excludable clock. *Id.*

121. *See* Adler, *supra* note 46, at 31 (suggesting federal investment in R&D is risk averse and subject to rules that can discourage participation); Josh Lerner & Colin Kegler, *Evaluating the Small Business Innovation Research Program: A Literature Review*, *in* THE SMALL BUSINESS INNOVATION RESEARCH PROGRAM: AN ASSESSMENT OF THE DEPARTMENT OF DEFENSE FAST TRACK INITIATIVE 307, 315–19 (Charles W. Wessner ed., 2000) (describing problems of politicization and poor design).

122. *See* Kremer, *supra* note 32, at 1143 (citing empirical studies).

patents, prizes, and government grants, Brian Wright stated that "[t]he special advantage of patents arises . . . from *ex ante* researcher information relating to the value of the invention."[123] And Nancy Gallini and Suzanne Scotchmer argue that one of the patent system's "obvious virtues" is that it leverages the "superior knowledge" of private-sector actors when "the costs and benefits of R&D investments are known only to firms, and not to government sponsors."[124]

What is less well understood is that tax expenditures can replicate many of the merits of a patent system under conditions of asymmetric information. With R&D tax incentives, as with patents, the government creates ground rules that are broadly applicable to most technologies; neither system requires the government to decide whether more resources should be directed toward, say, nanotechnology or turbulence research. And tax incentives, like patents, rely on potential innovators—rather than government officials—to decide (1) which inventions are worth pursuing and (2) which R&D projects are most likely to yield the inventions in question. Like patents, tax incentives cause innovators to pursue inventions that will succeed in the market: refundable tax credits do not refund 100% of R&D costs, so innovators will seek to recover the rest of their costs by appropriating some of the benefit of their invention through mechanisms such as first-mover advantage (or weak patents).[125] Thus, the "special advantage" and "obvious virtue" of patents can be reproduced through the use of R&D credits.[126]

Of course, this special advantage is only an advantage to the extent that the private rewards to innovation under either system align with the socially optimal transfer. Both patents and tax credits fare poorly when market signals are weak proxies for social value; for example, the social value of a malaria or tuberculosis vaccine may be enormous, but potential beneficiaries in developing countries lack the ability to pay high prices.[127] As Amy Kapczynski and Talha Syed note, "Patents . . . link the expected

123. Wright, *supra* note 1, at 703.

124. Gallini & Scotchmer, *supra* note 1, at 54–55.

125. Our argument here is analogous to Saul Levmore's discussion of the charitable deduction in Saul Levmore, *Taxes as Ballots*, 65 U. CHI. L. REV. 387 (1998). R&D credits, like the charitable deduction, "essentially cast[] the government as a financing partner," with taxpayers choosing which projects to pursue and the government providing a matching grant. *Id.* at 388.

126. To be sure, a drawback of tax credits is that firms do not internalize the full costs of R&D and thus may be more likely to invest in wasteful projects. But as discussed in the following subpart, this is also a problem with patents to the extent that inventors must grant funders a stake in their inventions, and the patent system may also screen out *too many* risky inventions.

127. *See, e.g.*, Michael Kremer, *Making Vaccines Pay: Creating Incentives To Stop AIDS, Tuberculosis and Malaria*, MILKEN INST. REV., First Quarter 2004, at 42, 45 (noting that less than 5% of private-sector global health R&D is devoted to treatments for diseases specific to poor countries).

private returns not to social value simpliciter, but rather to the portion of social value that can be effectively (or cheaply) extracted through the exercise of exclusionary rights."[128] Under a patent regime, even if private actors can identify the projects with the highest social benefit, they may instead pursue the projects that allow them to capture the largest chunk of that benefit. Similarly, the projects incentivized under a tax credit regime may not be the ones with the highest social benefit.

As explained in subpart I(A), optimal innovation policy depends on four key pieces of information: if C is the cost of a project, p is its probability of success, B is the social benefit if it is successful, and F is the reward the inventor will be able to appropriate in the absence of government intervention (such as through first-mover advantage), then for welfare-enhancing projects (those for which $C < pB$), the government should provide an additional incentive of size $C - pF$, or the difference between the expected cost and the expected private value to the innovator.[129] With government-set rewards such as grants and Longitude-type prizes, the government must identify particular projects or objectives that might be worth pursuing and then do its best to (1) figure out whether the project is welfare enhancing (whether $C < pB$) and then (2) estimate the optimal transfer $C - pF$.[130] With patents, innovators can claim some portion of the social benefit B (including any first-mover advantage F that is not subsumed by the patent reward); it falls upon the government to set up a system where the size of patent rewards at least roughly tracks the optimal transfer $(C - pF)/p$ (awarded with probability p). Finally, with tax credits, the government refunds a portion of the research costs C, effectively magnifying the reward from the first-mover advantage and other nonpatent appropriation mechanisms. The optimal reimbursement rate is equal to

128. Amy Kapczynski & Talha Syed, *The Continuum of Excludability and the Limits of Patents*, 122 YALE L.J. 1900, 1942 (2013).

129. *See supra* note 26.

130. One might ask why the optimal transfer is $C - pF$, as opposed to $pB - pF$, the expected social benefit of the project (less the portion of the social benefit that the innovator is able to appropriate absent any explicit transfer). *Cf., e.g.*, Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, J. ECON. PERSP., Winter 1991, at 29, 31 ("Given that the length and breadth of patent protection cannot depend on the expected costs of an R&D project, the only way to ensure that firms undertake every research project that is efficient is to let the firms collect as revenue all the social value they create."). While our analysis does not depend on the former formulation of optimal transfer size, we note that a transfer above $C - pF$ entails raising more revenue through taxation or allowing the patentee greater market power through the patent system—and thus generating greater deadweight loss—than is strictly necessary to achieve the desired incentive effect. Additionally, allowing successful innovators to appropriate the full social benefit B of their inventions creates the possibility of wasteful "racing" by multiple innovators. *See* Glenn C. Loury, *Market Structure and Innovation*, 93 Q.J. ECON. 395, 408–09 (1979) ("In any market structure, competing firms invest more in R&D than would be optimal because they do not take account of the parallel nature of their efforts."); Scotchmer, *supra* (citing Loury, *supra*); *see also infra* section II(D)(4).

$(C - pF)/C$, in which case the transfer through the tax credit system will be equal to the optimal transfer $C - pF$. At least in theory, the market will then allocate resources toward the highest-F projects, so projects with $C > pF$ (and thus potentially $C > pB$) will only be pursued once all $C < pF$ projects are off the table.

Critics of R&D tax credits note the difficulty of defining creditable research expenses as well as the risk that R&D credits will go to benefit inframarginal R&D expenditures (i.e., expenditures that would have been undertaken even in the absence of the credit).[131] But while these are real risks, they are in no sense unique to tax credits. Similar dangers arise in the context of patents. On the one hand, patentees might receive much less than the social benefit B: patents do not have infinite lifetimes, they do not allow patentees to capture spillover benefits, and a number of high-B projects might not be patentable.[132] On the other hand, patentees might receive much more than B: due to errors in setting claim scope or assessing obviousness, patentees might capture more than the value of their contribution.[133] (Note that these problems apply equally to market-based prizes that involve *ex post* assessments of B, such as patent buyouts.)

As long as the first-mover advantage F is nonzero and positively correlated with social benefit B, we may make fewer mistakes by keying transfer size to research costs (which are likely easier to estimate) than to the social benefit of the inventive contribution (which is more difficult to define). Credit recipients will pursue the highest-F projects, and we think it likely that F will be positively (although not linearly) correlated with B. Moreover, since transfers cannot be larger than C, we are unlikely to make the same order-of-magnitude mistakes that we make with respect to patents (e.g., granting a patent to a "discovery" that is not actually novel).[134]

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131. *See, e.g.*, Martin A. Sullivan, *Economic Analysis: Time To Scrap the Research Credit*, 128 TAX NOTES 891 (2010), *available at* http://www.taxanalysts.com/www/features.nsf/Articles/B4E4F1D6C2A8B58085257B470058A573.

132. On the problem of beneficial but unpatentable goods, see Kapczynski & Syed, *supra* note 128; Douglas Gary Lichtman, *The Economics of Innovation: Protecting Unpatentable Goods*, 81 MINN. L. REV. 693 (1997); and Benjamin N. Roin, *Unpatentable Drugs and the Standards of Patentability*, 87 TEXAS L. REV. 503 (2009). On the problem of distortions caused by the fixed patent term, see Michael Abramowicz, *The Danger of Underdeveloped Patent Prospects*, 92 CORNELL L. REV. 1065 (2007) and Eric Budish et al., Do Fixed Patent Terms Distort Innovation? Evidence from Cancer Clinical Trials (Sept. 5, 2013) (unpublished manuscript), *available at* http://economics.mit.edu/files/8651. On spillover benefits, see Brett M. Frischmann & Mark A. Lemley, *Spillovers*, 107 COLUM. L. REV. 257 (2007).

133. On the difficulty of setting claim scope, see generally Tun-Jen Chiang, *The Levels of Abstraction Problem in Patent Law*, 105 NW. U. L. REV. 1097 (2011).

134. We bracket the question of whether the consequences of Type I errors, or false positives (e.g., a transfer to an innovator pursuing a project with an expected social benefit below cost), and the consequences of Type II errors, or false negatives (e.g., a failure to recognize a project with positive expected social benefit as transfer-worthy), are symmetrical. On error-cost asymmetry in

To be sure, while we think it is reasonable to assume that *F* is positively correlated with *B*, the effectiveness of alternative appropriation mechanisms varies by technology: there will be some projects for which *F* is very close to *B* (where, for example, secrecy allows full appropriation),[135] and others for which *F* is much closer to zero (such as inventions that are quick and cheap to imitate and where there is little brand-name advantage). But as we discuss in section II(D)(2), the skew of tax credits toward inventions that are easier to keep secret can be reduced by requiring more disclosure as a condition of receiving the credit. And even if $F = 0$, a system that combines tax credits with weak patents could still be superior to a system that relies only on strong patents.

Both patents and tax incentives might be structured to more closely align their rewards with the optimal transfer size—in other words, to incentivize innovation only on the margins, rather than rewarding innovation that would have been performed without government inducement. As explained in section I(B)(4), the credit for increasing research activities (Section 41 of the Tax Code) seeks to *increase* R&D spending by only providing a credit for spending above a baseline determined by a firm's past research activities. Patent scholars have also proposed ways to make the patent system more strongly incorporate this principle.[136] The optimal balance of patents and tax incentives will depend on the extent to which each system can succeed in this goal. The desirability of patents versus tax credits will also depend on whether patent rents or the first-mover advantage are more closely correlated with social benefit—an empirical question for which the answer will vary by technological field.

Tax credits that are awarded on the basis of R&D expenditures are not the only tax policy tool that can leverage the special advantage that Wright attributes to the patent system. Some countries have adopted a patent box regime, meaning that they impose lower taxes on patent-related income than income from other sources.[137] Although R&D tax credits and patent

the copyright context, see generally MICHAEL A. CARRIER, INNOVATION FOR THE 21ST CENTURY: HARNESSING THE POWER OF INTELLECTUAL PROPERTY AND ANTITRUST LAW 131 (2009).

135. *See supra* note 37 and accompanying text.

136. *See, e.g.*, Michael Abramowicz & John F. Duffy, *The Inducement Standard of Patentability*, 120 YALE L.J. 1590 (2011) (urging the adoption of a patentability standard where rights are given to inventions "which would not be disclosed or devised but for the inducement of a patent"); Tun-Jen Chiang, *A Cost-Benefit Approach to Patent Obviousness*, 82 ST. JOHN'S L. REV. 39 (2008) (reframing the question of patentability based on cost-benefit analysis).

137. In Belgium, for example, 80% of qualifying patent income is exempt from the corporate tax. JIM SHANAHAN, PRICEWATERHOUSECOOPERS, IS IT TIME FOR YOUR COUNTRY TO CONSIDER THE "PATENT BOX"? 5 (2011), *available at* http://download.pwc.com/ie/pubs/2011_is_

boxes both operate through the tax code, an "important distinction" between the two mechanisms—as Michael Graetz and Rachael Doud point out—"is their timing: R&D incentives are provided when the expenses are incurred; patent boxes, in contrast, reduce taxes when, and if, income is earned."[138] We turn to the importance of this timing difference in the following subpart. For now we simply note that just like R&D tax credits, patent boxes replicate the supposedly special advantage of patents: with a patent box, nongovernment actors decide which inventions are worth pursuing and which projects are most likely to yield the inventions in question. The government simply enhances the ultimate reward.

Finally, we note that there are numerous possible reward systems that fall between the government-set and market-set ends of the "who decides" axis, in that they vary rewards based on government assessments of particular technologies but still tie the reward to some measure of actual performance in the market. For example, some commentators have argued that patent rights should be tailored on a case-by-case basis to the needs of individual industries;[139] these arguments apply equally in the tax incentive context, where the percentage of creditable research costs could be varied by technology. Similarly, policies such as the broadband sales tax exemption[140] operate like market-set transfers to some extent, but they involve greater government judgment as to the value of particular technologies than patents or generally applicable R&D tax credits. And as we have noted, commentators have proposed various performance-based prize schemes such as the Health Impact Fund, in which the size of the reward is based on tailored assessments of *ex post* outcomes rather than *ex ante* government valuation.[141] Although we focus on policies that fall near

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it_time_for_your_country_to_consider_the_patent_box.pdf. Given that the regular corporate tax rate in Belgium is 34%, this exemption equals a subsidy of € 0.272 (i.e., 0.8 × 0.34) for every euro of patent-derived profits. *See id.*

138. Michael J. Graetz & Rachael Doud, *Technological Innovation, International Competition, and the Challenges of International Income Taxation*, 113 COLUM. L. REV. 347, 363 (2013).

139. *See, e.g.*, Burk & Lemley, *supra* note 14, at 1630–68 (arguing for the consideration of economic policy and industry-specific variation when applying general patent rules); Benjamin N. Roin, *The Case for Tailoring Patent Awards Based on the Time-to-Market of Inventions*, 61 UCLA L. REV. (forthcoming 2014) (introducing a system for tailoring awards on a case-by-case basis).

140. Internet Tax Freedom Act, Pub. L. No. 105-277, §§ 1100–1104, 112 Stat. 2681-719, 2681-719 to -28 (1998) (codified as amended at 47 U.S.C. § 151 (2006 & Supp. V 2012)). *See generally* Austan Goolsbee, *The Value of Broadband and the Deadweight Loss of Taxing New Technology* (Nat'l Bureau of Econ. Research, Working Paper No. 11994, 2006) (analyzing the impact taxes might have had on the diffusion of broadband Internet access).

141. *See supra* notes 59–62 and accompanying text. These mechanisms have the advantage of allowing the government to make assessments *ex post*, when it has more information about the value of a technology. And as Michael Abramowicz has explained, what matters is whether these

the extremes of the government-set–market-set reward spectrum (with classic prizes and government grants on one side, and patents and R&D tax credits on the other), we emphasize that the space in between these extremes is fruitful ground for policy experimentation.

B. The Second Dimension: Ex Ante *Versus* Ex Post *Rewards*

A second dimension of innovation policy, distinct from the issue of *who decides*, is *when* should the reward be transferred? Rewards can either be transferred to potential innovators *ex ante*, as with grants and R&D tax incentives, or to only successful innovators *ex post*, as with prizes, patents, and patent boxes. The importance of reward timing is neglected in the patents-versus-prizes debate because that debate involves only *ex post* rewards.

Figure 1

		Reward Setting	
		Government-Set	Market-Set
Reward Timing	*Ex Ante*	Grants	R&D tax credits
	Ex Post	Longitude-type prizes	Patents (also: patent boxes)

Figure 1 lays out this two-dimensional scheme. The place that a policy falls along the horizontal axis is a function of *who decides* the size of the transfer to innovators. The place that a policy falls along the vertical axis is a function of *when* the transfer occurs. Each axis should be seen as continuous rather than dichotomous. Just as answers to the *who decides* question (reward setting) can fall between the two extremes of pure government-set and pure market-set transfers, answers to the *when* question (reward timing) fall along a spectrum, as transfers may occur at various junctures. Government grants may be dispensed before work on a project begins, or grants may be structured such that grantees claim reimbursements only after research costs are incurred.[142] R&D tax credits generally can be claimed in the year that funds are expended on qualifying

government assessments are expected *ex ante* to be on average correct *ex post*. *See* Abramowicz, *supra* note 32, at 124.

142. *See, e.g.*, U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-10-937, UNIVERSITY RESEARCH: POLICIES FOR THE REIMBURSEMENT OF INDIRECT COSTS NEED TO BE UPDATED 26–39 (2010) (evaluating reimbursement methods such as a single annual audit, a closeout process, and cognizant agency audits).

research, although there still may be a several-month delay between the time that the funds are expended and the time that the credit is claimed.[143] A Longitude-type prize can be structured so that it is paid out once an R&D project yields an innovation meeting certain technical specifications (before sales results are known), while proceeds from a performance-based prize may be transferred incrementally as outcomes are observed. And a patent system is, in effect, a series of transfers occurring over a twenty-year timeframe.[144]

Some economists have noted that an advantage of *ex post* patents and prizes over *ex ante* grants is that "money changes hands only after a successful product is developed—thus giving researchers strong incentives to self-select projects with the best prospects for success as useable products."[145] This "incentives" argument is one of the strongest advantages of *ex post* mechanisms, although we think it is a mistake to make too much of the point. Unless researchers are independently wealthy, they generally must raise outside capital in order to fund their projects at the early and intermediate stages. Thus, even if researchers themselves can "self-select projects with the best prospects for success," they will not necessarily be able to secure outside investment for these self-selected projects. And where researchers do succeed in securing outside investment in a particular project, they will likely have to cede a large equity stake in that project's potential profits to the outside investor—which, in turn, may weaken the researchers' incentives to devote time and energy to the endeavor (as the researchers no longer stand to reap 100% of the market rewards from their efforts).

Ultimately, the *when* question lacks a one-size-fits-all answer. The remainder of this subpart identifies the considerations that might lead policymakers to choose earlier or later delivery of rewards for R&D.

1. Capital Constraints.—While no capital market transaction is costless, there is reason to believe that transaction costs will be especially high for R&D funding. The first—and perhaps most familiar—source of

143. C corporations, S corporation shareholders, partners, sole proprietors, and self-employed individuals generally must make estimated income tax payments on a quarterly basis, *see* I.R.C. §§ 6654, 6655 (2006), which may reduce the period between the time that funds are expended on R&D and the time that the taxpayer benefits from the Section 41 credit.

144. *See* 35 U.S.C. 154(a)(2) (2006).

