

Prizes or Patents for Technology Procurement

*An Assessment and Analytical
Framework*

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Abstract

Policy and entrepreneurial communities are increasingly promoting innovation by using prizes but their distinguishing features remain inadequately understood. Models of patents treat winning a patent as winning a prize; other models distinguish prizes primarily as public lump-sum (re)purchase of a patent. We examine advantages of prizes based on the ability to customize rewards, manage competition, generate publicity, and cover achievements otherwise not patentable. We compare prizes to patents using a model based first on whether the procuring party knows its needs and technology, its needs but not its technology, or neither. The second factor is the risk that the investment in research will prove profitable, where the greater the risk, the more the procuring party should share in it through ex ante cost coverage or payment commitment. The model suggests a framework that may be extended to cover other means of technology inducement, including grants, customized procurement, and off-the-shelf purchase.

Key Words: prizes, procurement, contracts, patents, public sector, technological change, innovation, productivity

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Contents

1. Introduction.....	1
2. A Partial Snapshot of Contemporary Prizes	5
3. Prizes Are Not Patent Buyouts	9
4. Idiosyncratic Advantages of Prizes	13
Publicity	13
Reward Flexibility	14
Payment Precommitment	15
Contestant Management.....	16
Learning from Failure	16
Nonpatentability.....	17
Enforcement Differences	18
5. The Model	19
6. The Matrix.....	25
7. Conclusions.....	27
References	28

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“She said she later found a note he’d written about the award, which he was pleased to learn was officially called a prize. Because? ‘Because,’ said Kelly, with perfect Carlinesque timing, ‘because he said an award is what grown-ups win. A prize is something a kid wins.’”

—The Washington Post, quoting Kelly Carlin on the Twain Prize for American Humor awarded posthumously to her father, George (Farhi 2008)

1. Introduction

Policy and entrepreneurial communities are increasingly using prizes as means to promote innovation, particularly innovations to achieve specific outcomes.¹ Among the most publicized prizes in recent years was the \$10 million Ansari X Prize, an international competition for building a craft that could fly a person into suborbital flight (100 kilometers altitude) twice within two weeks.² Another was the \$1 million prize awarded by Netflix in 2009 for improving by 10 percent the accuracy of its system for recommending films to its customers.³

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¹ Prizes of this sort are sometimes referred to specifically as “innovation inducement prizes,” to distinguish them from prizes given not for achieving prespecified objectives but for achievements judged worthy after the fact, such as Nobel Prizes for scientific or literary achievement or Academy Awards for films.

² X Prize Foundation, “Ansari X Prize,” <http://space.xprize.org/ansari-x-prize>, accessed March 26, 2011.

³ Viewer enjoyment predictions are based on prior ratings of the film in question and other films the rating customers had viewed. The Netflix Prize Rules, <http://www.netflixprize.com/rules>, accessed March 17, 2011.

In 2010, three teams from around the world won the \$10 million Progressive Insurance Automotive X Prize for constructing cars that “achieved 100 miles per gallon in real-world driving.”⁴ The X Prize Foundation also is running a number of other prizes involving genome sequencing, oil spill recovery, and lunar robots.⁵

Interest in offering prizes goes beyond the private sector. For example, in 2006, the US Congress passed legislation requiring that the National Science Foundation (NSF) create a program of prizes to induce innovations.⁶ In response, a National Research Council (NRC) committee proposed that NSF start with “small-scale” prizes of \$200,000–\$2 million and begin planning for prizes up to \$30 million (NRC 2007, 3). The Obama administration has created a website, challenge.gov, to list and promote the use of prizes throughout the federal government. The National Aeronautics and Space Administration (NASA) has a number of prize competitions with awards of \$1-2 million for advances in aircraft, spacecraft, and related technologies.⁷ The US Department of Energy (DOE) has offered prizes for innovation in hydrogen energy and energy efficient lighting.⁸

Interest in prizes is also international in scope, going back to the earliest prominent examples.⁹ In 1714, the British government offered cash prizes for the development of clocks sufficiently precise to facilitate navigation over the oceans. The French government in the 18th century offered 100,000 francs to the first person who could extract soda from sea salt.¹⁰ More

⁴ Progressive Insurance Automotive X Prize, <http://www.progressiveautoxprize.org/prize-details>, accessed March 17, 2011.

⁵ “Archon Genomics X Prize,” <http://genomics.xprize.org/archon-x-prize-for-genomics/prize-overview>, accessed Mar. 17, 2011; “Wendy Schmidt Oil Cleanup X Challenge,” <http://www.iprizecleanoceans.org/Page/Home>, accessed March 17, 2011; “Google Lunar X Prize,” <http://www.googlelunarxprize.org/lunar/about-the-prize>, accessed March 17, 2011.

⁶ Science, State, Justice, Commerce and Related Agencies Appropriations Act (Public Law 109-108).