145. Rachel Glennerster et al., *Creating Markets for Vaccines*, INNOVATIONS: TECH., GOVERNANCE, GLOBALIZATION, Winter 2006, at 67, 71. These economists have referred to *ex ante* rewards as "push programs" and *ex post* rewards as "pull programs." *See, e.g.*, MICHAEL KREMER & RACHEL GLENNERSTER, STRONG MEDICINE: CREATING INCENTIVES FOR PHARMACEUTICAL RESEARCH ON NEGLECTED DISEASES 45 (2004); Michael Kremer & Heidi Williams, *Incentivizing Innovation: Adding to the Tool Kit*, *in* 10 INNOVATION POLICY AND THE ECONOMY 1, 2 (Josh Lerner & Scott Stern eds., 2010).

such frictions arises from Arrow's information paradox: in order to raise outside capital to finance R&D projects, potential innovators must reveal sufficient information to satisfy investors. But what's to stop the investor from then running off and pursuing the idea himself?[146] The potential innovator may protect herself by requiring the investor to sign a nondisclosure agreement at the outset of talks, but negotiating a nondisclosure agreement is itself a cost.[147]

While Arrow's information paradox pertains to the risk that investors will take advantage of innovators, a second source of capital market frictions is the flip side of the first: what's to stop the potential innovator from using the investor's money to develop a new idea and then commercializing the well-developed idea on her own, thus cutting the investor out of the profits? In non-R&D contexts, investors can protect themselves through secured transactions: if an investor lends $10,000 to Alice's Restaurant, Inc., the investor need not be too worried that Alice is going to default on the loan, reincorporate as Rick's Café, and leave the investor in the lurch. The investor can insure himself against this risk by taking out a mortgage on the restaurant premises, a security interest in the dishware, etc. But if Alice's, Inc., is a start-up company working toward the first-ever perpetual motion machine, and if Alice needs a $10,000 loan to cover living expenses while she perfects her invention, then a secured transaction might give the investor very little security at all. The principal asset of Alice's, Inc., is Alice's know-how, and it will be challenging for the investor and Alice to craft a contract that gives the investor an enforceable claim to that asset. Of course, once Alice has a patent on the perpetual motion machine, the investor could acquire a security interest in the patent title.[148] But for pre-patent projects, drafting a security agreement that gives the investor an enforceable claim to any ultimate invention may be costly—and in some cases, virtually impossible.[149]

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146. *See* Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Innovation*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 615 (1962) ("Any one purchaser can destroy the [potential inventor's] monopoly, since he can reproduce the information at little or no cost.").

147. For more on the costs of information exchange under different incentive mechanisms, see *infra* notes 236–40 and accompanying text.

148. *See, e.g.*, Sky Techs. LLC v. SAP AG, 576 F.3d 1374, 1381 (Fed. Cir. 2009) (mentioning "a large number of patent titles [that are] presently subject to security interests"); *see also* U.C.C. § 9-102 cmt. 5(d) (2011–2012) (defining "general intangibles" covered by Article 9 to include intellectual property rights).

149. *See* Paul J. Heald, *A Transaction Costs Theory of Patent Law*, 66 OHIO ST. L.J. 473, 496–98 (2005) (describing substantial monitoring costs and the risks of using trade secrets as collateral). In some jurisdictions (e.g., California), a contract that bars an inventor from "job hopping" to a new corporation will be unenforceable. *See* Ronald J. Gilson, *The Legal Infrastructure of High Technology Industrial Districts: Silicon Valley, Route 128, and Covenants*

Third, even when there is no concern regarding opportunistic behavior, problems of asymmetric information and uncertainty may be particularly difficult to overcome with respect to R&D-intensive ventures. Investors may find it especially challenging to value a business proposition organized around a product at the technological cutting edge—either because generalist investors lack the subject-matter expertise to understand the product design details or because the potential revenue stream for an as-yet-nonexistent product is impossible to model with any precision. Investors will demand a rate of return that not only compensates them for the risk associated with the project, but also compensates them for the cost of acquiring information to evaluate the risk.[150]

These problems may be compounded when outside capital takes the form of an equity investment (e.g., when a venture capital firm offers researchers cash today in exchange for a share of any future profits).[151] Researchers who stand to gain only a portion of the rewards from success (since the venture capitalists will share in the profits) will have weaker incentives to devote time, energy, and other private resources toward the project than if they stood to reap the rewards *in toto*. Equity investors will take the risk of moral hazard into account when deciding whether to commit capital to a new project.[152]

In sum, even when *ex post* mechanisms such as prizes and patents offer the promise of large returns for a successful project, potential innovators may have trouble raising the required capital to pursue the project (unless the innovator is independently wealthy).[153] An advantage of *ex ante* incentives, then, is that they provide capital either *now* (grants) or *soon* (credits) rather than providing delayed rewards and forcing potential innovators to rely on expensive outside capital in the meantime.

Not To Compete, 74 N.Y.U. L. REV. 575, 578 (1999) (suggesting California's distinct legal rules regarding employee mobility contributed to the Silicon Valley's economic success).

150. *See* Bronwyn H. Hall & Josh Lerner, *The Financing of R&D and Innovation* 9–10 (Nat'l Bureau Econ. Research, Working Paper No. 15325, 2009) (describing the high cost required to mitigate the asymmetric information problem).

151. The same problem arises at large companies: even if employee–researchers are compensated through stock options, they capture only a fraction of the returns generated by their projects. On this agency-cost problem, see generally Jennifer Francis & Abbie Smith, *Agency Costs and Innovation: Some Empirical Evidence*, 19 J. ACCT. & ECON. 383 (1995) and Bengt Holmstrom, *Agency Costs and Innovation*, 12 J. ECON. BEHAV. & ORG. 305 (1989).

152. *See* Michael C. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure*, 3 J. FIN. ECON. 305, 308–10 (1976) (explaining that agency costs track moral hazard and affect the terms of an investment).

153. As Michael Abramowicz has argued in a more general context, this problem could be mitigated by having inventors auction *ex ante* the right to a fraction of the *ex post* value determination (which shifts the reward toward the *ex ante* end of our spectrum). Michael Abramowicz, *Predictive Decisionmaking*, 92 VA. L. REV. 69, 114–15 (2006). Such *ex ante* auctions are less likely to be successful where the inventor has private information regarding the probability of success that she can't easily reveal to the market.

Note, though, that federal tax incentives for R&D—as currently designed—may provide very little encouragement to start-up companies. A taxpayer only benefits from the expensing of research and experimental expenditures or the credit for increasing research activities if the taxpayer has income to offset. Otherwise, the taxpayer can carry back the deduction for two years or the credit for one year, or carry forward either benefit for twenty years.[154] And if a corporation with unused credits or deductions undergoes an ownership change (which occurs—roughly speaking—when 50% of its stock changes hands[155]), then the corporation's ability to claim carryforward credits and deductions is severely limited.[156] When ventures fail, they take their credits and deductions down with them.[157] And even where start-up companies ultimately succeed, these tax incentives only provide tangible benefits once they begin to turn a profit.

Thus, the structure of federal R&D tax incentives favors well-established corporations that can use credits and losses to offset current-year income, and it disadvantages start-up companies that cannot now (and may never be able to) claim deductions and credits.[158] However, this is not an intrinsic feature of tax credits. Several states (including Iowa, Louisiana, Minnesota, Nebraska, and Virginia) offer fully refundable R&D credits, whereas credits in Arizona, Connecticut, Massachusetts, and West Virginia are fully or partially refundable under certain circumstances.[159] Some countries (including Australia, Canada, France, and Norway) offer refundable credits to start-up firms.[160] When a jurisdiction offers refundable R&D tax credits, the credit operates effectively like a grant issued at the end of the tax year: the firm gets the credit regardless of whether it has taxable income.[161] Legislation introduced in 2012 and reintroduced in 2013 would expand the availability of the federal R&D tax

154. I.R.C. §§ 39(a)(1), 172(b)(1)(A) (2006).

155. *See id.* § 382(g).

156. As of the time of this writing, the limit was 2.84% times the value of the corporation prior to the ownership change. *Id.* §§ 382(a), (b), (e), (f), 383(a); I.R.S. Rev. Rul. 2013-1, 2013-2 I.R.B. 252, 253 tbl.1.

157. Calvin H. Johnson, *Why Do Venture Capital Funds Burn Research and Development Deductions?*, 29 VA. TAX REV. 29, 38 (2009).

158. Gregory Tassey, *Tax Incentives for Innovation: Time To Restructure the R&D Tax Credit*, 32 J. TECH. TRANSFER 605, 608 (2007).

159. STATE OF TEX. LEGISLATIVE BUDGET BD., OVERVIEW OF RESEARCH AND DEVELOPMENT TAX INCENTIVES 6 (2013), *available at* http://www.lbb.state.tx.us/Other_Pubs/Overview%20of%20Research%20and%20Development%20Tax%20Incentives.pdf.

160. ROBERT D. ATKINSON & STEPHEN J. EZELL, INNOVATION ECONOMICS: THE RACE FOR GLOBAL ADVANTAGE 173 (2012).

161. For an overview, see Lily L. Batchelder et al., *Efficiency and Tax Incentives: The Case for Refundable Credits*, 59 STAN. L. REV. 23, 32–42 (2006).

credit to start-ups by allowing them to claim the credit against their employment taxes.[162]

The bias against small firms embedded in the structure of U.S. federal R&D tax incentives may be mitigated or even reversed by other tax advantages for start-ups that large corporations cannot capture.[163] Thus, our argument is *not* that federal R&D tax incentives give an unfair advantage to well-established firms with positive taxable income and the ability to finance R&D internally. Rather, our argument is that *ex ante* mechanisms such as grants and refundable tax credits reduce the need for start-ups to rely on external financing for new research contracts. *Ex post* mechanisms such as patents and prizes induce reliance on external financing to bridge the lag between the timing of expenditures and the timing of rewards. Nonrefundable credits share some of the characteristics of *ex post* mechanisms: just as a one-product start-up cannot capture patent rewards until its product is marketable, a one-product start-up cannot capture the benefits of federal R&D tax incentives until the start-up is—at the very least—profitable.

In sum, an important advantage of *ex ante* mechanisms over *ex post* mechanisms—and of refundable over nonrefundable tax credits—is that *ex ante* mechanisms mitigate the welfare loss due to capital market frictions (and as we have shown in this section, those frictions are likely to be significant). Arguably, a countervailing advantage of *ex post* mechanisms over *ex ante* mechanisms is that *ex post* mechanisms solve the moral-hazard problem that arises when potential innovators don't capture the full rewards

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162. Startup Innovation Credit Act of 2013, S. 193, 113th Cong. (2013); Startup Innovation Credit Act of 2012, S. 3460, 112th Cong. (2012).

163. Founders may form start-ups as partnerships, limited liability companies, or S corporations to obtain the benefits of "pass-through" taxation (although in practice, high-tech start-ups often opt for the C corporation structure nonetheless). *See* Joseph Bankman, *The Structure of Silicon Valley Start-Ups*, 41 UCLA L. REV. 1737, 1739–41, 1759 (1994) (describing how high-tech start-ups typically begin as limited partnerships and are later transformed into corporations). *See generally* Victor Fleischer, *The Rational Exuberance of Structuring Venture Capital Start-ups*, 57 TAX L. REV. 137 (2003) (explaining how start-ups benefit from a corporate structure by examining "agency costs, transaction costs, and the practical application of some key tax rules"); Johnson, *supra* note 157 (discussing and criticizing the tendency of start-ups to organize as C corporations). A start-up that pays no salary to its founder cannot claim an R&D credit for the founder's opportunity cost, but the founder also does not have to include wage income on his individual income tax returns, which is more valuable if his individual income tax rate is higher than the start-up's corporate tax rate. To the extent that the founder is ultimately compensated through the sale of stock, he may qualify for the generally lower long-term capital gains rate (rather than the ordinary income tax). Victor Fleischer, *Taxing Founders' Stock*, 59 UCLA L. REV. 60, 62 (2011). And the founder may also qualify for the Section 1202 (or "qualified small business stock") exemption, which allows individuals to pay *no* ordinary income or capital gains taxes on the first $10 million of their gains on certain stock sales. I.R.C. § 1202 (2006 & Supp. V 2012).

of their work.[164] But we are skeptical of this critique. As we have noted, *ex post* mechanisms often require potential innovators to sell equity in their ventures to bridge the period between expenditure and reward, reducing their own share of the profits from success. *Ex post* mechanisms thus introduce another moral-hazard problem arising from the separation of ownership and control.

The flip side of this concern is that outside investors, such as venture capital firms, may bring valuable expertise to R&D projects.[165] While there is some empirical evidence to support this view,[166] we cannot say with any confidence that—on balance—potential innovators are better off (or worse off) if they receive an infusion of funds from venture capitalists than if they receive an equal size transfer through a government grant or a tax credit. At most, we can say that *if* outside investors make substantial nonmonetary contributions to the success of innovative start-ups, then this consideration would weigh in favor of *ex post* reward systems such as patents or prizes.

Finally, we note that our concern about capital market frictions is significantly less salient with respect to R&D projects pursued inside large corporations such as Microsoft and Apple that have ample cash reserves with which they can finance new ventures.[167] Indeed, for these firms, the transaction costs associated with internal financing may be much lower than the costs associated with applying for government grants or claiming R&D tax credits (although the other transaction costs of the patent system may still be significant). Thus, inasmuch as concerns regarding capital constraints militate in favor of *ex ante* rewards for R&D, this argument is much more powerful with respect to industries populated primarily by start-ups and small businesses than with respect to industries dominated by large, cash-rich corporations.

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164. *See, e.g.*, David Webber & Michael Kremer, *Perspectives on Stimulating Industrial Research and Development for Neglected Infectious Diseases*, 79 BULL. WORLD HEALTH ORG. 735, 738–39 (2001) (comparing *ex ante* and *ex post* mechanisms to incentivize research on neglected medical diseases).

165. *See, e.g.*, Christine W. Letts et al., *Virtuous Capital: What Foundations Can Learn from Venture Capitalists*, HARV. BUS. REV., Mar.–Apr. 1997, at 36, 38.

166. *See* Thomas Hellman & Maju Puri, *The Interaction Between Product Market and Financing Strategy: The Role of Venture Capital*, 13 REV. FIN. STUD. 959 (2000) (providing evidence that venture capital financing affects the product-market strategies and outcomes of start-ups); Rebecca Zarutskie, *The Role of Top Management Team Human Capital in Venture Capital Markets: Evidence from First-Time Funds*, 25 J. BUS. VENTURING 155 (2010) (conducting a study and finding that the work experience of venture capitalists is a predictor of their fund's future performance).

167. *See* John Koetsier, *Apple's Cash Hoard Reaches $137 Billion*, VENTURE BEAT (Jan. 23, 2013), http://venturebeat.com/2013/01/23/apples-cash-hoard-reaches-137-billion (reporting that Apple has cash reserves of around $137 billion and Microsoft has cash reserves of over $60 billion).

2. Optimism Bias and Risk Aversion.—Our initial model in subpart I(A) assumed that potential innovators are rational and risk-neutral actors. Here, we relax these assumptions and explain how two well-documented phenomena—optimism bias and risk aversion—affect the choice between *ex ante* and *ex post* mechanisms.

Optimism bias, or overestimation of the probability of positive outcomes, has been observed across a wide variety of situations, including in the contexts of independent inventors[168] and valuing one's creative work.[169] When innovators overestimate the probability that their projects will succeed, they may be more responsive to *ex post* mechanisms than to *ex ante* mechanisms. For a project that has a 10% chance of success, a rational, risk-neutral innovator would view a $1,000 prize or patent reward equivalently to a $100 grant or credit. But an innovator who erroneously estimates the chance of success at 20% will value the *ex post* reward at $200 and will be willing to invest twice as much in research at the same cost to society.

Dennis Crouch has argued that the patent system exploits the optimism bias of potential innovators; in his view, this is a positive feature of the patent system because it allows society to incentivize innovation in a cost-minimizing manner.[170] A similar argument would apply to other *ex post* mechanisms such as prizes. But the flip side of this argument is that *ex post* mechanisms may cause over-optimistic entrepreneurs to invest in projects that have negative net present value. For example, if an over-optimistic innovator spends $200 on a project with a 10% chance of success in pursuit of a $1,000 prize, this is inefficient if the social benefit of the successful project is only $1,500.[171]

In addition to exhibiting optimism bias, individual decision makers tend to be risk averse, "normally preferring a sure thing to a gamble of equal expected value."[172] A risk-neutral innovator would be indifferent

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168. *See* Thomas Åstebro et al., *Inventor Perseverance After Being Told To Quit: The Role of Cognitive Biases*, 20 J. BEHAVIORAL DECISION MAKING 253, 253 (2007) (finding that even after being advised to stop, a third of inventors continue to spend money and half of inventors continue to spend time on their projects).

169. *See* Christopher Buccafusco & Christopher Jon Sprigman, *The Creativity Effect*, 78 U. CHI. L. REV. 31, 31–32 (2011) (finding creators value their work more than potential buyers).

170. Dennis D. Crouch, *The Patent Lottery: Exploiting Behavioral Economics for the Common Good*, 16 GEO. MASON L. REV. 141, 141–43 (2008).

171. Another negative effect of optimism bias is that patentees may overestimate the value of their innovations and thus set the price of licensing rights at an irrationally high level, impeding potential transfers. *See* Buccafusco & Sprigman, *supra* note 169, at 42 (describing how creators are unwilling to sell a work for "anything close to its objective value").

172. Daniel Kahneman & Dan Lovallo, *Timid Choices and Bold Forecasts: A Cognitive Perspective on Risk Taking*, 39 MGMT. SCI. 17, 18 (1993). Risk aversion could simply be a rational response to diminishing marginal utility—people value the first $100 more than the $100 that takes them from $900 to $1,000—but Daniel Kahneman and Amos Tversky have

between a guaranteed $100 *ex ante* reward (such as a grant or tax credit) and a 10% chance at a $1,000 *ex post* reward (such as a patent or prize). But a risk-averse innovator would prefer the guaranteed $100 *ex ante* and place less value on the speculative $1,000 *ex post* reward. Thus, to the extent that potential innovators are risk averse, *ex ante* rewards may provide greater "bang for our buck" (i.e., more inventive activity incentivized per dollar spent) than *ex post* rewards.[173]

Publicly traded firms may not display the same risk aversion as individuals because investors in those firms can diversify their portfolios. Indeed, a basic tenet of modern finance theory is that idiosyncratic (firm-specific) risks do *not* raise a firm's capital costs.[174] However, firms are run by their managers rather than by their diversified investors, and executives at a publicly traded firm have a substantial portion of their wealth tied up with the firm.[175] This is especially true when executives are compensated through stock options or other equity-based mechanisms, but all executives know that if their firms' fortunes sag, they may receive a pay cut or lose their jobs, and their value on the managerial labor market will decrease. Thus, even if investors in publicly traded firms are not risk averse, the decision makers at those firms very well might be.[176] Risk aversion is thus a concern for both small inventors and large firms; in fact, "the forces that produce risk aversion . . . may be even stronger in the managerial context."[177]

While optimism bias makes potential innovators more willing to pursue risky projects and risk aversion has the opposite effect, innovators may be subject to both phenomena at the same time. If a $1,000 prize is

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demonstrated numerous deviations from a rational-actor model; for example, decision makers overvalue certainty and weigh losses more heavily than equivalent gains. *E.g.*, Amos Tversky & Daniel Kahneman, *Advances in Prospect Theory: Cumulative Representation of Uncertainty*, 5 J. RISK & UNCERTAINTY 297, 298–99 (1992). Their "prospect theory" is unrelated to the prospect theory of patents.