⁷ “All Federal Government Challenges,” <http://challenge.gov/search?order=prize>, accessed March 17, 2011.

⁸ Department of Energy, “L Prize Competition Overview,” <http://www.lightingprize.org/overview.stm>, accessed March 17, 2011.

⁹ Interest in prizes is not novel. Reviews of the history of prizes include Adler (2011, 19-28), X-Prize Foundation, “Incentivized Competition Heritage,” <http://www.xprize.org/x-prizes/incentivized-competition-heritage>, accessed March 18, 2011, and Knowledge Ecology International (2008). Macauley (2005) details the use of prizes offered by the public and private sectors in the early history of automobiles, aviation, and rocketry.

¹⁰ X-Prize Foundation, “Incentivized Competition Heritage,” <http://www.xprize.org/x-prizes/incentivized-competition-heritage>, accessed March 18, 2011.

recently, Nesta, an independent organization formerly financed from revenues from the United Kingdom's National Lottery, has established prize competitions for a host of innovations in health, environmental management, and other activities.¹¹ The British National Health Service has also instituted a set of "Innovation Challenge Prizes" for treatments of diabetes, stroke, and dementia.¹² Section 2 provides a snapshot of the prize universe.

All of this attention invites the question of why one should use prizes when there are other means to encourage innovation. Most notable is the patent, which in the United States entails a government grant of the exclusive right to produce a sufficiently novel and nonobvious product or process, generally for 20 years from the filing date.¹³ Private parties or government agencies could also induce innovation through off-the-shelf procurement or purchase through contract. Increased demand for solutions to particular needs should influence supply of innovations through the market. Innovation solicitors can also issue requests for proposals in which they fund the research, and such proposals may leave it to the proposers to define the innovation they seek funding to pursue.

Formal analysis of instrument choice has needed an adequate formal framework. Perhaps the most significant indicator of the need for such a framework is that virtually all models of patents treat winning a patent and winning a prize as formally equivalent, making it impossible

¹¹ See <http://www.nesta.org.uk/home1>, accessed September 2, 2012.

¹² NHS Innovation Challenge Prizes, Breakthrough Challenges, <http://www.challengeprizes.institute.nhs.uk/the-challenges>, accessed September 6, 2012.

¹³ 35 U.S.C. 102, 103 154(a)(2). Our legal reference point here is US patent law. Our legal reference point here is US patent law. Our sense is that EU patent law, while differing in some respects regarding rights of users prior to the patent, is largely similar in respects pertinent here (Philippidis 2012). One possible exception is the set of criteria for patentability (RSW 2002; Philippidis 2012); we discuss this below at n. 37 in looking at non-patentability as a justification for prizes.

Until recently, the most significant difference between US and other legal regimes was that under US law, a patent would go to the first inventor, not the first person to file for a patent, so the person who files has to make a case that the proposed invention was not known beforehand. The "America Invents Act," enacted in September 2011, includes a proviso that, starting in March, 2013, the first inventor to file will win in the event of a conflict, but that obtaining a patent will still require a showing that one's work is not covered by prior art, not just in the United States, but around the world (Richards 2011).

The term of a patent may be extended to take into account regulatory review, particularly for pharmaceuticals. 35 U.S.C. 155, 156. The term of a design patent is fourteen years. 35 U.S.C. 173. Scotchmer (2004) and Encaoua et al. (2006) provide useful summaries of the economics of patents and innovation; the latter discuss the possibility that neither patents nor prizes are necessary to reward innovation unless reverse engineering or copying is particularly easy.

to distinguish reasons for choosing one over the other. In these models, winning a patent is equivalent to winning a prize equal to the expected discounted present value of the profits flowing from the patent (Scotchmer 2004, 98–123). Rogerson (1989) characterizes profit from cost-plus defense contracting as an innovation-inducing prize, but it is not a lump sum; the rewards are akin to what would be obtained under a patent for the defense-related innovation were there a market for it.

Most of the analyses distinguishing patents and prizes builds on a theme put forth in Wright (1983), in which the reward to innovators in a patent comes from the ability to charge a price over marginal cost for each use of the process or unit of the product, while a prize is a lump-sum payment that does not induce the same marginal distortions. In our view, the experience with and policy advocacy for prizes indicates that their current use has little if anything to do with the patent-buyout rationale prevalent in the literature. Section 3 presents problems with designing and implementing a patent-buyout scheme and interpreting prizes as such in light of how they are designed and implemented. This leads to a discussion in Section 4 of what may be called idiosyncratic arguments for prizes, exemplified (not facetiously) by George Carlin’s reported observation regarding the Mark Twain Prize.