173. Indeed, to compensate for the undervaluation of patents by risk-averse innovators, Robert Merges has proposed that patent policy compensate for risk aversion "by creating an extra-high payoff for those successful projects whose inventors faced a high-variance project," such as by lowering the standard of patentability. Robert P. Merges, *Uncertainty and the Standard of Patentability*, 7 HIGH TECH. L.J. 1, 47 (1992). For a thorough discussion of the different types of risk involved in R&D investments, see Frischmann, *supra* note 11.

174. *See, e.g.*, STEPHEN A. ROSS, RANDOLPH W. WESTERFIELD & JEFFREY JAFFE, CORPORATE FINANCE 379 (9th ed. 2010).

175. *See* Eugene F. Fama, *Agency Problems and the Theory of the Firm*, 88 J. POL. ECON. 288, 291–92 (1980) (explaining how managers have their human capital bound to a firm, giving them a "stake in [its] success").

176. Under certain conditions, firms can use stock-option-based pay packages to reduce managers' risk aversion. *See* Stephen A. Ross, *Compensation, Incentives, and the Duality of Risk Aversion and Riskiness*, 59 J. FIN. 207, 209 (2004) (arguing that granting stock options to managers helps align their interests with the interests of the owners of the firm).

177. Kahneman & Lovallo, *supra* note 172, at 22.

offered for a project with a 10% probability of success (so that the expected value is $100), an innovator might overestimate the probability of success at 20% but also undervalue a 20% chance of $1,000 at well less than $200.

Which of these effects dominates is context-specific, but we can be fairly confident that in general, optimism bias is insufficient to offset the combined effects of capital constraints and risk aversion because the private rate of return on R&D spending is greater than the rate of return on ordinary capital investment.[178] If private actors were systematically overestimating the probability of success, then the private rate of return on R&D spending would be less than the rate of return on other investments. Thus, the net impact of these effects is that when deciding whether to pursue costly projects with risky returns, potential innovators will be more responsive to *ex ante* mechanisms that provide an immediate, certain transfer than to *ex post* mechanisms that provide a speculative payout in the future.

3. Differing Discount Rates.—Our discussion so far has proceeded without any consideration of discount rates—the rates at which individuals, firms, and society discount future cash flows relative to present payments. *Ex ante* and *ex post* mechanisms both involve transfers from society to innovative individuals and firms. With *ex ante* mechanisms, transfers from society to potential innovators occur now; neither the transferor nor the transferee discounts costs or benefits. With *ex post* mechanisms, transfers from society to innovators occur in the future; the transferor discounts the future cost of the payment, while the transferee discounts the future benefits.

We have already discussed two reasons why a potential innovator may place greater value on $1 today than a 1-in-10 chance of $10 (inflation-adjusted) at a future date: risk aversion and capital constraints. But from the perspective of social welfare (rather than private preference), should we also place a higher value on present-period transfers that are certain than on future-period transfers that are uncertain?

With regard to risk aversion, it is commonly believed that social discount rates do not reflect the risk premium incorporated into private discount rates because the government's larger number of projects pools these risks.[179] A more difficult question is whether—risk pooling aside—

178. Bronwyn H. Hall et al., *Measuring the Returns to R&D*, *in* 2 HANDBOOK OF THE ECONOMICS OF INNOVATION 1033, 1073 (Bronwyn H. Hall & Nathan Rosenberg eds., 2010).

179. *See* Kenneth J. Arrow & Robert C. Lind, *Uncertainty and the Evaluation of Public Investment Decisions*, 60 AM. ECON. REV. 364, 364–66 (1970) (arguing that society pools risk more efficiently than individuals and, thus, that the social discount rate is lower than the private discount rate because the latter incorporates a risk premium); William J. Baumol, *On the Social Rate of Discount*, 58 AM. ECON. REV. 788, 794–95 (1968) (describing this argument but

the social discount rate is lower than the private discount rate. In other words, should policymakers place a higher value on consumption in the present than on consumption in the future, assuming no uncertainty?

We address this issue at greater length in subpart II(C), where we consider intergenerational equity. Here, we note that when the payor discounts future cash flows at a lower rate than the payee discounts future cash flows, then—all else equal—a transfer from the payor to the payee *today* is more efficient than a transfer of the same amount (inflation-adjusted) from the same payor to the same payee twenty years down the line. Thus, if one believes that the social discount rate is lower than the private discount rate, grants and credits (i.e., transfers today) will be more efficient than prizes and patents (i.e., transfers in the future).

Stephen Marglin and Amartya Sen have argued that, independent of risk-pooling considerations, the social discount rate is lower than the private discount rate because individuals fail to internalize the full benefit from delaying consumption (i.e., saving).[180] Thus, private individuals place a higher value on consumption today (relative to consumption at a future time) than a social planner would. Accordingly, *ex post* transfers are costlier from the social planner's perspective than they are beneficial from the innovator's perspective. If one accepts the Marglin–Sen thesis, then this claim remains true even aside from the phenomenon of risk aversion and even when capital markets are frictionless.

The Marglin–Sen thesis and the question of private versus social discount rates is a topic of much discussion (and dissent[181]) among economists. Our claim is limited to the following: the decision to use grants, credits, prizes, or patents (or a combination of incentives) reflects a decision regarding the timing of costs and a decision regarding the timing

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ultimately not endorsing the view that the social discount rate is lower than the private discount rate).

180. *See, e.g.*, Stephen A. Marglin, *The Social Rate of Discount and the Optimal Rate of Investment*, 77 Q.J. ECON. 95, 96, 111 (1963) (arguing that although "the brevity and uncertainty of life may influence an individual's disposition of his income in favor of the present," the social discount rate should not be affected by this bias); Amartya K. Sen, *Isolation, Assurance and the Social Rate of Discount*, 81 Q.J. ECON. 112, 112–16 (1967) (discussing the difference between the social and public discount rate in light of the "isolation paradox," in which individuals chose not to save even though the group would be better off if everyone did so); Amartya Kumar Sen, *On Optimising the Rate of Saving*, 71 ECON. J. 479, 479 (1961) (discussing the difficulty of determining the optimum rate of saving in light of the isolation paradox); *see also* RICHARD W. TRESCH, PUBLIC FINANCE: A NORMATIVE THEORY 740 (2d ed. 2002) (summarizing the Marglin–Sen view).

181. *See, e.g.*, Gordon Tullock, *The Social Rate of Discount and the Optimal Rate of Investment: Comment*, 78 Q.J. ECON. 331, 331 (1964); Peter G. Warr & Brian D. Wright, *The Isolation Paradox and the Discount Rate for Benefit-Cost Analysis*, 96 Q.J. ECON. 129, 130 (1981); Stanislaw Wellisz, *Savings in Isolation and Under a Collective Decision Rule*, 91 Q.J. ECON. 663, 663 (1977).

of benefits. As with all transfers, differences between the transferor's and transferee's discount rate should affect the optimal timing of the transfer. One's view regarding differential discount rates should therefore affect one's view regarding optimal innovation policy.[182]

4. Distribution Among Innovation Producers.—To the extent IP commentators have considered distribution to *innovators*, the distributional question is typically between an innovator (who wants a reward) and consumers (who want to use the innovation). A long strand of literature argues that setting aside efficiency considerations, the innovator *deserves* a reward under a desert-based conception of distributive justice. For example, Robert Merges has recently argued that while efficiency is an important midlevel principle for IP, the real normative foundations are Lockean appropriation (innovators have a desert-based property right in their creations), Kantian individualism (ownership of one's ideas is essential for human freedom), and Rawlsian attention to distribution (IP achieves a fair distribution of desert-based rewards for innovators and benefits for third-parties).[183]

Yet the belief that an innovator deserves to benefit from her labor does not lead ineluctably to a pro-patent conclusion. As Edwin Hettinger has argued, "Property rights in the created object are not the only possible reward. Alternatives include fees, awards, acknowledgement, gratitude, praise, security, power, status, and public financial support."[184] For those who believe that innovators deserve not simply a reward, but a *property* right, Hettinger's argument is unconvincing.[185] But unless one believes that Locke's political theory demands twenty-year patents or that alternative economic rewards are inappropriate, the innovator's desert-based right to reap the rewards of her creation could be satisfied through a pluralistic approach to innovation incentives (say, ten-year patents combined with R&D tax credits or patent boxes).

In any case, we think this debate over the type of reward a single innovator receives overlooks another important distributional question:

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182. Tun-Jen Chiang notes that the patent incentive may be diminished because the social discount rate is lower than the private discount rate, although he only analyzes differential responses to *risk*, rather than the more difficult question of whether the rates vary even in frictionless capital markets. Tun-Jen Chiang, *Fixing Patent Boundaries*, 108 MICH. L. REV. 523, 545–49 (2010).

183. MERGES, *supra* note 12, at 13.

184. Edwin C. Hettinger, *Justifying Intellectual Property*, 18 PHIL. & PUB. AFF. 31, 41 (1989).

185. *See* Adam Mossoff, *Saving Locke from Marx: The Labor Theory of Value in Intellectual Property Theory*, 29 SOC. PHIL. & POL'Y 283, 284 (2012) (interpreting Locke's theory of value as justifying property rights, including innovators' intellectual property rights, on the basis of natural law ethical principles).

How should the rewards for R&D be divided among multiple researchers? It is not clear that offering a winner-takes-all reward is the best incentive structure.[186] As we discuss below in section II(D)(3), winner-takes-all systems can set off socially wasteful races in which inventors compete against each other to capture a particular reward (e.g., a patent or a prize). Efficiency considerations aside, one might ask whether researchers whose work contributes to the ultimate solution to a technical problem—but whose work never yields an invention that satisfies the standards for patentability—nonetheless deserve some compensation from society for their efforts. Government grants and tax credits allocate rewards before the result of the race is known (and regardless of whether the race ultimately results in a patentable invention). Some readers may consider this more egalitarian allocation to be a positive feature of nonpatent rewards; others may consider it to be a bug. In either case, one's view about the desirability of winner-takes-all rewards may affect one's choice between *ex ante* and *ex post* policy options.[187]

C. The Third Dimension: Cross-Subsidization Versus User-Pays

As emphasized above, government-set and market-set transfer systems embody different answers to the question of *who decides* transfer size. A separate question, distinct from *who decides*, is: *who pays?* This third question has clear distributive implications, but it also has an efficiency dimension: the distribution of the costs of R&D affects the deadweight loss of different incentive mechanisms.

In the case of government grants, the answer to *who pays* is generally taxpayers. For example, everyone's tax dollars are used to fund the budget of the National Institute on Deafness—no special tax is imposed on the hearing impaired.[188] Thus, government funding for the National Institute on Deafness entails a transfer of wealth from the non-hearing impaired to the hearing impaired. Most readers will not consider this transfer to be

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186. To be sure, patents are not winner-takes-all in that they merely provide a limited right to exclude, but only the first inventor to file a patent application for a specific improvement is legally entitled to a patent. *See* Leahy-Smith America Invents Act, Pub. L. No. 112-29, § 3(b)(1), 125 Stat. 284, 285–87 (2011) (codified at 35 U.S.C. § 102 (Supp. V 2012)).

187. We note that prize systems need not be winner-takes-all: as Michael Abramowicz has suggested, a prize system could be structured such that rewards are shared among all researchers whose work contributed to the ultimate product. Abramowicz, *supra* note 32, at 188. Similarly, an independent invention defense to patent infringement would weaken the winner-takes-all thrust of current patent law. *See* Samson Vermont, *Independent Invention as a Defense to Patent Infringement*, 105 MICH. L. REV. 475, 476–79 (2006) (recommending independent invention as a defense that would enable a second inventor to compete with a first inventor).

188. Indeed, the Hearing Aid Assistance Tax Credit Act 2011, H.R. 1479, 112th Cong., would have allowed a $500 income tax credit for the purchase of a qualified hearing aid.

objectionable because of both our own likelihood of future hearing loss[189] and as a matter of moral obligation (although this claim is not universally accepted).[190]

Other innovation policy mechanisms may have redistributive properties as well. For example, a tax credit for hearing-related research would redistribute wealth from the non-hearing impaired to the hearing impaired, but with less government involvement in the allocation of funds than a pure grant system. Prizes for hearing-related discoveries would have a similar redistributive effect. Of the principal policy mechanisms discussed above, the patent system is unique in that the payors are purchasers of the patented products, such that the patent system limits the extent to which nonusers subsidize users.[191] This may be a virtue in some cases: as Gallini and Scotchmer note, while there might be few objections to taxpayer support for R&D designed to find cures for chronic or terminal diseases, "[t]axpayers might rightfully revolt if asked to bear the costs of developing, say, computer games."[192]

While the patent system may limit the extent to which nonusers subsidize users, it also creates the reverse phenomenon: users subsidize

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189. *Quick Statistics*, NAT'L INST. ON DEAFNESS & OTHER COMMC'N DISORDERS, http://www.nidcd.nih.gov/health/statistics/Pages/quick.aspx (last updated June 16, 2010) ("47 percent of adults 75 years old or older have a hearing loss.").

190. *See* MARK S. STEIN, DISTRIBUTIVE JUSTICE AND DISABILITY: UTILITARIANISM AGAINST EGALITARIANISM 267 (2006) ("When we attend to issues of disability, it seems right that resources be distributed to those who can most benefit rather than to those who are in some way worse off."); Mark S. Stein, *Ronald Dworkin on Redistribution to the Disabled*, 51 SYRACUSE L. REV. 987, 988 (2001) (advocating for utilitarianism as the principle by which to redistribute wealth to people with disabilities).

191. We note three caveats: First, a fraction of the patent system's administrative costs are funded from general Treasury revenues. *See infra* notes 282–87 and accompanying text. Second, insurance markets may spread the costs of certain patented goods to nonusers, such as for many medical innovations. *See* Darius Lakdawalla & Neeraj Sood, *Health Insurance as a Two-Part Pricing Contract* 2 (Nat'l Bureau of Econ. Research, Working Paper No. 12681, 2006) (calculating that the presence of insurance markets for U.S. pharmaceuticals lowers monopoly loss by 82%). Third, some consumers might object that they are paying higher prices due to patents that are really invalid or that have been given an overly broad scope, even though they are not "users" of the "true" invention. But patent validity and claim scope are aspects of the reward size and thus involve the question of *who decides*, not *who pays*. (Although judges may be influenced by who pays when evaluating claim scope.) Once we decide (perhaps wrongly) that the inventor of a minor smartphone feature gets an overly broad patent that covers the entire smartphone market, we still have to decide whether that reward should be paid by all taxpayers or only by smartphone users.

192. Gallini & Scotchmer, *supra* note 1, at 55. Kapczynski suggests that Gallini and Scotchmer's "intuition may be funded by the sense that video games are not goods at all, but rather are 'bads.'" Amy Kapczynski, *The Cost of Price: Why and How To Get Beyond Intellectual Property Internalism*, 59 UCLA L. REV. 970, 1005 n.132 (2012); *cf.* Transcript of Oral Argument at 17, Brown v. Entm't Merchs. Ass'n, 131 S. Ct. 2729 (2011) (No. 08-1448) ("JUSTICE ALITO: Well, I think what Justice Scalia wants to know is what James Madison thought about video games.").

nonusers due to information spillovers,[193] which would occur even with patents of infinite duration. And assuming that an inventor only obtains a patent of limited duration (e.g., twenty years), early users (who pay supracompetitive prices during the period in which the patentee enjoys exclusivity) effectively cross-subsidize users who come later in time. This modest amount of cross-subsidization could be limited in some cases using trade secret protection, which may create fewer information spillovers and may have infinite duration. (Trade secret protection, like patent protection, is an *ex post*, market-set transfer, although it may be unavailable in many product markets.)[194]

Cross-subsidization can also be curtailed beyond the *ex post*, market-set transfer box of our taxonomy. Indeed, we believe that *who pays?* is a distinct third dimension to innovation policy. In theory, for each of the four categories in Figure 1, one can imagine some revenue-raising mechanisms that would entail cross-subsidization and others that would not. Government grants, credits, and prizes funded out of general treasury revenues do entail cross-subsidization; government grants, credits, and prizes funded out of dedicated sales tax revenues might not (depending on how narrowly tailored the sales tax is toward the types of consumers that might be benefited by the assisted research).[195] Patent boxes do entail cross-subsidization, assuming that the revenues lost through the patent box are offset by general tax revenues. (The loss of revenue from patent boxes could be offset through a dedicated sales tax on the products aided by the patent box, but that would render the patent box ineffectual: the tax advantage from the patent box would be offset by the tax disadvantage from the levy on sales.) Patents and trade secrets come closest to satisfying the user-pays principle.

193. *See* BRETT M. FRISCHMANN, INFRASTRUCTURE: THE SOCIAL VALUE OF SHARED RESOURCES 111 (2012) (discussing the difficulty of measuring cross-subsidization because of the difficulty in predicting the source or magnitude of spillovers); Frischmann & Lemley, *supra* note 132, at 257–61 (discussing spillovers in the intellectual property context).

194. For instance, it is difficult to imagine a pharmaceutical company successfully utilizing trade secret protections to extract monopoly rents from a small-molecule drug. *But see* Robert Graham Gibbons & Bryan J. Vogel, *The Increasing Importance of Trade Secret Protection in the Biotechnology, Pharmaceutical and Medical Device Fields*, 89 J. PAT. & TRADEMARK OFF. SOC'Y 261, 270–77 (2007) (cataloging cases in which alleged trade secret holders, including pharmaceutical companies, prevailed).

195. For example, hearing-aid-related grants, prizes, and tax credits could be funded by a sales tax on hearing aids and cochlear implants. (This cost might then be spread to the non-hearing impaired by insurance, although the tax could in theory be made nonreimburseable.) A perfect one-to-one match between the payers of the sales tax and the beneficiaries of the government-assisted R&D is unlikely, but the more narrowly one defines the pool of people who are taxed and the class of research that the tax revenues will be used to fund, the less cross-subsidization of users by nonusers will occur.

Difficulties arise when R&D is directed toward products that do not yet exist (e.g., a hoverboard[196]). Hypothetically, the government could issue original discount bonds to pay for grants for hoverboard-related research (or to offset revenue lost due to credits claimed by hoverboard researchers); the government could roll over the bonds until a hoverboard was actually invented and then impose a tax on hoverboard sales, using the revenues to retire its bonds. Concededly, the rollover strategy might run into trouble if—much to the chagrin of *Back to the Future* fans—hoverboards never come into existence,[197] in which case the user-pays principle could not be satisfied because there would never be a user who could pay. But the important point is that the amount of cross-subsidization within any of the four categories is not constant, although that amount can never assuredly be zero.

Figure 2

		Reward Size	
		Government-Set	Market-Set
Reward Timing	*Ex Ante*	Grants funded from general revenues	R&D credits offset by general revenues
		Grants funded through targeted sales tax	R&D credits offset by targeted sales taxes
	Ex Post	Prizes funded from general revenues	Market-based prizes funded by general revenues; patent boxes
		Prizes funded from targeted sales taxes	Patents; trade secrets

[unshaded] Cross-Subsidization [shaded] User-Pays

Figure 2 adds this third dimension to our taxonomy. The unshaded boxes indicate policies that involve cross-subsidization of users by nonusers because rewards are financed through taxes levied on a broad base. The shaded boxes indicate policies that limit cross-subsidization. We think adding this dimension illuminates that cross-subsidization is one among several variables that policymakers can manipulate in designing innovation

196. *See generally* BACK TO THE FUTURE PART II (Universal Pictures 1989).

197. For more on this disappointing possibility, see Will Oremus, *Let's Face It, We're Never Getting Our Hoverboards*, SLATE (Nov. 16, 2012), http://www.slate.com/articles/technology/future_tense/2012/11/where_s_my_hoverboard_sorry_you_re_probably_never_getting_one.single.html.

incentives, rather than a feature tied to grants, credits, or prizes. Even if one considers the user-pays principle to be normatively significant, patents are not the only solution. Likewise, even if one favors cross-subsidization, this is not a reason to reject all *ex post* programs where transfer size is market-set.

The consensus of IP commentators is that the user-pays principle of patents is in tension with distributive values.[198] For example, Amy Kapczynski argues that "government procurement and the commons (and especially the former) are institutional approaches with inherent distributive advantages [over IP] because they sever the links both between ability to pay and production."[199] We do not want to minimize the grave human rights considerations at issue in this debate; millions of people die each year from preventable diseases in part because they cannot afford the supracompetitive cost of patented medicines.[200] But we think that this literature has overlooked a distributive-justice argument *for* the patent system in the case of nonessential goods, which becomes apparent by looking at the distribution of costs rather than the distribution of benefits. A simple example will illustrate:

Consider an inventor who discovers a drug that cures male pattern baldness. Let's say that the drug costs $1 to produce, that there are 100 bald men in the world willing to pay at least $1 for the drug, and that the demand schedule for the drug is linear: 100 bald men will purchase the drug if it is priced at $1, 50 bald men will purchase the drug if it is priced at $1.50, and no bald men will purchase the drug if it is priced above $2. Stipulate that the inventor should receive a benefit of $25 for her discovery (either on desert-based grounds or efficiency grounds). We could allocate this benefit to the inventor in the form of a patent or a prize.

If the inventor obtains a patent on her baldness cure, and if she behaves as a profit-maximizing monopolist, she will produce 50 doses of the drug and sell them at $1.50. Subtracting production costs, her total

198. *See, e.g.*, Margaret Chon, *Intellectual Property and the Development Divide*, 27 CARDOZO L. REV. 2821, 2823 (2006) (proposing that IP should incorporate a substantive equality principle because it does not presently address distributional concerns); Kapczynski, *supra* note 192, at 993–1006; Peter Lee, *Toward a Distributive Commons in Patent Law*, 2009 WIS. L. REV. 917, 919–28 (acknowledging that the current patent system adversely affects low-income populations and is in need of "distributive safeguards"); James Love, *Measures To Enhance Access to Medical Technologies, and New Methods of Stimulating Medical R & D*, 40 U.C. DAVIS L. REV. 679, 681 (2007) (arguing that the patent system should be modified to increase access to health technology in developing countries).

199. Kapczynski, *supra* note 192, at 1005.

200. *See* William W. Fisher & Talha Syed, *A Prize System as a Partial Solution to the Health Crisis in the Developing World*, *in* INCENTIVES FOR GLOBAL PUBLIC HEALTH: PATENT LAW AND ACCESS TO ESSENTIAL MEDICINES 181, 181–82 (Thomas Pogge et al. eds., 2010) (describing how each year approximately nine million people die from preventable diseases partly due to high medication costs).

profit will be $25. However, 50 men will continue to suffer from baldness even though they were willing and able to pay a price above marginal cost. Alternately, if the inventor receives a $25 prize instead of a patent, then market competition will push the output of the drug to 100. In this respect, the prize system seems preferable to the patent system because it allows for 100 rather than 50 men to cure their baldness while also allowing the inventor to receive the reward that we believe she is due.

But where does the $25 for the inventor's prize come from? In theory, we could fund the prize by imposing a 25-cent sales tax on baldness drugs such that all users contribute equally to the cure, while the rest of society bears no cost. Upon first glance, this might seem fair: why should taxpayers with full heads of hair pay for a cure to an ailment from which they do not suffer? (And, perhaps more to the point: why should men who are content with their baldness subsidize those who are not?)

But with a 25-cent sales tax, the price of the drug rises to $1.25, and only 75 bald men are willing to buy the drug for that price. If only 75 bald men are paying the 25-cent sales tax, then the tax only raises $18.75—not enough to give the inventor the full $25 we said she was due. In order to raise the full $25, we would have to impose a 50-cent sales tax, which brings us right back where we started from with patents: the tax-included price would be $1.50, and once again, 50 bald men go uncured even though they are willing to pay at least the marginal cost of the baldness drug. The only way to fund a $25 prize without reverting back to the 50-uncured-bald-men starting point is through some mechanism other than a targeted sales tax. More generally, in the case of a good that is non-rivalrous but also not consumed universally, the only way to satisfy the user-pays principle is to sacrifice the goal of allocative efficiency, and vice versa.

We expect that the strength of the intuition that users should pay will vary from reader to reader and from context to context. The user-pays principle may seem heartless with respect to treatments for debilitating diseases; it may seem more attractive with respect to lifestyle drugs. (A cure for male pattern baldness may fall into the latter category, although the physical and psychological harms of male pattern baldness are not to be discounted.)[201] We do not attempt a full-throated justification for or critique of the user-pays principle here. Our point is only that marginal-cost pricing and cross-subsidization are two sides of the same coin, and that society's choice among innovation policies should turn at least in part on the relative weights we assign to these two sides.

Similarly, while proponents of progressive redistribution of wealth may favor cross-subsidized mechanisms that can be funded through

201. *See* Dow Stough et al., *Psychological Effect, Pathophysiology, and Management of Androgenetic Alopecia in Men*, 80 MAYO CLINIC PROC. 1316, 1316 (2005).

graduated income taxes, the distributional effect of user-pays systems depends on users' income profile.[202] Taxpayer financing (through grants, prizes, and credits) of R&D related to luxury goods may be regressive relative to patents and other user-pays mechanisms if the portion of the population that purchases the luxury goods in question is smaller—and more skewed toward the upper end of the income distribution—than the taxpaying public at large.

A different distributive-justice consideration that has also been overlooked is that choices among innovation policies affect distribution across generations. A patent is, in effect, a twenty-year payment plan for R&D: if a product is patented today, purchasers will pay prices above marginal cost for the next two decades. Should future generations be "charged" for present innovation? The answer might depend on whether the promise of patent rights incentivizes innovation that would otherwise not occur or merely accelerates innovation that was inevitable in any event. If, for example, a cure for male pattern baldness would have been found in the next decade regardless of the IP regime but the promise of patent rights triggered a race that resulted in a cure today, then arguably consumers eleven years from now should not bear the cost of the cure in the form of above-marginal-cost prices: after all, they did not benefit from the acceleration. If, on the other hand, a cure for male pattern baldness would not have been found *ever* but for the incentive created by patent rights, then a patent of long duration might raise no intergenerational-equity concerns. Moreover, while grants, prizes, and credits involve only present-period outlays for R&D, these policy tools may raise intergenerational-equity concerns as well inasmuch as present-period outlays are financed through public debt that will be repaid over the long term. In this respect, twenty-year patents may raise fewer concerns from an intergenerational equity perspective than grants and prizes that are paid out today (or than credits that are claimed today) but financed through thirty-year Treasury bonds.[203]

Ultimately, we are agnostic as to when and whether cross-subsidization of users by nonusers—and cross-subsidization of current consumers by future generations—accords with distributive-justice

202. The user-pays principle is easiest to implement through a sales tax (or shadow sales tax) on the resulting products, and sales taxes are generally considered to be more regressive than income taxes (or, at least, more regressive than the federal income tax as currently structured). *See, e.g.*, Daniel R. Feenberg et al., *Distributional Effects of Adopting a National Retail Sales Tax*, *in* 11 TAX POLICY AND THE ECONOMY 49, 86 (James M. Poterba ed., 1997) (finding that under a retail sales tax, the tax burden on high income households would be lower than that under the present income tax).

203. *See, e.g.*, Richard A. Epstein, Essay, *Justice Across the Generations*, 67 TEXAS L. REV. 1465, 1483 (1989) ("If there is a long-term debt for an asset with a short expected life, then some portion of the cost is externalized on the next generation in ways that cut against the goal of intergenerational justice.").

principles. Society tolerates cross-subsidization in a range of contexts: airline passengers are subsidized by taxpayers who choose other forms of travel;[204] outdoors enthusiasts who use national parks and other federal lands are subsidized by taxpayers who prefer other forms of recreation;[205] and, as Mitt Romney famously noted in a 2012 presidential debate, Big Bird is subsidized by taxpayers who don't watch (or whose children don't watch) PBS.[206] The choice among innovation-incentive mechanisms reflects a series of implicit decisions about the ethics of cross-subsidization (across persons and across time). Our framework simply serves to bring this dimension of innovation policy to the fore.

D. Beyond the Three Dimensions

The three dimensions outlined above—reward setting, reward timing, and cost distribution—constitute central design features of innovation-incentive systems, but innovation policy implicates a range of other considerations. In this subpart, we show how our three-dimensional framework sheds light on four of these considerations: (1) nonmonetary motivations for innovation; (2) disclosure of technical information; (3) racing among multiple innovators; and (4) administrative costs.

1. Nonmonetary Motivations.—We have already explored the ways in which real-world innovators diverge from the risk-neutral rational actors who populate neoclassical economic models. But even while discussing optimism bias and risk aversion, we have retained the assumption that potential innovators are motivated by monetary rewards alone. Yochai Benkler has convincingly argued, however, that many innovators are also motivated by "social-psychological rewards" such as the respect of colleagues.[207] Benkler also argues that extrinsic financial rewards can

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204. *See* Edward L. Glaeser, Opinion, *Funds Up in the Air*, BOS. GLOBE, Mar. 7, 2013, http://www.bostonglobe.com/opinion/2013/03/07/sequester-presents-opportunity-for-airline-fliers/FVRqVXemYPliaSZoBv74IO/story.html (criticizing the use of general tax revenue to fund airport-related services).

205. *See* Jin Young Chung et al., *Fairness of Prices, User Fee Policy and Willingness To Pay Among Visitors to a National Forest*, 32 TOURISM MGMT. 1038, 1039 (2011) (discussing the relative merits of using tax revenue versus user fees to fund parks).

206. *See, e.g.*, Michael Medved, *Get Big Bird Off Welfare!*, DAILY BEAST (Oct. 9, 2012, 4:45 AM), http://www.thedailybeast.com/articles/2012/10/09/get-big-bird-off-welfare.html (noting that despite the attention surrounding the issue, the Corporation for Public Broadcasting receives less than 18% of its overall funding from Congress).

207. YOCHAI BENKLER, THE WEALTH OF NETWORKS: HOW SOCIAL PRODUCTION TRANSFORMS MARKETS AND FREEDOM 43 tbl.2.1, 63–67, 97–101 (2006) [hereinafter BENKLER, WEALTH OF NETWORKS]; Yochai Benkler, *Coase's Penguin, or, Linux and* The Nature of the Firm, 112 YALE L.J. 369, 426–27 (2002) [hereinafter Benkler, *Coase's Penguin*]; *see also* James Boyle, *The Second Enclosure Movement and the Construction of the Public Domain*, LAW & CONTEMP. PROBS., Winter/Spring 2003, at 33, 45 (arguing that free and open-source software "is

"crowd out" these intrinsic or altruistic motivations, such that higher monetary rewards will not always lead to greater information production.[208] As an alternative to intellectual property systems, Benkler advocates "commons-based peer production," which involves large, loose aggregations of individuals sharing information and self-assigning tasks, as has occurred with Wikipedia.[209]

Yet even Wikipedia benefits from indirect government support (even aside from support for the Internet infrastructure on which it depends): the Wikimedia Foundation is supported by private donations, which are effectively subsidized through income tax deductions for charitable contributions.[210] Moreover, the Wikimedia Foundation's largest supporters are private foundations that can accumulate investment income largely tax-free.[211] Similarly, the Free Software Foundation—which sponsored the development of the free and open-source operating system Linux—benefits from implicit government subsidies through its tax-exempt status.[212] Meanwhile, proponents of commons-based peer production in biology advocate a shift to more government funding, not an elimination of financial incentives for R&D.[213] In short, even commons-based peer

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an example of widespread, continued, high-quality innovation" sustained by nonmonetary incentives such as "the innate human love of creation"). *But see* Lior Jacob Strahilevitz, *Wealth Without Markets?*, 116 YALE L.J. 1472 (2007) (reviewing BENKLER, WEALTH OF NETWORKS, *supra*, and questioning Benkler's optimism about nonmarket production). This focus on nonmonetary incentives is distinct from the broader critique by proponents of commons-based innovation that the transaction costs associated with granting IP rights outweigh any efficiency gains from those rights. *See infra* section II(D)(2).

208. *See* BENKLER, WEALTH OF NETWORKS, *supra* note 207, at 92–97; Benkler, *Coase's Penguin*, *supra* note 207, at 427–33.

209. Benkler, *Coase's Penguin*, *supra* note 207, at 375–76, 386–87.

210. *See Deductibility of Donations*, WIKIMEDIA FOUND., http://wikimediafoundation.org/wiki/Deductibility_of_donations (last updated Aug. 23, 2013) (discussing the tax deductibility of donations to the Wikimedia Foundation).

211. *See* Press Release, Wikimedia Found., Stanton Foundation Awards Wikimedia $3.6 Million for Technology Improvements (Oct. 5, 2011), http://wikimediafoundation.org/wiki/Press_releases/Stanton_Foundation_Awards_Wikimedia_$3.6_Million_for_Technology_Improvements; Jay Walsh, *Wikimedia Welcomes $3 Million Gift from the Sloan Foundation*, WIKIMEDIA BLOG (July 11, 2011), https://blog.wikimedia.org/2011/07/11/wikimedia-welcomes-3million-gift-from-the-sloan-foundation.

212. *See Support the Free Software Foundation*, FREE SOFTWARE FOUND., https://my.fsf.org/associate/support_freedom (representing the Free Software Foundation as a 501(c)(3) organization).

213. *See, e.g.*, Arti K. Rai, *"Open and Collaborative" Research: A New Model for Biomedicine*, *in* INTELLECTUAL PROPERTY RIGHTS IN FRONTIER INDUSTRIES: SOFTWARE AND BIOTECHNOLOGY 131, 141, 143, 152 (Robert W. Hahn ed., 2005) (praising the "publicly funded project to sequence the human genome" and "'systems biology' projects funded by the NIH" but arguing against "copyleft style licensing that undermines patents on downstream information").

production systems rely on direct or indirect government support to offset the private costs of innovative activity.[214]

As Benkler himself acknowledges, monetary rewards for innovation do not inevitably crowd out social-psychological rewards, but the relationship between social-psychological and monetary rewards is culturally contingent and ever shifting.[215] It is therefore difficult to make generalizable claims about the interaction between nonmonetary motivations and any of the innovation policies analyzed above. We do know from observation that the Wikimedia Foundation and the Free Software Foundation are perfectly willing to accept indirect government subsidies through tax deductions for charitable contributions;[216] it remains to be seen whether these organizations would willingly accept direct government grants. Meanwhile, free and open-source software guru Linus Torvalds—the engineer who drove the creation of Linux—expresses a strong aversion to software patents[217] but gladly accepts government-financed prizes.[218] But these are not necessarily stable conditions. Jean-Paul Sartre famously declined the 1964 Nobel Prize in Literature on the ground that "[a] writer must refuse to allow himself to be transformed into an institution,"[219] but he appears to have accepted royalties from his intellectual property.[220]

214. The role of monetary motivations in commons-based peer production systems also ought not be ignored. *See* Jonathan M. Barnett, *The Host's Dilemma: Strategic Forfeiture in Platform Markets for Informational Goods*, 124 HARV. L. REV. 1861, 1863 (2011) (describing the economic rationale behind giving away valuable intellectual assets); Jonathan M. Barnett, *The Illusion of the Commons*, 25 BERKELEY TECH. L.J. 1751, 1802 (2010) (discussing the robust revenue streams available to academic and scientific researchers); Eric von Hippel & Georg von Krogh, *Free Revealing and the Private-Collective Model for Innovation Incentives*, 36 R&D MGMT. 295, 295 (2006) (asserting that freely sharing findings can be "the best practical route for innovators to increase profit from their innovations").

215. For example, Benkler notes that "professional performers or athletes may have been treated with less respect than amateurs a hundred years ago, but this has obviously changed quite dramatically" so that "[s]omeone who loves to play basketball will, all other things being equal, prefer to be paid for playing at Madison Square Garden over playing at West Third and Sixth Avenue without being paid." Benkler, *Coase's Penguin*, *supra* note 207, at 432–33.

216. *See supra* notes 210–12.

217. Graeme Burton, *'Abolish Software Patents,' Says Linus Torvalds*, COMPUTING (Oct. 23, 2012), http://www.computing.co.uk/ctg/news/2219375/-abolish-software-patents-says-linus-torvalds.

218. *See Linux Creator Linus Torvalds Shares Millennium Technology Prize*, BBC NEWS (June 13, 2012), http://www.bbc.co.uk/news/technology-18423502.

219. Jason English, *Odd Facts About Nobel Prize Winners*, CNN (Oct. 6, 2009), http://edition.cnn.com/2009/LIVING/wayoflife/10/06/mf.nobel.odd.facts/index.html. *But cf.* Strahilevitz, *supra* note 207, at 1498 n.101 (arguing that a prize reward is "unlikely to 'crowd out' altruistic contributions").

220. *See* HAZEL ROWLEY, TÊTE-À-TÊTE 284 (2005) (describing how Sartre's daughter would inherit the money made from his "royalties, copyright permissions, and translations").

Where innovators harbor moral objections to patents on certain subject matter (such as software, genes, or animals[221]), patent rights may be inconsistent with nonmonetary motivations for R&D activity, making other innovation policies more effective. But here, too, views are not necessarily set in stone. In 1980, the Association of American Medical Colleges supported patent rights over living organisms to facilitate commercialization of biomedical research;[222] in 2005, it joined a Supreme Court amicus brief stating that "[s]ince the time of Hippocrates, a basic tenet of medical ethics has been that discoveries and advances in medical care should be freely shared and openly disseminated."[223] Whether or not these two views are reconcilable, the point remains that in the former case, the organization urged the Supreme Court to adopt an expansive interpretation of patentable subject matter, while in the latter case, the same organization asked the Supreme Court to impose limits on the scope of patentable subject matter. More generally, the example illustrates that professional communities that embrace intellectual property protections in one time period and in one context may oppose them in a later period or under different circumstances.

Ultimately, the importance of social-psychological over monetary rewards for some innovators does not weigh uniformly in favor of one incentive mechanism or another. However, monetary rewards for innovation are likely to be more effective when they are complementary to nonmonetary motivations, and we believe that policymakers should—at the very least—be attentive to this factor.