We call these explanations for prizes “idiosyncratic” not because they are unimportant, but because they do not fit within the model we propose in Section 5 to compare prizes with patents. Our model is designed to illustrate the importance of two dimensions in that comparison. The first is the degree to which the procuring party knows what it wants: it may know its needs and technology, its needs but not its technology, or neither. The second dimension is the risk that the investment in research will prove profitable, where the greater the risk, the more the procuring party should share in it through ex ante payments. Patents are more likely to be appropriate instruments when needs are not known but when potential innovators are the most efficient bearers of risk, while prizes are likely to be better when the needs can be specified, necessary or preferred technological solutions are not known, and the procuring party needs to share the risk by guaranteeing a minimum return to the first successful innovator.

Building on our model that illustrates the importance of risk spreading and ex ante knowledge of which innovation is desired in identifying whether patents or prizes would lead to more desirable innovations, we describe in Section 6 a general innovation procurement matrix based on these two dimensions. That matrix suggests conditions for when other means of procuring innovations—research grants, contracts, or off-the-shelf purchases—might be preferable. The model and matrix should facilitate not only theoretical advances in understanding

innovation instrument choice, but also empirical tests of the comparative effectiveness of these instruments in different information settings. Section 7 summarizes and concludes.

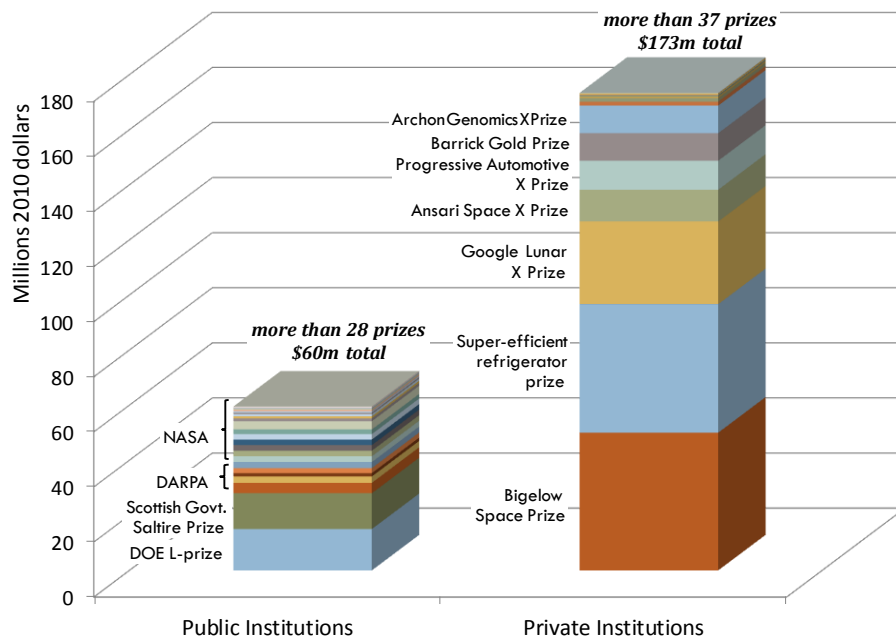
2. A Partial Snapshot of Contemporary Prizes

To get a sense of what and how prizes have been implemented, we gathered data from McKinsey (2009), Knowledge Ecology International (2008), and InnoCentive (2010). These datasets provided the title of the prize, the amount of the prize purse, and a brief description of the objective. Prizes that did not aim to induce an innovation—for example, those that reward lifetime achievements and do not have a specific goal in mind—were removed from the data.¹⁴ This left us with a total of 66 prizes, sponsored by a variety of public and private institutions (Figure 1).