2. Disclosure, Transactions, and Signals.—The different innovation incentives also vary with respect to how much an inventor claiming the subsidy must disclose regarding the subsidized innovation as a condition for claiming the reward. Patents are unique among the four main innovation incentives in that disclosure of the invention is a universal requirement for

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221. *See, e.g.,* Ass'n for Molecular Pathology v. U.S. Patent & Trademark Office, 689 F.3d 1303, 1346 (Fed. Cir. 2012) (Moore, J., concurring in part) ("[T]he [gene] patents in question raise substantial moral and ethical issues related to awarding a property right to isolated portions of human DNA—the very thing that makes us humans, and not chimpanzees."), *aff'd in part, rev'd in part sub nom.* Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 133 S. Ct. 2107 (2013); Rebecca Dresser, *Ethical and Legal Issues in Patenting New Animal Life*, 28 JURIMETRICS J. 399 (1988); Michael Risch, *Two Worlds of Software Patents*, PRAWFSBLAWG (Nov. 27, 2012, 10:28 PM), http://prawfsblawg.blogs.com/prawfsblawg/2012/11/two-worlds-of-software-patents.html (describing "friends of free software" who "believe that software is thought, and math, and that no one can own it").

222. Brief of Dr. Leroy E. Hood et al. as Amici Curiae, Diamond v. Chakrabarty, 447 U.S. 303 (1980) (No. 79-136), 1980 WL 339764, at *1–3.

223. Brief for the American Medical Association et al. as Amici Curiae in Support of Petitioner at 1, Lab. Corp. of Am. Holdings v. Metabolite Labs., Inc., 548 U.S. 124 (2006) (No. 04-607), 2005 WL 3597812, at *1.

patentability.[224] Government grants require patentable inventions to be disclosed to the government,[225] but ensuring that government grantees and contractors disclose discoveries that they do not seek to patent is far from straightforward.[226] Meanwhile, taxpayers claiming the credit for increasing research activities must comply with recordkeeping regulations[227] and must disclose information to the IRS when audited,[228] but the IRS is severely restricted in its ability to share taxpayer information publicly.[229] And while prizes can be structured such that claimants must disclose their discoveries as a condition for receiving the reward,[230] many existing prize sponsors allow contestants to keep information regarding their inventions confidential during and after the competition.[231]

One of us has argued that while disclosure is not a compelling *justification* for the patent system, the technical information in patents is an important benefit that likely outweighs the costs of requiring these disclosures.[232] This principle applies equally to any innovation incentive: the award of a grant, prize, or tax credit should be conditioned on public disclosure to the extent that such disclosure does not significantly undermine the innovation incentive. Requiring disclosure would potentially dilute the incentive effect of prizes, grants, and R&D tax credits, as potential claimants would have to weigh the benefit from these innovation incentives against the cost from loss of secrecy. But firms subject to a disclosure requirement could still earn profits through first-mover

224. *See* 35 U.S.C. § 112 (2006 & Supp. V 2012); TRIPS, *supra* note 67, art. 29.1 ("Members shall require that an applicant for a patent shall disclose the invention in a manner sufficiently clear and complete for the invention to be carried out by a person skilled in the art . . . .").

225. *See supra* note 43. However, these requirements are often not followed and the data that is reported is "shrouded in secrecy." Arti K. Rai & Bhaven N. Sampat, *Accountability in Patenting of Federally Funded Research*, 30 NATURE BIOTECHNOLOGY 953, 956 (2012).

226. *See generally* Rebecca S. Eisenberg, *Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research*, 82 VA. L. REV. 1663, 1674–75 (1996) (discussing the challenge of encouraging disclosure of discoveries by government contractors).

227. *See* 26 C.F.R. § 1.41-4(d) (2013).

228. *See generally* Kreig D. Mitchell, *Code Sec. 41 Research and Experimentation Tax Credit Audit Considerations*, J. TAX PRAC. & PROC., Feb.–Mar. 2008, at 69 (providing an overview of the Section 41 audit process).

229. *See* I.R.C. § 6103 (2006 & Supp. V 2012) (providing for the confidentiality of tax return information).

230. *See, e.g.*, John S. Irons & Carl Malamud, *Encouraging the Production of Open Source Software*, CTR. FOR AM. PROGRESS (Apr. 27, 2006), http://www.americanprogress.org/issues/technology/news/2006/04/27/1936/encouraging-the-production-of-open-source-software (proposing a "National Open Source Prize").

231. *E.g.*, Google Lunar X Prize, Master TEAM Agreement, Version 1.0 §§ 11.1–.5 (Nov. 24, 2009), *available at* http://wikileaks-press.org:81/file/googlelunarx-prize-final-master-team-agreement-review.pdf.

232. Lisa Larrimore Ouellette, *Do Patents Disclose Useful Information?*, 25 HARV. J.L. & TECH. 531 (2012).

advantage, brand-name status, and other barriers to entry. And a delay before the required disclosure, such as the current eighteen-month delay for patent publication,[233] could reduce any loss to innovation incentives. Disclosure requirements for nonpatent incentives would reduce their skew toward projects that are easier to keep secret.[234]

A second strand of the disclosure literature has focused on the role of patents not in *requiring* disclosure in the patent specification, but in *allowing* disclosure to occur through other channels. It is well understood that patents help solve Arrow's information paradox, enabling inventors to disclose their ideas to potential buyers.[235] Some commentators contend that patents' ability to facilitate information exchange at low cost is the primary justification for the patent system,[236] although Mark Lemley argues that empirical evidence on whether patents in fact promote exchange of valuable information "is not encouraging."[237] Michael Burstein notes that information is often exchanged without IP, relying instead on excludable aspects of the information, contracts, norms, or other strategies.[238] As Burstein acknowledges, such methods may be more costly than patents,[239] although the existence of trade secret law helps reduce wasteful investments in protecting secrecy.[240]

The transaction costs of information exchanges involving nonpatented innovations will vary across contexts, and a full evaluation of those costs lies far beyond the scope of this Article. Note, though, that even when

233. *See* 35 U.S.C. § 122(b)(1)(A) (2006) ("[E]ach application for a patent shall be published . . . promptly after the expiration of a period of 18 months from the earliest filing date for which a benefit is sought . . . ."); *see also* IAIN M. COCKBURN & REBECCA HENDERSON, SURVEY RESULTS FROM THE 2003 INTELLECTUAL PROPERTY OWNERS ASSOCIATION SURVEY ON STRATEGIC MANAGEMENT OF INTELLECTUAL PROPERTY, at B.1 (2003) (reporting that only 5% of surveyed patent owners thought they were negatively affected by requiring publication of patent applications after eighteen months).

234. *Cf.* Petra Moser, *How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs*, 95 AM. ECON. REV. 1214, 1231 (2005) (examining innovations from world's fairs in 1851 and 1876 and concluding that "[i]nnovators in countries without patent laws concentrated in industries where secrecy was an effective alternative").

235. *See supra* note 146 and accompanying text.

236. *See, e.g.*, Heald, *supra* note 149, at 476 ("[T]he transaction costs theory and complementary non-incentive theories provide an adequate economic justification for patent law."); Robert P. Merges, *A Transactional View of Property Rights*, 20 BERKELEY TECH. L.J. 1477, 1503 (2005) (describing how the protections of patent law allow an inventor to be "more likely to pursue deals, making necessary disclosures along the way").

237. Mark A. Lemley, *The Myth of the Sole Inventor*, 110 MICH. L. REV. 709, 748 (2012).

238. Michael J. Burstein, *Exchanging Information Without Intellectual Property*, 91 TEXAS L. REV. 227, 262–74 (2012).

239. *Id.* at 276.

240. *See* Mark A. Lemley, *The Surprising Virtues of Treating Trade Secrets as IP Rights*, 61 STAN. L. REV. 311, 333–37 (2008) (describing trade secret law as a complement to patent law because it reduces the need for physical investment in secrecy and partly solves Arrow's information paradox).

patents facilitate informational exchanges between innovators and investors early in the R&D process, the patent system solves a problem partly of its own making. Innovators need to attract outside funding *because* rewards are allocated primarily *ex post*. Under a system of *ex ante* rewards such as government grants or tax credits, innovators might be able to pursue their projects without relying on private-sector investment to cover early-stage costs.

A final argument for the disclosure benefits of patents over other innovation incentives is Clarisa Long's theory that patents act as "signals," or a way to "credibly convey information about the invention to observers."[241] Long's argument is distinct from Arrow's information paradox: in Arrow's paradox, the inventor who discloses information regarding her discovery to a potential purchaser conveys *too much*; the potential purchaser now has no incentive to purchase the information (because he has the information already).[242] In Long's model, the inventor who discloses information regarding her discovery conveys *too little*; the party on the other side of the information exchange may have no reason to believe the inventor's claims. Long argues that patents (partially) resolve this trust problem because "the penalties for intentionally misrepresenting material information in a patent are severe,"[243] whereas "[i]f a firm merely issued press releases about its research, investors could have no way of knowing if the information was credible."[244]

We think that Long's argument may overstate the signaling benefit of patents: securities laws already allow firms (including non-publicly traded companies) to credibly convey information to observers.[245] The penalties for misrepresenting material information in a corporate disclosure or press release are even more severe than the invalidation of a patent, including potential criminal sanctions.[246] Moreover, in cases in which the government takes no prosecutorial action, securities laws allow for the

241. Clarisa Long, *Patent Signals*, 69 U. CHI. L. REV. 625, 636 (2002).

242. Arrow, *supra* note 146.

243. Long, *supra* note 241, at 636–37.

244. *Id.* at 650.

245. Section 10(b) of the Securities Exchange Act makes it unlawful to use "any manipulative or deceptive device or contrivance" in connection with the sale of a security. 15 U.S.C. § 78j(b) (2012). The SEC rule promulgated under this section, Rule 10b-5, specifies that it is unlawful "[t]o make any untrue statement of a material fact or to omit to state a material fact . . . in connection with the purchase or sale of any security." 17 C.F.R. § 240.10b-5 (2013). These rules apply even if the company issuing securities is private. Erika L. Robinson, *SEC Reaffirms the Broad Reach of Rule 10b-5 to Private Companies*, WILMERHALE (Dec. 22, 2011), http://wilmerhale.com/pages/publicationsandnewsdetail.aspx?NewsPubId=90979.

246. *See* 15 U.S.C. §§ 78r, 78ff (2006) (providing for penalties for making misleading statements and for willful violations, including fines of up to $5,000,000 for a natural person and imprisonment for up to 20 years).

possibility of private action by injured investors.[247] By contrast, while adversaries in patent infringement suits can bring inequitable conduct claims against patentees who misrepresented material information in the application process,[248] an injured investor would have no standing to sue a patentee for violation of the Patent Act. And while we think Long is correct that patents "are (at least) a rough measure of the value of a firm's inputs into R&D,"[249] the firm's audited financial statements would provide a much better measure of inputs into R&D.[250]

3. Racing and Coordination.—The presence of multiple innovators can create a "common-pool" problem: because any of them may pursue a given project, duplicative research may dissipate the rewards from innovation in a process known as "racing."[251] Importantly, this problem only arises when the reward for a project is too large—as we have explained, the reward only needs to be sufficiently large so that an innovator's expected private reward outweighs the cost.[252] But racing does not necessarily mean too much investment in innovation—after all, the reason we offer innovation rewards is to increase R&D. The main concern is duplicative investment; it may be inefficient for multiple innovators to attempt to reach the same goal in a way that does not increase the ultimate probability of success.[253]

The extent to which racing is problematic varies with different policy tools. Racing is most obviously a concern for *ex post* rewards such as

247. *See, e.g.*, Basic Inc. v. Levinson, 485 U.S. 224, 230–31 (1988).

248. *See, e.g.*, Baxter Int'l, Inc. v. McGaw, Inc., 149 F.3d 1321, 1327 (Fed. Cir. 1998) (analyzing an inequitable conduct claim against a patentee for withholding material information on his patent application).

249. Long, *supra* note 241, at 652.

250. For an early-stage start-up, this function is also served by tax returns, which a potential investor would presumably want to see.

251. *See* Yoram Barzel, *Optimal Timing of Innovations*, 50 REV. ECON. & STAT. 348, 352 (1968) ("[T]he first to complete the innovation will rob subsequent introductions of all economic value . . . ."); Partha Dasgupta & Joseph Stiglitz, *Uncertainty, Industrial Structure, and the Speed of R&D*, 11 BELL J. ECON. 1, 18 (1980) ("[A]ll the potential social gains will be dissipated in the form of excessive entry.").

252. *See supra* subpart II(A). We thus do not think Suzanne Scotchmer is correct in concluding that for "fully efficient incentives," each innovator "must earn the entire social surplus of his innovation." Scotchmer, *supra* note 130, at 34. Awarding the entire social surplus guarantees that there will be no under-incentivization errors, but unless the government is confident that no one else is in the race, it might lead to costly over-incentivization errors. *See* Wright, *supra* note 1, at 693–94 (explaining why it is not true that "an optimal patent policy would protect the full value of the invention"). Furthermore, "the norm in a market economy is for private parties to capture only a portion of the social value of their output," Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEXAS L. REV. 2163, 2167 (2007) (citing Frischmann & Lemley, *supra* note 132), and uncaptured "spillovers" can lead to further innovation, *see* Frischmann & Lemley, *supra* note 132, at 276.

253. *See* Abramowicz, *supra* note 32, at 185.

patents and prizes; firms may duplicate efforts in pursuit of an inflated reward. But racing is also a concern for R&D tax credits: if the percentage of creditable costs is too high, the same duplicative investment may result.[254] The only innovation policy for which racing is not a significant concern is grants, for which the government determines the optimal amount to be spent on a problem, thus ensuring that the innovation pool is not "common" (although there may be wasteful lobbying to capture overly generous grants).

Edmund Kitch claimed, in his influential "prospect theory" of patents, that early, broad patents solve the racing problem by allowing the patentee to coordinate follow-on research and prevent duplicative R&D.[255] But this theory has fundamental theoretical problems,[256] and a number of patent scholars contend that racing should not be discouraged. Robert Merges and Richard Nelson have argued that in practice, patent prospects are typically *under*developed due to high transaction costs[257] and that "when it comes to invention and innovation, faster is better."[258] John Duffy argues that the goal of the patent system "is not to curb rivalry but merely to channel it into a relentless quest for earlier patenting and thus earlier dedication to the public."[259] And Mark Lemley recently stated that "racing can have substantial benefits" such as leading to useful alternatives and providing "deadline pressure."[260] These scholars argue that as a descriptive matter,

254. In particular, if N is the number of firms, p is the probability of success, B is the social benefit (of which a patentee can capture x percent), F is the first-mover advantage, and C is the cost of development (of which a user of tax credits must still pay t percent), the expected value for a firm in a patent regime is roughly $(p/N)(F + xB) - C$, so one would expect $N = p(F + xB)/C$, and the expected value for a firm in a tax credit regime is roughly $pF/N - tC$, so one would expect $N = pF/tC$. Thus, there will be more firms under the patent regime when $F + xB > F/t$; i.e., if the patent reward is larger than the tax credit reward.

255. Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265, 276–79 (1977). Though primarily remembered for his focus on coordination of follow-on research, Kitch also noted the benefits of patents in incentivizing commercialization (which involves the same gap between social benefit and private cost that we have been discussing, just translated in time) and facilitating disclosure without the contracts necessary to protect trade secrets (which we discussed earlier in this subpart). *See id.* at 277–78.

256. *See* Roger L. Beck, *The Prospect Theory of the Patent System and Unproductive Competition*, *in* 5 RESEARCH IN LAW AND ECONOMICS 193, 195 (Richard O. Zerbe, Jr. ed., 1983) (noting that patents do not in fact grant the patentee legal control over future research); Donald G. McFetridge & Douglas A. Smith, *Patents, Prospects, and Economic Surplus: A Comment*, 23 J.L. & ECON. 197, 202 (1980) (arguing that any surplus will be dissipated in competition for the initial patent).

257. *See* Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 872–75 (1990).

258. *Id.* at 878; *see also* Rebecca S. Eisenberg, *Patents and the Progress of Science: Exclusive Rights and Experimental Use*, 56 U. CHI. L. REV. 1017, 1042 & n.108 (1989).

259. John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439, 446 (2004).

260. Lemley, *supra* note 237, at 754–55.

racing tends to support, not undermine, patents' innovation incentive. It may be that the winner-takes-all incentive of a patent is the key driver of innovation, but this is simply a restatement of one of the main arguments for *ex post* mechanisms over *ex ante* mechanisms, as we have already discussed.

Whether rivalry for patents (or racing under tax credits) is in fact efficient is an empirical question. Where the innovation market is able to eliminate racing's inefficiencies, this factor becomes neutral and does not weigh in favor of any particular innovation mechanism. In contrast, where inefficient racing is a significant concern, we agree that early and broad prospect patents do not solve the problem. If the government has good information before R&D begins, racing could be eliminated by awarding grants to only those firms best situated to conduct the project. We also think Michael Abramowicz is correct that patents can be outperformed on this ground by well-designed prizes, such as by setting the reward such that the efficient number of teams works on the problem and conditioning the prize on disclosure and cooperation.[261]

4. Administrative Costs.—The main costs we have considered thus far are the deadweight loss associated with providing the reward (either from general taxation or the patent system's shadow sales tax), the possibility of rent dissipation through racing if the reward is set too high, and the transaction costs involved in information exchange. But all of the innovation incentives we have discussed also have administrative costs, which may be sufficiently large to inform the innovation policy choice.

Administrative costs include the costs of establishing the legal regime, determining which projects qualify for rewards, and policing the system. In subpart I(B), we roughly estimated that current annual federal spending on innovation incentives is \$130–\$140 billion for grants,[262] well under \$0.1 billion for prizes,[263] about \$10 billion for R&D tax credits,[264] and probably over \$30 billion[265] (but less than \$700 billion[266]) for the shadow sales tax caused by patents. How do the costs of administering these four systems compare? Our goal here is not to definitively determine the cost of administering a given reward under each system, but rather to get a sense of where the largest costs come from and to suggest that more careful estimations of administrative costs are feasible. The actual costs will vary

261. *See* Abramowicz, *supra* note 32, at 181–90 ("An ideal prize system would allow for shared rewards in contexts in which shared rewards are more efficient than the alternative.").

262. *See supra* note 75 and accompanying text.

263. *See supra* notes 51–52 and accompanying text.

264. *See supra* notes 85, 103 and accompanying text.

265. *See supra* note 72 and accompanying text.

266. *See supra* notes 70–71 and accompanying text.

with the details of the rewards administered, and it may be possible to improve the efficiency of any of these systems as currently implemented.

For grants, there are administrative costs both for the funding agencies, which are 6%–7% of rewards administered for two of the funding agencies,[267] and for recipients, which "shall be limited to 26% of modified total direct costs" and are included in the total grant award.[268] Total administrative costs could thus be up to a third of the reward received by researchers. Current federal prize expenditures are too small to permit an estimation of administrative costs; while these costs will vary with the type of prize and method of administration, we do not think they will drastically differ from the intensive government review involved in administering federal grants.

There are no detailed estimates of the total administrative and compliance costs associated with R&D incentives under the U.S. federal tax code. Brett Frischmann suggests that "the tax system may have high administrative costs compared with" patents or grants, but he offers no explanation for this intuition.[269] One reason costs associated with R&D tax incentives might be higher than costs associated with *ex post* programs is that for R&D tax incentives, an eligibility determination (whether an expenditure qualifies for the credit or deduction) must be made regardless of the ultimate success of the project. Failed projects, by contrast, typically do not lead to claims for patents or prizes.[270] But the cost of each eligibility

267. Five agencies were responsible for over 90% of the $134 billion in federal outlays for direct R&D support in fiscal year 2011: DOD (51%), NIH (23%), DOE (9%), NASA (4%), and NSF (4%). *See* NAT'L SCI. FOUND., *supra* note 76, at 12 tbl.3 (dividing 2011 R&D outlays for each agency by the sum of the outlays for all agencies). Estimating administrative costs is easiest for the NSF and NIH because they are primarily research focused. In fiscal year 2011, the NSF spent $313 million on agency operations, award management, and independent oversight (Office of Inspector General), which is 6% of the $5.6 billion it provided in R&D support. *See* NAT'L SCI. FOUND., FY 2013 BUDGET REQUEST TO CONGRESS 2 (2012), *available at* http://www.nsf.gov/about/budget/fy2013/pdf/EntireDocument_fy2013.pdf. The NIH spent $2.1 billion on research management and support and its Office of the Director in fiscal year 2011, which is 7% of its $30.9 billion budget. *See* NAT'L INSTS. OF HEALTH, DEP'T OF HEALTH & HUMAN SERVS., FY 2013 BUDGET REQUEST: EXECUTIVE SUMMARY 31 (2012), *available at* http://officeofbudget.od.nih.gov/pdfs/FY13/FY2013_Overview.pdf.

268. Principles for Determining Costs Applicable to Grants, Contracts, and Other Agreements with Educational Institutions (OMB Circular A–21), 2 C.F.R. pt. 220, app. A at para. G(8)(a) (2013). Modified total direct costs are the total reward minus certain costs such as equipment and capital expenditures, *id.* § G(2), so the recipient's administrative costs will be less than 26% of the total reward.

269. *See* Frischmann, *supra* note 11, at 385.

270. Because "an invention may be patented before it is reduced to practice," Pfaff v. Wells Elecs., Inc., 525 U.S. 55, 61 (1998), patents may be granted for inventions that do not actually work very well.

determination, though non-negligible,[271] is likely far lower for tax incentives than for patents.[272]

Although disputes between taxpayers and the IRS do arise over R&D tax incentives, the number of reported cases involving Section 41 and Section 174 is small relative to the number of patent-related cases: for the year 2012, the LexisNexis database identifies 12 reported cases citing Section 41 or Section 174, compared to 378 reported cases citing the statutory requirements for patentability.[273] Certainly, this suggests that the litigation-related costs associated with the R&D tax incentives are a fraction of those associated with the patent system. The costs borne by the IRS itself are likely much higher than the costs borne by the courts. A 1989 report by the General Accounting Office found that IRS agents disputed approximately 20% of total credits claimed under Section 41, although the IRS sought to reduce the frequency of such disputes through clarifying regulations.[274] One prominent tax lawyer has argued that IRS efforts to clarify the scope of the Section 41 credit have actually had the opposite effect,[275] and in 2007 the IRS designated the credit as a "Tier I issue" meriting extra attention during the tax auditing process.[276] However, the IRS discontinued its "tiered" approach in 2012; it remains to be seen

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271. While other items that corporations must report to the IRS (e.g., gross receipts) are items that the company would track anyway, compliance costs associated with the R&D tax incentives are additional to the costs that the company would otherwise incur as part of its internal control and auditing processes. *See* David R. Seltzer, *Federal Income Tax Compliance Costs: A Case Study of Hewlett-Packard Company*, 50 NAT'L TAX J. 487, 493 (1997) (explaining that the R&D tax credit "pose[s] compliance challenges, because [it] incorporate[s] tax-only concepts that may be only tenuously linked to financial accounting principles or to the classifications used by the company's operational units").

272. The IRS estimates that the annual burden on taxpayers (aside from individuals) who claim the credit for increasing research activities under Section 41 will include 10 hours, 2 minutes of recordkeeping work, 2 hours, 5 minutes of learning about the law, and 2 hours, 20 minutes for preparing and sending Form 6765 to the IRS. *See* I.R.S. Form 6765, Credit for Increasing Research Activities 4 (2012). The IRS does not explain how it arrived at these figures, but even if it grossly underestimates, the cost per project is still likely far less than a conservative estimate of $10,000 in legal fees for prosecuting a single patent (which does not include the internal costs to the company of working with the patent agent). *See infra* note 285.

273. Searches were conducted in LexisNexis's "Federal Court Cases, Combined" database—which includes Tax Court cases. The search terms were "26 usc sec 41 or 26 usc sec 174" and "35 usc sec 101 or 35 usc sec 102 or 35 usc sec 103."

274. U.S. GEN. ACCOUNTING OFFICE, GAO/GGD-89-114, TAX POLICY AND ADMINISTRATION: THE RESEARCH TAX CREDIT HAS STIMULATED SOME ADDITIONAL RESEARCH SPENDING 3 (1989).

275. *See* Philip A. Stoffregen, *Giving Credit Where Credit Is Due: A Brief History of the Administration of the R&D Credit*, TAX NOTES TODAY, Jan. 18, 1995, *available at* 95 TNT 11-151 (Lexis) ("The IRS's attempts to narrow the scope of the R&D credit have created substantial ambiguity and uncertainty regarding the scope of the credit.").

276. Memorandum from Patricia C. Chaback, Indus. Dir., Commc'ns, Tech. & Media, Internal Revenue Serv. (Apr. 4, 2007) (on file with author).

whether this will reduce the frequency of disputes related to the R&D provisions.[277]

These isolated data points tell us very little about the administrative and compliance costs of R&D tax incentives *relative* to other innovation policies. A 1995 study found that the compliance costs associated with Canada's scientific research and experimental development tax incentives were only 0.7% of credits claimed, which was only about a third of the costs associated with direct grants (even before including the costs borne by unsuccessful grant applicants).[278] A 2007 study found that average administrative and compliance costs associated with the Canadian credit were approximately 10 cents per dollar of credit claimed, with higher compliance costs for smaller firms.[279] The Canadian and U.S. systems differ in implementation details,[280] so administrative and compliance costs likely differ, too. What little we know about the subject suggests that although R&D tax incentives pose some compliance challenges for taxpayers, there is no evidence to support the claim that the administrative and compliance costs associated with R&D tax incentives are any greater than those associated with other innovation policy tools.

Patents are unique in that just as the reward to innovators is not reflected in the federal budget, the administrative and enforcement costs are almost entirely paid by private parties through nontax mechanisms.[281] The main publicly funded administrative cost is that of the federal courts (including facilities costs, salaries for judges and other court employees, and per diems and opportunity costs for jurors), which is probably under $100 million per year.[282] The administrative costs borne by private parties

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277. GRANT THORTON LLP, IRS DISCONTINUATION OF "TIERED" ISSUE MANAGEMENT WILL AFFECT R&D TAX CREDIT CLAIMS (2012), *available at* http://www.grantthornton.com/~/media/content-page-files/tax/pdfs/tax-insights/Tax%20Insights%202012-06%20tiered%20issue%20management.ashx.

278. Sally Gunz et al., *Measuring the Compliance Cost of Tax Expenditures: The Case of Research and Development Incentives*, 43 CAN. TAX J. 2008, 2029–31 (1995).

279. Mark Parsons & Nicholas Phillips, *An Evaluation of the Federal Tax Credit for Scientific Research and Experimental Development* 15–16 (Dep't of Fin. Can., Working Paper No. 2007-08, 2007), *available at* http://www.fin.gc.ca/pub/pdfs/wp2007-08e.pdf.

280. *See* DELOITTE GLOBAL SERVS. LTD., 2013 GLOBAL SURVEY OF R&D TAX INCENTIVES 7–8, 43 (2013), *available at* http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/Tax/US_Tax_RD_Global_RD%20Survey_March_2013.pdf (summarizing the nature of incentives, eligible industries, and qualified costs for each country).

281. Of course, one could say that all government costs are ultimately paid by private parties through taxation.

282. *See* Department of Defense and Full-Year Continuing Appropriations Act, 2011, Pub. L. No. 112-10, §§ 1524–1529, 125 Stat. 38, 134 (providing the federal judiciary with a fiscal year 2011 budget of approximately $5.5 billion, including juror per diems and excluding public defender services); ADMIN. OFFICE OF THE U.S. COURTS, JUDICIAL BUSINESS OF THE UNITED STATES COURTS: 2011 ANNUAL REPORT OF THE DIRECTOR 149 tbl.C-4 (2012) (reporting that approximately 1.2% of cases terminated during the prior year were patent cases).

are much larger: fees from patent applicants fund the $2- to $3-billion PTO budget,[283] the legal fees for patent prosecution add up to at least $5 billion per year,[284] and patent litigation can be very roughly estimated to cost another $2.5 billion per year,[285] adding up to total administrative costs on the order of $10 billion. Whether this is large depends on the total reward to patentees from the patent system's shadow sales tax—$10 billion is a third of $30 billion, but less than 2% of $700 billion. And there are other costs unique to patents, such as nonlitigation legal costs (e.g., conducting freedom-to-operate analyses[286]) and the costs of uncertainty and delay, which may push the total costs far higher than $10 billion.[287] But it is noteworthy that despite the growing complaints about the high costs of

283. *See* U.S. PATENT & TRADEMARK OFFICE, FISCAL YEAR 2013 PRESIDENT'S BUDGET 142 app. 2 (2012) (reporting approximately $2.1 billion in total patent fee collections for the 2011 fiscal year).

284. *See* AM. INTELLECTUAL PROP. LAW ASS'N, REPORT OF THE ECONOMIC SURVEY 2011, at 28 (2011) (reporting median patent prosecution costs, from which one can conservatively estimate legal fees of $10,000 per patent); U.S. PATENT & TRADEMARK OFFICE, PERFORMANCE AND ACCOUNTABILITY REPORT: FISCAL YEAR 2012, at 176 tbl.2 (2012) (showing that in recent years the PTO has received around 500,000 patent applications each year).

285. A very rough estimate of $5 million for 100 patent trials, $3 million for 400 cases taken through discovery, and $300,000 (one-tenth of the legal fees through discovery) for 2500 cases terminated before pretrial yields a total annual patent litigation cost of about $2.5 billion. *See* ADMIN. OFFICE OF THE U.S. COURTS, FEDERAL JUDICIAL CASELOAD STATISTICS: MARCH 31, 2011, at 57 tbl.C-4 (2011) (reporting that 3,049 patent cases were terminated during the previous twelve months, 430 during or after pretrial (but before trial), and 104 during or after trial); AM. INTELLECTUAL PROP. LAW ASS'N, *supra* note 284, at 35 (reporting median patent litigation costs per side for cases with $1–$25 million at stake as $1.5 million through the end of discovery and $2.5 million for all costs); Karthika Perumal, *Jury Patent Damages Verdicts*, PATSTATS.ORG, http://patstats.org/Verdicts_to_5-31-2013.post.xls (compiling data showing a median award around $8 million in cases where a jury awarded damages to the patentee from 2005 to 2013).

286. *See* Linda J. Thayer, *When Is a "Freedom to Operate" Opinion Cost Effective?*, FINNEGAN (Feb./Mar. 2013), http://www.finnegan.com/resources/articles/articlesdetail.aspx?news=14c90ae5-514d-4473-9b8a-ce88ef9ae85a.

287. Bessen and Meurer have argued that the "business costs" of patent litigation are much higher than the legal costs and have estimated the aggregate litigation losses incurred by a sample of public firms in 1999 to be about $16 billion in 1992 dollars, which is over $26 billion today. BESSEN & MEURER, *supra* note 72, at 132–39 (employing economists' event-study technique to estimate losses based on the reaction of the stock market to news of each lawsuit); *CPI Inflation Calculator*, *supra* note 72. *But see* Glynn S. Lunney, Jr., *On the Continuing Misuse of Event Studies: The Example of Bessen and Meurer*, 16 J. INTELL. PROP. L. 35, 36–37 (2008) (criticizing this technique because it reflects losses to the shareholder rather than losses to the firm and furthermore "does not survive empirical testing"). Bessen and Meurer also estimated that patent suits by non-practicing entities (including rewards to patentees) cost $29 billion in 2011. James Bessen & Michael J. Meurer, *The Direct Costs from NPE Disputes* 31 (Bos. Univ. Sch. of Law, Working Paper No. 12-34, 2012). *But see* David L. Schwartz & Jay P. Kesan, *Analyzing the Role of Non-Practicing Entities in the Patent System* (Ill. Program in Law, Behavior & Soc. Sci., Working Paper No. LBSS13-03, 2012) (criticizing Bessen and Meurer's study on litigation costs and settlement expenses for methodological deficiencies). While there may be flaws in Bessen and Meurer's specific figures, we note their work simply to suggest that estimating the administrative costs of the patent system is feasible.

patent litigation, these administrative costs of the patent system may be no larger than the administrative costs for government grants.

Furthermore, the high costs of patent litigation reflect the fact that patent law incorporates a second level of checks and balances through private enforcement, whereas tax law merely relies on administrative review. When a patentee claims a larger subsidy than that to which she is entitled by law (i.e., by advocating for overbroad claims), other private actors who face liability for infringing those claims have an incentive to push back. By contrast, when a taxpayer claims a larger R&D tax credit than that to which she is entitled, no other taxpayer is likely to challenge that claim.[288] Thus, while the second level of review in the patent system likely increases administrative costs, infringement litigation may also reduce the shadow budgetary costs of overbroad patent claims.

However the administrative costs of patents in fact compare with other incentives, it seems clear that the costs that appear on the federal budget are far smaller. But it would be wrong to conclude that just because these administrative costs of the patent system are not paid out of tax revenues, it is the cheapest incentive system—the privately borne administrative costs are still real costs of the system.[289] These costs, like the private reward for patentees, will mostly be reflected in the higher prices of patented

288. It is exceedingly rare for a private citizen to bring R&D credit abuses to the government's attention, and the few whistleblowers who have alerted the IRS to R&D tax credit abuses have reportedly met with a less than enthusiastic response from the agency. *See* Jesse Drucker & Peter S. Green, *IRS Resists Whistle-Blowers Despite Wide U.S. Tax Gap*, BLOOMBERG (June 19, 2012), http://www.bloomberg.com/news/2012-06-19/irs-resists-whistleblowers-despite-wide-u-s-tax-gap.html (describing how out of 1,300 claims filed over the past five years, only three have resulted in success for the whistleblower). There are at least three reasons for private citizens' reluctance: First, private citizens are unlikely to have a sufficient financial incentive to challenge another taxpayer's aggressive R&D credit claim. (This is a version of what Brian Galle has called "the tragedy of the carrots." *See* Brian Galle, *The Tragedy of the Carrots: Economics and Politics in the Choice of Price Instruments*, 64 STAN. L. REV. 797, 840–41 (2012) (suggesting that large producers are more incentivized because they have more to gain). Second, except in the case of certain tax-exempt organizations and nonexempt charitable trusts and private foundations, taxpayers are not required to make their annual returns publicly available, making it difficult to acquire the necessary information. *See* I.R.C. § 6104(a)(1) (2006). And third, private citizens generally do not have standing to compel the IRS to audit or investigate the tax returns of another taxpayer. *See* Allen v. Wright, 468 U.S. 737, 765–66 (1984) (holding that respondent did not have standing to challenge the IRS's failure to deny tax-exempt status to a racially discriminatory school); Salter v. United States, No. 91-36344, 1992 U.S. App. LEXIS 23792, at *3–4 (9th Cir. Sept. 15, 1992) (holding that respondent did not have standing to compel the IRS to audit and investigate the tax returns of a bankrupt corporation).

289. *Cf.* Richard B. Stewart & Cass Sunstein, *Public Programs and Private Rights*, 95 HARV. L. REV. 1193, 1298 (1982) ("If private enforcement is substantially more costly than additional public enforcement, private rights of action should presumptively be denied.").

products,[290] and can thus be thought of as part of the shadow sales tax paid by users of these goods and services. In Part III, we describe a proposal that would allow more direct comparisons between these shadow costs and the costs of other incentive systems.

III. Applying the Framework

Thus far, we have developed a framework for policymakers to consider when determining the optimal innovation policy in a given context. In this Part, we identify specific circumstances in which alternatives to the patent system—prizes, grants, and tax credits, alone or in combination—are likely to be more effective than the status quo in incentivizing innovation. Before proceeding to our specific suggestions in subpart III(B), however, we address an anticipated criticism in subpart III(A). A skeptic of our proposals might argue that the patent system is so entrenched at this point that fundamental reform of innovation policy is a pie-in-the-sky idea—no more likely to come to fruition than the hoverboards we discussed in subpart II(C). We acknowledge that the obstacles to innovation policy reform are considerable; in particular, we highlight the barriers to reform that arise from international law as well as domestic politics. However, we argue that fundamental innovation policy reform is neither inconsistent with the United States' international legal obligations nor inconceivable in light of political economy considerations.

A. Obstacles to Reform

The framework developed in Part II illustrates that many of the benefits of the patent system can be replicated by other innovation policies (including grants, credits, and prizes). Moreover, we have argued that alternative incentive mechanisms may avoid some of the pitfalls of the patent system, such as the large transaction costs arising from capital market frictions and the significant distortions due to monopoly pricing. What, then, explains the persistent popularity of the patent system in the United States and other advanced economies?

1. Cross-Border Considerations.—One answer is that the patent system is embedded in international law: as noted earlier, TRIPS requires World Trade Organization members to make twenty-year patents available for "any inventions" that "involve an inventive step and are capable of industrial application" (with limited exceptions).[291] But this answer is itself

290. We say "mostly" because some of the administrative costs of the patent system are borne by nonpatentees, such as the expenses of generic pharmaceutical companies in challenging brand-name drug patents.

291. TRIPS, *supra* note 67, arts. 27, 33.

question-begging, as it fails to explain the initial attraction to patents that led the United States and the European Community to push for strong patent protections in TRIPS.[292]

At the time of TRIPS, policymakers in advanced industrialized countries—and especially the United States—were concerned about the "free rider problem" of manufacturers in developing countries copying products without paying for patent licenses.[293] Thus, one attraction of international coordination in innovation policy—at least from a U.S. perspective—was to ensure that other countries contributed to the cost of R&D, rather than the United States (a net exporter of intellectual property) giving its innovations away to the rest of the world.[294]

In theory, international coordination around other innovation policies could address the problem that the financial burdens of grants, credits, and prizes typically fall on only one country's shoulders. The International Finance Facility for Immunisation—established in 2006 with commitments totaling $6.3 billion over twenty-three years from the governments of the United Kingdom, France, Italy, Norway, Australia, Spain, the Netherlands, Sweden, and South Africa—represents a step in this direction.[295] Donor countries also share the costs of grants for R&D through the World Health

292. On the role of the United States and European Commission in negotiating TRIPS, see Laurence R. Helfer, *Regime Shifting: The TRIPs Agreement and New Dynamics of International Intellectual Property Lawmaking*, 29 YALE J. INT'L L. 1, 20–23 (2004).

293. *See* Peter Drahos, *Global Property Rights in Information: The Story of TRIPS at the GATT*, 13 PROMETHEUS 6, 8–9, 18 n.13 (1995) (discussing U.S. concerns and the development of its trade-based strategy for intellectual property).

294. On TRIPS and the political economy of innovation policy in the United States, see F.M. Scherer, *The Political Economy of Patent Policy Reform in the United States*, 7 J. ON TELECOMM. & HIGH TECH. L. 167, 201–07 (2009). The U.S. status as a net IP exporter may be changing. *See* Dennis Crouch, *Does the Shift in IP Ownership Predict a Political Shift in the IP Debate*, PATENTLY-O (Mar. 11, 2013), http://www.patentlyo.com/patent/2013/03/does-the-shift-in-ip-ownership-predict-a-political-shift-in-the-ip-debate.html (showing that an increasing percentage of U.S. utility patents originate in foreign countries). Other advanced economies that are already net importers of IP—including France, Germany, Spain, and Japan, *see* KEITH E. MASKUS, INTELLECTUAL PROPERTY RIGHTS IN THE GLOBAL ECONOMY 81 (2000), may be more likely to emerge as sources of pressure for reform.

295. *See Overview*, INT'L FIN. FACILITY FOR IMMUNISATION, http://www.iffim.org/about/overview. Brazil has announced a $20 million commitment as well. BROOKINGS INST., BROOKINGS GLOBAL HEALTH FINANCING INITIATIVE SNAPSHOT SERIES: INTERNATIONAL FINANCE FACILITY FOR IMMUNIZATION, *available at* http://www.brookings.edu/~/media/Projects/global%20health/iffim.PDF. So far, the United States, Canada, and Japan have remained on the sidelines—possibly because of internal budgetary rules that would require them to account for their commitments to the facility differently than EU countries can. Todd Moss, *Ten Myths of the International Finance Facility* 6 (Ctr. for Global Dev., Working Paper No. 60, 2005), *available at* http://www.cgdev.org/files/2728_file_WP60.pdf.

Organization,[296] although budget slashing may prevent any expansion of these programs.[297] In short, international coordination *could* allow for cost-sharing as part of a prize regime (and potentially as part of a grant regime as well), but coordination efforts have been lackluster so far.[298] In the meantime, the global patent system remains the only robust regime that enables advanced economies to distribute R&D costs to consumers in other countries. Moreover, now that the TRIPS agreement is enshrined in international law (with 159 WTO member nations as signatories),[299] the United States is bound by the agreement.[300] Thus, even if international coordination around alternative incentive mechanisms is possible in theory, innovation policy reform at the domestic level is unlikely in practice unless it can be reconciled with the terms of TRIPS.

To the extent that prizes, grants, and tax credits are used only as *supplements* to the current patent regime, innovation policy pluralism poses no TRIPS-related challenges at all. Problems are more likely to arise where alternative incentive mechanisms are employed as *substitutes* for patent protection. Article 27 of TRIPS allows some exceptions to patentable subject matter,[301] so there is no difficulty if a country substitutes other incentives for patents in any of these areas. Furthermore, Article 30 states that patent rights may have "limited exceptions" that "do not unreasonably

296. *See generally* WORLD HEALTH ORGANIZATION, FINANCIAL REPORT AND AUDITED FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 DECEMBER 2012 (2013) (providing information on donor countries and research expenditures).

297. Stephanie Nebehay & Barbara Lewis, *WHO Slashes Budget, Jobs in New Era of Austerity*, REUTERS (May 19, 2011), http://www.reuters.com/article/2011/05/19/us-who-idUSTRE74I5I320110519.

298. As another example, the Health Impact Fund international medical-prize proposal, HOLLIS & POGGE, *supra* note 60, at 1–2, has received much publicity over the past five years but has not advanced to a pilot stage. *See generally* HEALTH IMPACT FUND, http://healthimpactfund.org (describing media coverage and progress).

299. *Members and Observers*, WORLD TRADE ORG., http://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm (last updated Mar. 2, 2013).

300. The United States' compliance record, however, has been less than perfect. *See* William New, *United States Chided as TRIPS Scofflaw at WTO*, INTELL. PROP. WATCH (Mar. 26, 2013, 8:02 PM), http://www.ip-watch.org/2013/03/26/united-states-chided-as-trips-scofflaw-at-wto (reporting on the United States' failure to comply with the WTO dispute settlement system because of an appropriations bill that unfairly denies trademark rights and protects a rum company's U.S. market).

301. TRIPS, *supra* note 67, art. 27.1 (requiring patents for "new" inventions "in all fields of technology" but not defining, for example, whether software or business methods are "fields of technology" or whether genes could be categorically excluded from patentability as not "new"); *id.* art. 27.3 (allowing exceptions from patentability for medical methods and many plants and animals); *see also* John M. Golden, *Patentable Subject Matter and Institutional Choice*, 89 TEXAS L. REV. 1041, 1092–93 (2011) (noting the Article 27.3 exclusions); Amy Kapczynski, *Harmonization and Its Discontents: A Case Study of TRIPS Implementation in India's Pharmaceutical Sector*, 97 CALIF. L. REV. 1571, 1595–96 (2009) (noting that countries have substantial leeway in interpreting Article 27.1 requirements).

prejudice the legitimate interests of the patent owner," which could arguably include a robust alternative incentive regime in a limited technical area.[302]

Where TRIPS requires patents on a particular subject matter, *mandatory* substitutes for patents are problematic, but *voluntary* substitutes are unobjectionable: Congress could condition the availability of enhanced R&D tax credits—or the availability of prizes or grants—on an innovator's agreement to a shorter patent life (or an innovator's agreement to forgo patent protection altogether).[303] Congress could similarly respond to calls for a U.S. "patent box"[304] by allowing individuals and firms to benefit from a preferential tax rate on patent-related income only if they accept a shorter patent life. The details of a "tax fix" for patent law lie beyond the scope of this Article. Presumably, such a reform would need to be accompanied by rules to ensure that innovators don't accept grants or claim tax credits for a project and then file a patent through a related entity based on the fruits of that project. Moreover, whatever mixture of prizes, grants, and tax incentives is offered for innovators who forgo twenty-year patent protection would have to be at least as attractive from the innovators' perspective as the patent status quo (or else the innovator would not opt into the voluntary system). The important point, however, is that international law does not prevent the United States from adopting a pluralistic approach to innovation policy that makes greater use of prizes, grants, and tax incentives, so long as innovators retain the option of sticking with the TRIPS-compliant status quo.

2. Domestic Political Economy.—While we do not believe that the TRIPS agreement presents an insurmountable obstacle to innovation policy reform, we acknowledge that the obstacles to innovation policy reform are

302. *See* TRIPS, *supra* note 67, art. 30. *But see* WILLIAM W. FISHER III & TALHA SYED, INFECTION: THE HEALTH CRISIS IN THE DEVELOPING WORLD AND WHAT WE SHOULD DO ABOUT IT (forthcoming) (manuscript ch. 7, at 34, 36), *available at* http://cyber.law.harvard.edu/people/tfisher/Drugs_Chapter7.pdf (acknowledging this argument but concluding that while the question is "not free from doubt," it "is likely that . . . a mandatory prize system would be deemed to violate the TRIPS Agreement").

303. Commentators have noted that voluntary medical-prize systems are thus TRIPS compliant. *See, e.g.*, HOLLIS & POGGE, *supra* note 60, at 106 (proposing such a system as "an additional option that firms could choose selectively" and noting it "is clearly compliant with the TRIPS Agreement"); FISHER & SYED, *supra* note 302, at 33–36 (proposing an optional prize system to respond to the health crisis in the developing world). Similarly, Edward Lee has suggested that Congress establish a preferential tax rate (a "copyright gains tax") on royalty revenue for copyright holders who agree to accept a copyright term shorter than the statutory maximum. Edward Lee, *Copyright, Death, and Taxes*, 47 WAKE FOREST L. REV. 1, 26–28 (2012).

304. *See, e.g.*, Peter R. Merrill et al., *Is It Time for the United States To Consider the Patent Box?*, 134 TAX NOTES 1665 (2012) (discussing how and whether to design a U.S. patent box).

not purely international. Domestic political economy considerations also contribute to the patent system's persistent popularity with U.S. policymakers. Two features of the political economy of patent law deserve particular mention.

a. The Patent System's Hidden Costs.—First, patent rewards—unlike grants, credits, and prizes—are "off-budget."[305] As Robert Merges observes, patent rights (mostly) "do not involve a direct expenditure of government funds."[306] Thus, "intellectual property represents something of a free lunch in the eyes of the government: a valuable benefit for which business constituents will be grateful, but which also has a zero impact on the federal budget deficit."[307]

Patents do, of course, impose costs on consumers: as explained above, patent rights operate as shadow taxes that enable patentees to charge prices above marginal cost. And we see little reason why consumers should prefer to pay $100 in higher prices for patented products rather than paying $100 in higher taxes to fund grants, credits, or prizes. The challenge for advocates of innovation policy reform, then, is to make the patent system's costs more salient to the voting public—and thus more relevant to elected officials.[308]

One way to encourage elected officials to view the patent system's shadow taxes as real costs borne by constituents would be to include these shadow taxes in budget figures. Although estimating the size of the shadow tax is complicated, the obstacles are not insuperable. The IRS already requires U.S. corporations to report gross royalties on their Form 1120 tax returns;[309] Carol Robbins of the U.S. Bureau of Economic Analysis (a division of the U.S. Department of Commerce) has used these data and other sources to estimate that domestically earned corporate income from

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305. William M. Sage, Commentary, *Funding Fairness: Public Investment, Proprietary Rights and Access to Health Care Technology*, 82 VA. L. REV. 1737, 1750 (1996).

306. Robert P. Merges, *The Economic Impact of Intellectual Property Rights: An Overview and Guide*, 19 J. CULTURAL ECON. 103, 111 (1995). Exceptions include the government's costs of administering the PTO (which is charged to patentees), adjudicating patent-related disputes (which is a relatively minor cost), and purchasing patented products itself (for which the patent-related cost is not salient). *See supra* notes 25, 282–83.

307. Merges, *supra* note 306.

308. On salience and taxation, see David Gamage & Darien Shanske, *Three Essays on Tax Salience: Market Salience and Political Salience*, 65 TAX L. REV. 19 (2011); Deborah H. Schenk, *Exploiting the Salience Bias in Designing Taxes*, 28 YALE J. ON REG. 253 (2011); and Jacob Goldin, Note, *Sales Tax Not Included: Designing Commodity Taxes for Inattentive Consumers*, 122 YALE L.J. 258 (2012).

309. I.R.S. FORM 1120, U.S. CORPORATION INCOME TAX RETURN (2012).

patents and trade secrets was approximately $50 billion in 2002.[310] This is, at the very least, the same order of magnitude as other estimates of IP-related rents.[311] More precise estimates might be possible if the IRS added specific line items to Form 1120 asking corporate taxpayers to differentiate patent-related revenues from copyright-, trademark-, and trade-secret-related royalties. Form 1120 figures also do not account for profits attributable to goods with IP "embedded" in them when the producer of the good is also the holder of the patent, but data on the market values of publicly traded companies allows for rough estimates of patent rents even when these rents are not broken out into separate licensing transactions.[312]

We acknowledge that estimates of the patent system's shadow tax will always be inexact. Note, though, that current federal budget figures do not account for the patent system's shadow taxes *at all*. While we might not know the exact size of the shadow tax imposed by the patent system, we can state with certainty that the number is greater than zero. From our perspective, the critical question is not whether the shadow tax can be estimated perfectly, but whether an imperfect estimate is better than the zero estimate that federal budget figures currently reflect.

The Congressional Budget Office (CBO) already operates under a statutory mandate to prepare, "to the extent practicable," an estimate of the costs associated with each bill or resolution reported by a House or Senate committee to the chamber's floor.[313] At least in theory, patent law changes could also be "scored" by the CBO and that office could produce supplemental budget estimates that account for the patent system's shadow taxes and expenditures. Moreover, CBO budget outlooks could account for the foreseeable shadow taxes that consumers of patented products will have to pay, just as the CBO already accounts for the long-term tax burden arising from on-budget expenditures.[314] Until the CBO takes up this task, private research organizations could fill the void to ensure that lawmakers and taxpayers are made aware that the patent system's subsidies for

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310. Carol A. Robbins, *Measuring Payments for the Supply and Use of Intellectual Property*, *in* INTERNATIONAL TRADE IN SERVICES AND INTANGIBLES IN THE ERA OF GLOBALIZATION 139, 141, 158–61 (Marshall Reinsdorf & Matthew Slaughter eds., 2009).

311. *Id.* at 164–66; *see, e.g.*, BESSEN & MEURER, *supra* note 72 (estimating that U.S. public firms earned patent rents in 1999 of about $18.4 billion in 1992 dollars); Stephen A. Degnan, *The Licensing Payoff from U.S. R&D*, 42 RES.–TECH. MGMT., no.2, 1999, at 22, 24 (estimating that U.S. industries' royalty receipts from domestic payer corporations in 1996 were approximately $97 billion, although some of this was attributable to copyrights and trademarks).

312. *See also, e.g.*, James Bessen, *Estimates of Firms' Patent Rents from Firm Market Value* (Bos. Univ. Sch. of Law Working Paper Series, Law & Econ. Working Paper No. 06-14, 2007).

313. 2 U.S.C. § 653 (2012).

314. *See* CONG. BUDGET OFFICE, THE 2012 LONG-TERM BUDGET OUTLOOK 85 (2012), *available at* http://www.cbo.gov/sites/default/files/cbofiles/attachments/06-05-Long-Term_Budget_Outlook_2.pdf.

innovators—although not paid directly out of general treasury revenues—are anything but a free lunch. Vendors who support innovation policy reform might also choose to include estimates of patent-related costs on consumer receipts.[315]

However, it is unlikely that CBO scoring of the patent system's hidden costs will—on its own—shift the political landscape in favor of patent reform. For one thing, CBO scores are most relevant in the budget-balancing process, as members of Congress rely on CBO estimates to gauge whether proposed legislation will increase the national debt.[316] While the patent system imposes shadow taxes on consumers through increased prices, and while the patent system entails shadow outlays to patentees in the form of monopoly profits, the shadow taxes and the shadow outlays exactly offset each other. Moreover, the example of tax expenditure reporting illustrates the difficulty of altering lawmakers' incentives through data alone: since 1974, the President has been required to include an estimate of federal tax expenditures in his annual budget,[317] but greater transparency with respect to tax expenditures has not stopped persistent growth in the number and value of tax expenditures.[318] While we believe that greater transparency with respect to the patent system's costs would serve the cause of reform, we do not believe that transparency on its own will cause the crumbling of barriers to change.

b. Innovation Policy Reform and Interest Group Politics.—A further barrier to innovation policy reform arises because the costs of the patent system are dispersed across a large number of consumers, while the number of market actors who reap the rewards of patent monopolies is much smaller. As William Landes and Richard Posner note, this asymmetry should make it easier to organize patentees on behalf of intellectual

315. Whether printing the patent tax on receipts makes sense will depend on both its economic and political salience. *See* Gamage & Shanske, *supra* note 308, at 20, 22–59 (examining the empirical literature on how tax presentation affects "market decisions and economic activity" (market salience) as well as "voting behavior and political outcomes" (political salience)); Schenk, *supra* note 308, at 272–73 (similarly introducing both types of salience).

316. *See, e.g.*, Suzy Khimm, *Why Does Anyone Trust the CBO?*, WONKBLOG, WASH. POST (July 28, 2011, 7:00 AM), http://www.washingtonpost.com/blogs/wonkblog/post/why-does-anyone-trust-the-cbo/2011/07/27/gIQARUVfeI_blog.html (explaining how the CBO influences the legislative process by analyzing effects on various budgets).

317. 31 U.S.C. § 1105(a)(16) (2006).

318. *See* STAFF OF THE JOINT COMM. ON TAXATION, JCX-15-11, BACKGROUND INFORMATION ON TAX EXPENDITURE ANALYSIS AND HISTORICAL SURVEY OF TAX EXPENDITURE ESTIMATES 18–25 (2011) (reporting persistent growth in the number and value of tax expenditures in four-year periods from 1975 to 2014).

property rights expansions than to organize opposing interests against expansion.[319]

Even so, we are currently seeing the emergence of a well-organized lobby whose members oppose the expansion of patent rights.[320] Most prominently, Google executives have argued publicly that patents operate increasingly as obstacles rather than incentives for innovators.[321] Facebook—likewise a target of patent infringement claims[322]—has also joined efforts to limit the reach of patent law.[323] Admittedly, the interests on the other side of the debate may be just as powerful.[324] But whereas incumbents historically have used patent rights to preserve market dominance,[325] we now see market-dominant firms deploying their vast resources to lobby legislators for changes to intellectual property laws.[326]

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319. WILLIAM M. LANDES & RICHARD A. POSNER, THE POLITICAL ECONOMY OF INTELLECTUAL PROPERTY 14 (2004).

320. Landes and Posner acknowledge that political economy considerations do not weigh exclusively in favor of stronger intellectual property protections. *See id.* at 15 ("Tugging the other way . . . is that most creators of intellectual property use intellectual property created by others as inputs into the creation of their own intellectual property.").

321. *See* Declan McCullagh, *Google: Time To Ditch Our Current Software Patent System?*, CNET (Aug. 20, 2012, 1:31 PM), http://news.cnet.com/8301-13578_3-57496747-38/google-time-to-ditch-our-current-software-patent-system (interviewing Google's public policy director, who commented that software patent wars are "not helpful to innovation").

322. *See* Joe Mullin, *Before Facebook There Was "Surfbook"—Now Pay Up*, ARSTECHNICA (Feb. 7, 2013, 5:45 PM), http://arstechnica.com/tech-policy/2013/02/before-facebook-there-was-surfbook-now-pay-up (describing two patent infringement suits brought against Facebook).

323. *See* Mike Isaac, *Facebook, Google and Others Rally Against Sweeping Claims in Financial Patent Case*, ALL THINGS D (Dec. 9, 2012, 11:36 AM), http://allthingsd.com/20121209/facebook-google-and-others-rally-against-sweeping-claims-in-financial-patent-case (describing an amicus brief filed by Facebook and others arguing for the limitation of wide-ranging patent claims).

324. *See* Jay P. Kesan & Andres A. Gallo, *The Political Economy of the Patent System*, 87 N.C. L. REV. 1341, 1353, 1359–61 (2009) (showing that pharmaceutical companies spend more money on lobbying than any other industry, much of which is devoted to maintaining a strong patent system); Susan Decker, *Microsoft Joins Oracle as Computing Companies Fight Patent Suits*, BLOOMBERG (Feb. 21, 2013), http://www.bloomberg.com/news/2013-02-21/microsoft-joins-oracle-to-defend-software-patents-against-google.html (noting the concerns of Microsoft and Oracle over calls to weaken patent protection laws).

325. *See, e.g.*, Hayley Chouinard & David I. Rosenbaum, *Alcoa and the U.S. Aluminum Industry*, *in* MARKET DOMINANCE: HOW FIRMS GAIN, HOLD, OR LOSE IT AND THE IMPACT ON ECONOMIC PERFORMANCE 55 (David I. Rosenbaum ed., 1998) (telling the history of the Aluminum Company of America which owed its decades-long industry dominance in part to a patent-granted monopoly).

326. *See, e.g.*, Jennifer Martinez, *Facebook Escalates Lobbying Spending*, THE HILL: HILLICON VALLEY (Apr. 23, 2013, 6:07 PM), http://thehill.com/blogs/hillicon-valley/technology/295579-facebook-escalates-lobbying-spending (noting that both Facebook and Google spend millions in lobbying efforts that are aimed in part at patent reform); T.C. Sottek, *Google Joins the Lobbying Elite with Record Spending on Lawmakers in 2012*, THE VERGE (Apr. 23, 2012, 3:25 PM), http://www.theverge.com/2012/4/23/2968686/google-joins-lobbying-elite (stating that Google has become one of the largest lobbies in Washington by total spending).

In short, innovation policy reform remains an uphill battle, but powerful forces are giving it a boost.

B. Tailoring Innovation Policy

Assuming innovation policy reform is at least plausible, then what would optimal innovation policy look like? Our framework does not provide easy answers: the optimal mix of incentive mechanisms will vary with changing technologies.[327] But our framework at least identifies the considerations that ought to guide this choice. In this subpart, we describe the circumstances under which each of the four main innovation policy tools will be optimal, and we suggest specific technological contexts that appear to meet these criteria. We also suggest contexts in which different tools can be fruitfully combined.

First, 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. Moreover, since grants are government-set *ex ante* transfers that are typically funded out of general revenues, the case for grants is strongest 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. For example, grants may be the optimal mechanism for funding space exploration. Due to NASA's vast institutional knowledge,[328] the government likely has an informational advantage over private markets in this field. Space exploration is extraordinarily capital-intensive, and researchers are unlikely to find private-sector financing.[329] The potential social benefits—including the detection and deflection of asteroids that would otherwise collide with Earth[330]—are classic public goods that are difficult to finance through market mechanisms. Moreover, even the most ardent libertarians generally

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327. Several scholars have suggested that the shift to an information economy has decreased the efficiency of patents relative to other innovation incentives. *See, e.g.*, BENKLER, WEALTH OF NETWORKS, *supra* note 207, at 56–58; Saul Levmore, *The Impending iPrize Revolution in Intellectual Property Law*, 93 B.U. L. REV. 139, 140 (2013).

328. *See A Brief History of NASA*, NASA, http://history.nasa.gov/factsheet.htm.

329. In contrast, private "'space tourism' . . . could become a billion-dollar market" by 2026. FED. AVIATION ADMIN., THE ECONOMIC IMPACT OF COMMERCIAL SPACE TRANSPORTATION ON THE U.S. ECONOMY IN 2009, at 7 (2010).

330. *See New NASA Mission To Help Us Better Understand Asteroid Impact Hazard*, NASA (Feb. 7, 2013), http://www.nasa.gov/topics/solarsystem/features/osiris-rex-security.html.

agree that planetary defense is an appropriate government function[331] (although this view is not universally shared).[332]

Second, 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*. One type of research problem that fits this description is a specific mathematical or algorithmic challenge. For example, determining the optimal control algorithm for electrical power grid operations is extremely difficult, especially with the rise of distributed renewable energy sources.[333] The government could offer a prize for a desired algorithmic improvement under a specific set of constraints, with a prize size based on the benefit of that improvement as applied to U.S. power grids. Working on this project does not require significant capital investments, so the prize incentive will not be significantly dulled by the *ex post* nature of the reward. And because almost all taxpayers use electrical power and thus benefit from more efficient grid operations, financing this research through tax revenue would not necessarily entail cross-subsidization of users by nonusers.

Patents, like prizes, 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. But patents are superior to prizes of a fixed size where the government is ill-suited to pick winners and losers and where market signals provide reliable proxies for social benefits. Patents also may be optimal when their user-pays feature is distributionally preferable. For example, patents may be the most preferable tool for incentivizing the production of "lifestyle" drugs such as Viagra or baldness treatments.[334] While the clinical trials necessary for

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331. *See, e.g.*, DAVID D. FRIEDMAN, THE MACHINERY OF FREEDOM: GUIDE TO RADICAL CAPITALISM 175–76 (1989) (asserting that the avoidance of an asteroid strike is "also of great value").

332. *See* Justin Raimondo, *Government and the Killer Asteroid*, THE FREE MKT. (July 1998) http://mises.org/freemarket_detail.aspx?control=72 (expressing skepticism about the effectiveness of government management in an asteroid-collision scenario); Sasha Volokh, *Asteroid Defense and Libertarianism*, VOLOKH CONSPIRACY (Feb. 15, 2011, 10:17 AM), http://www.volokh.com/2011/02/15/asteroid-defense-and-libertarianism ("[T]here's a good case to be made that taxing people to protect the Earth from an asteroid, while within Congress's powers, is an illegitimate function of government from a moral perspective.").

333. *See* Albert Y.S. Lam et al., *Distributed Algorithms for Optimal Power Flow Problem*, 51 IEEE CONF. ON DECISION & CONTROL 430, 430 (2012) (discussing the complexities of optimal power flow and power generation).

334. *See generally* Tim Atkinson, *Lifestyle Drug Market Booming*, 8 NATURE MED. 909 (2002) (reporting on the growing market for drugs for weight loss, impotence, smoking cessation, and hair restoration).

FDA approval are extremely costly,[335] they are generally carried out by large pharmaceutical firms that can self-finance the trials using cash reserves. And we anticipate that many readers will share the intuition that nonusers of lifestyle drugs ought not be compelled to subsidize users.

Patents might also be optimal in technology fields populated by many very early-stage start-ups—for innovators such as William Hewlett and David Packard, who famously began operations in a Palo Alto garage (albeit with resources from larger laboratories nearby).[336] New unforeseen products cannot be achieved with government-chosen prizes for discrete goals. And while refundable research tax credits could help cash-strapped start-ups manage research costs, it is very difficult to calculate costs for garage entrepreneurs whose main costs are their forgone wages from lost labor market opportunities.[337]

Finally, R&D tax credits, like patents, are most effective when the government is at a comparative disadvantage in evaluating potential projects and where market signals (such as the returns from first-mover advantage) are reliable proxies for a product's social benefits. And tax credits may be more effective than *ex post* rewards when researchers face a high risk of failure and where capital constraints are binding. Tax credits may also be more effective than patents for products that combine many cumulative innovations so that the transaction costs of the patent system are high. The field of battery technology may meet these criteria. Current lithium-ion technologies are insufficient for practical electric cars or for large-scale storage of renewable energy.[338] Unlike the space exploration example (where NASA enjoys reservoirs of institutional knowledge), government agencies do not have an obvious informational advantage over

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335. *See* Lisa Larrimore Ouellette, Note, *How Many Patents Does It Take To Make A Drug? Follow-on Pharmaceutical Patents and University Licensing*, 17 MICH. TELECOMM. & TECH. L. REV. 299, 302 & nn.10–12 (2010) (noting that estimates of the cost per drug range from $100 million to $1.3 billion).

336. *See generally* Pino G. Audia & Christopher I. Rider, *A Garage and an Idea: What More Does an Entrepreneur Need*, 48 CAL. MGMT. REV. 6, 14–16 (2005) (describing the founding of Hewlett-Packard). The extent to which lone inventors produce significant innovations is contested. *See id.* at 7 (arguing that the "garage entrepreneur" is a contemporary legend that obscures the industry support such entrepreneurs typically have); Eric D. Isaacs, *Forget About the Mythical Lone Inventor in the Garage*, SLATE (May 18, 2012), http://www.slate.com/articles/technology/future_tense/2012/05/argonne_national_lab_director_on_the_myth_of_the_lone_inventor_in_the_garage.html (contending that the popular image of the lone garage inventor is inaccurate and harmful to public support for scientific innovation).

337. *See supra* notes 159–62 (describing how research tax credits could be made more useful for start-ups without income).

338. *See* Michael M. Thackeray et al., *Electrical Energy Storage for Transportation—Approaching the Limits of, and Going Beyond, Lithium-Ion Batteries*, 5 ENERGY & ENVTL. SCI. 7854, 7854 (2012) (explaining that "[e]nergy densities 2 [to] 5 times greater [than today's lithium-ion batteries] are required to meet the performance goals of a future generation of plug-in hybrid-electric vehicles").

the private sector in the battery technology field. Moreover, it is unclear whether the transformative technology will be lithium-air or magnesium-tin or something completely different, and the $2.4 billion the Obama administration invested in twenty-nine private firms has proven unsuccessful.[339] Given the tacit knowledge involved in battery manufacturing, the first firm to succeed would likely enjoy a significant first-mover advantage. And given the high risk and speculative future payoff, the *ex ante* reward of a tax credit may have a larger incentive effect than patents for small firms.

This kind of field-specific evaluation of different innovation policy tools is not without precedent: Congress has already identified certain technological contexts with insufficient R&D incentives. Consider the example we began with in subpart I(A): incentivizing a pharmaceutical company to develop a cure for a rare disease.[340] Until the early 1980s, efforts to develop drugs to treat rare diseases proceeded at a sluggish pace: the U.S. pharmaceutical industry brought only ten such drugs to market between 1973 and 1983.[341] For victims of rare diseases such as Tourette's syndrome and Huntington's disease, the slow pace of progress was infuriating.[342] At a series of high-profile hearings in the early 1980s, members of Congress heard heartbreaking testimony from rare disease victims—as well as their doctors and caregivers—who emphasized that existing financial incentives were woefully insufficient to spark development of drugs that addressed these conditions.[343]

Even with the patent system's current political economy advantage, Congress recognized that there are other options in its innovation policy toolkit. At the end of 1982, Congress passed the Orphan Drug Act,[344]

339. *See The Search for a Better Battery*, THE WEEK (May 5, 2013) http://theweek.com/article/index/243576/the-search-for-a-better-battery (stating that many of those twenty-nine firms "have struggled financially because they haven't made progress they can bring to the market").

340. Rare diseases are those that affect fewer than 200,000 Americans, and despite their name, they are actually quite common: nearly 7,000 such diseases affect almost one in ten people in the country. *Rare Disease Information*, NAT'L ORG. FOR RARE DISORDERS, http://www.rarediseases.org/rare-disease-information.

341. *Developing Products for Rare Diseases & Conditions*, U.S. FOOD & DRUG ADMIN., http://www.fda.gov/ForIndustry/DevelopingProductsforRareDiseasesConditions/default.htm (last updated Oct. 30, 2013).

342. *See* HENRY WAXMAN WITH JOSHUA GREEN, THE WAXMAN REPORT: HOW CONGRESS REALLY WORKS 53–54 (2009) (illustrating how the United States lags behind in developing treatments for orphan diseases whose drugs lack a sufficient profit potential for pharmaceutical companies to invest).

343. *See* H.R. REP. NO. 97-840, pt. 1, at 5–7 (1982) ("[T]his country's system of financing and conducting biomedical research and for discovering and developing new drugs does not adequately account for the inherent disincentives in orphan drug development.").

344. Pub. L. No. 97-414, 96 Stat. 2049 (1983); *see also* WAXMAN WITH GREEN, *supra* note 342, at 53–73 (narrating the story behind the creation of the Orphan Drug Act).

which took three different approaches to increasing innovation incentives. First, the Act increased government grants for orphan drug development.[345] Second, the Act ensured that new orphan drugs would enjoy at least seven years of market exclusivity (i.e., a patent-like reward), even if fewer than seven years were left on the life of the corresponding patents by the time that the company brought the drug to market.[346] Third, the Act allowed pharmaceutical companies to claim a tax credit for 50% of their clinical testing expenses for drugs designed to treat rare diseases.[347] The results were dramatic. In the first twenty-five years after passage of the Act, the development of drugs to treat rare diseases accelerated at a remarkable rate: 326 new drugs were approved for rare diseases, a thirteen-fold increase over the prior decade's pace.[348]

But why this particular mix of innovation policies? Would either tax credits or patent-like exclusivity alone have been more effective than the combination? Why not provide prizes for demonstrating improved efficacy in treating a rare disease? Studies of the Orphan Drug Act have not attempted to answer these questions,[349] but we can now begin to tease out these distinctions. Both grants and tax credits help reduce the high capital cost of pharmaceutical R&D, allowing smaller firms and university researchers to be more involved in the search for new orphan drugs. By deploying both forms of *ex ante* incentives, the government can use what information it has about the most promising research paths while still eliciting private information about the many drug candidates for the large number of rare diseases.

Combining these *ex ante* rewards with a seven-year period of patent-like exclusivity is also synergistic. A tax credit alone would be ineffective because small-molecule drugs are relatively easy to replicate, meaning that

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345. Orphan Drug Act, § 5, 96 Stat. at 2056–57.

346. *Id.* § 2, 96 Stat. at 2049–51. A pharmaceutical company will generally seek patent protection for a new drug long before completing the clinical trials that are required to obtain FDA approval. Thus, there may be fewer than seven years left on the life of the patent by the time the drug comes to market (and in the extreme, it may mean that the patent has already expired). *See* Budish et al., *supra* note 132, at 8.

347. Orphan Drug Act § 4, 96 Stat. at 2053–56.

348. M. Miles Braun et al., *Emergence of Orphan Drugs in the United States: A Quantitative Assessment of the First 25 Years*, 9 NATURE REVS. DRUG DISCOVERY 519, 522 (2010) (reporting 326 drug approvals in the twenty-five years after the Act in comparison to ten drug approvals in the ten years prior to the Act).

349. *See, e.g.*, Michael Abramowicz, *Orphan Business Models: Toward a New Form of Intellectual Property*, 124 HARV. L. REV. 1362 (2011) (discussing the seven-year exclusivity but not the tax or grant provisions); Wesley Yin, *Market Incentives and Pharmaceutical Innovation*, 27 J. HEALTH ECON. 1060 (2008) (analyzing the Act's effects without attempting to disentangle the different incentives).

the first-mover advantage is small.[350] The exclusivity provision effectively creates a first-mover advantage, allowing the tax credit to be more effective. In the context of technologies with significant capital constraints and low first-mover advantage, patents and tax credits can thus work together to provide a combined incentive that is likely more effective than either alone. Similarly, grants alone would be ineffective unless the government covered most of the cost of clinical trials, and it is far from clear that government agencies have the institutional competence to manage clinical trial programs.[351] By allowing the drug candidates identified with grant-funded research to also receive a period of market exclusivity, the Orphan Drug Act incentivizes pharmaceutical companies to conduct these costly clinical trials. Finally, while the user-pays aspect of patents may be objectionable with respect to many medical treatments for life-threatening conditions, in practice the cost of orphan drug treatments is largely spread to nonusers through insurance.[352]

While the precise optimal balance of innovation policies is difficult to determine (Would eight years of exclusivity have been better? Or a 60% tax credit?), the Orphan Drug Act's pluralistic approach appears to effectively combine the features of grants, tax credits, and patents for incentivizing new drugs to treat rare diseases. But this does not mean that the different policy tools should *always* be combined. Where one tool alone provides efficient incentives, adding an additional tool will *over*-incentivize innovation, wastefully directing resources from more valuable projects and creating unnecessary deadweight loss.[353] For example, although the Bayh-Dole Act allows the results of research funded by federal grants to be patented and exclusively licensed by the grant recipient, this additional patent incentive is often unnecessary to incentivize commercialization.[354]

Of course, determining *which* policymakers should make these judgments raises a host of issues—including questions of institutional

350. *See* Ouellette, *supra* note 335, at 302 ("After one pharmaceutical company has undertaken the expense of discovering a drug and proving its efficacy and safety through clinical trials, it is comparatively inexpensive for a generic company to enter the market . . . .").

351. *Cf.* Roin, *supra* note 132, at 553–55 (arguing that the few publicly funded clinical trials are "slow to influence physician practices" due to poor marketing).

352. *See supra* note 191.

353. *See supra* notes 130, 251–52 and accompanying text.

354. *See* Lisa Larrimore Ouellette, Comment, *Addressing the Green Patent Global Deadlock Through Bayh-Dole Reform*, 119 YALE L.J. 1727, 1731 (2010) (emphasizing instead "a lower ratio of regulatory barriers to imitation costs, the cumulative nature of innovation, and [nonpatent] methods of obtaining competitive advantage" (footnotes omitted)); Lisa Larrimore Ouellette, *When Should Universities Patent?*, WRITTEN DESCRIPTION (Feb. 15, 2013), http://writtendescription.blogspot.com/2013/02/when-should-universities-patent.html.

competence—that we have not addressed.[355] And determining the optimal innovation policy for different technological contexts on a case-by-case basis is itself costly and subject to its own hazards. Case-by-case determinations, for instance, may open up more opportunities for rent-seeking by powerful interest groups. But as we have explained, the patent-dominated status quo is not the only innovation policy that avoids case-by-case determinations: a similar one-size-fits-all policy could be achieved by weakening the patent system and adding additional incentives through patent boxes, market-based prizes, or stronger tax credits. When the true costs of the patent system are taken into account, these alternatives might seem very attractive.

Conclusion

Thus far, the patents-versus-prizes-versus-grants debate has generated useful insights regarding innovation policy choices. For instance, the patent system aggregates privately held information regarding the private costs and benefits of potential projects. Meanwhile, prizes and grants channel R&D efforts toward innovations that yield limited profits in the marketplace but significant benefits for society. Prizes and grants also avoid the deadweight losses associated with patent monopolies, although they correspondingly entail cross-subsidization of product users by nonusers. Finally, grants—unlike patents and prizes—deliver *ex ante* transfers and thus reduce the social costs of capital market frictions.

However, by truncating the menu of policy options, the framing of the debate has led participants to overlook the potential benefits of tax incentives for innovation. For example, we show that even when market actors have superior information regarding R&D projects than government officials do, patents are not the only mechanism for aggregating this privately held information and allocating R&D expenditures accordingly: tax credits can achieve similar outcomes. Alternately, even if one believes that *ex ante* incentives are superior to *ex post* rewards because of capital market frictions, this belief does not necessarily suggest that government grants are the best option: refundable tax credits can replicate many of the advantages of government grants. And even if one favors user-pays

355. For thorough comparisons of different innovation policy institutions, see Stuart Minor Benjamin & Arti K. Rai, *Fixing Innovation Policy: A Structural Perspective*, 77 GEO. WASH. L. REV. 1, 14, 32–45 (2008); Mahaffy, *supra* note 11, manuscript at 23–28. *See generally* Golden, *supra* note 301. Note that capture may be a more significant problem for nonpatent incentives: Judge Posner has noted that the "asymmetry of interests" between IP owners and infringers helps "explain[] the expansion of intellectual property rights," Posner, *supra* note 15, at 72, but this asymmetry may be less stark for patents than for tax credits, grants, and prizes, since the expansion of patent rights may impose costs on concentrated private interests whereas tax credits, grants, and prizes are typically funded through general tax revenues.

systems over cross-subsidization, this preference does not necessarily require adoption of the patent mechanism: targeted sales taxes funding grants, prizes, or credits can mimic the user-pays features of patent law.

This last dimension of the innovation policy debate—the distribution of costs—is all too often overlooked, and while we do not provide an exhaustive treatment of the moral and ethical issues associated with user-pays and cross-subsidization systems, we provide a preliminary analysis of the normative considerations that ought to inform innovation policy choices. Moreover, although our Article provides only a broad overview of the obstacles to innovation policy reform arising out of international treaties and domestic political configurations, we believe that this overview reveals that the obstacles to reform—while considerable—are not insurmountable.

Ultimately, we do not argue that one innovation policy option strictly dominates the others in all instances. To the contrary, we sketch out the case for innovation policy pluralism—with patents, prizes, grants, and tax incentives all playing a role in efforts to encourage research and development. With a more nuanced understanding of the similarities and differences among patents, prizes, grants, and tax credits, scholars and policymakers will be better positioned to imagine new combinations of innovation incentives that improve upon the status quo.