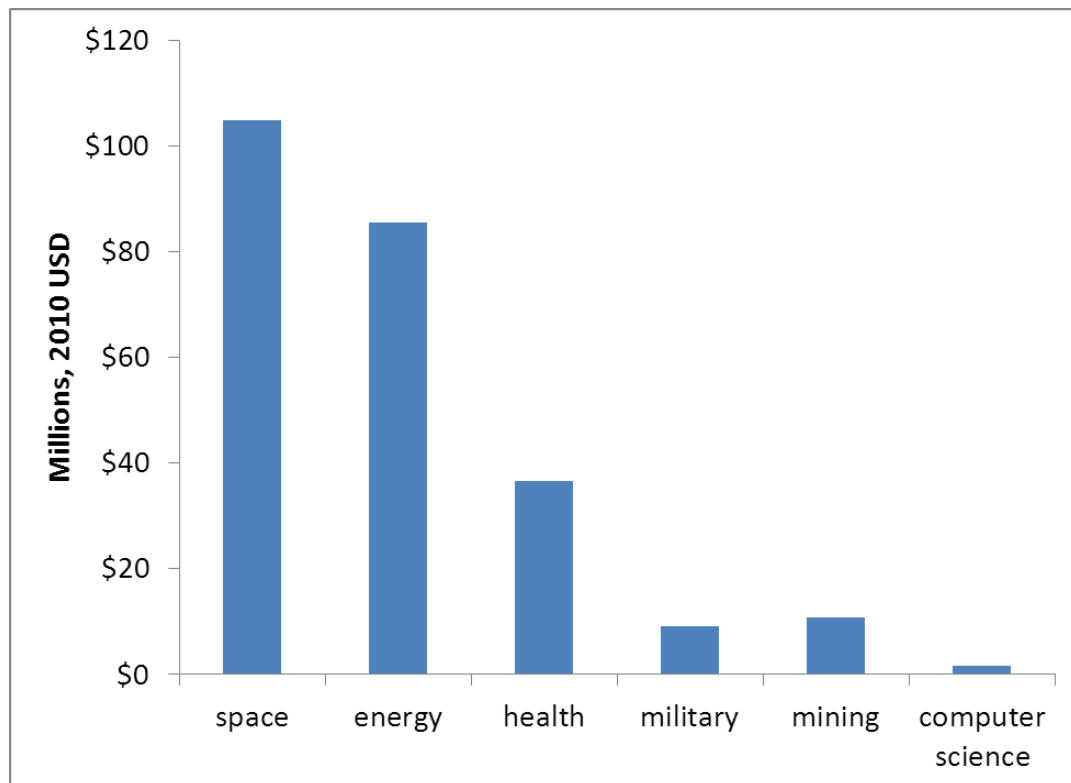
At the outset, we want to be clear that these data need not represent what the prize universe has been or, more importantly, will be. This is only a snapshot. Among other things, a public or private donor offering a prize in the tens or hundreds of millions of dollars to pursue a particular goal could alone change the mix of prizes along the public-private dimension or across various subject areas. We provide these only to illustrate prize sponsorship, the breadth of activities they have been supporting, and whether prize winners get to keep the intellectual property generated by their innovative effort.

¹⁴ For instance, the Blue Planet prize, which awards “outstanding achievements in the social sciences, natural sciences or technologies and their applications in solving global environmental problems” (Asahi Glass Foundation 2010), is not included because of its broad objective and history of awarding research occurring over the large part of a career. On the other hand, the Progressive Automotive X Prize is included because the objective “to win a long-distance stage race for clean, production-capable vehicles that exceed 100 miles-per-gallon energy equivalent” (X Prize Foundation 2009) is more likely to entice researchers to pursue the solution in order to win the prize.

Figure 1. Prize Purse Categorized by Whether the Primary Sponsor Was a Public or Private Institution



We supplemented this data set with information from the prize organizers' websites and news articles discussing the prizes. Information collected from these sources includes the number and amount of prizes awarded (which we converted to thousands of 2010 dollars) and the competition deadline. The terms of any intellectual property transfer or licensing requirements were available for only 41 percent of the prizes. The prizes were also classified into seven subject categories based on the challenge specifications: space, energy, health, military-applications, mining, computer science, and other (Figure 2).

Figure 2. Prize Purses Categorized by the Prize's Subject Areas

Because our focus is on the comparison of patents to prizes, it is useful to see the extent to which prizes either substitute for patents as an innovation inducement—as indicated by transferring rights to the prize sponsor, or complement patents—indicated when the prize winner gets to retain intellectual property, albeit perhaps with a license to the prize sponsor. Table 1 indicates how this works for some major prizes. Note that the “organizer” in the table need not be the sponsor or funder of the prize. It can be a separate institution that manages and implements a prize that a sponsor wants to fund, InnoCentive and the X Foundation being leading examples of organizers that are not themselves sponsors.

Table 1. Intellectual Property Requirements of Selected Prizes

Prize name	Year(s) completed	Organizer(s)	Winner required to transfer IP	Winner required to license IP
Darpa Grand Challenge	2004, 2006	DARPA	No	No
Darpa Urban Challenge	2007	DARPA	No	No
Wearable Power Prize	2008	DARPA	No	No
Apophis Mission	2007	Planetary Society	No	Yes
Astronaut Glove Challenge	2007, 2009	NASA, Volanz Aerospace, Inc.	No	Yes
General Aviation Challenge	2007	NASA, CAFE Foundation	No	Yes
Open Architecture Sportables Challenge	2008	Architecture for Humanity	No	Yes
General Aviation Challenge	2008	NASA, CAFE Foundation	No	Yes
Open Architecture Classroom Challenge	2009	Architecture for Humanity	No	Yes
Lightning Energy Source Prize	2010	InnoCentive	No	Yes
River Turbines Prize	2010	InnoCentive, Rockefeller Foundation, Global Giving	No	Yes
Open Architecture Grand Acres Community Garden Prize	2010	Architecture for Humanity	No	Yes
Small, Green, Affordable Housing Prize	2010	US Green Building Council, Salvation Army	No	Yes
Continuous Flow Reactor Prize	2010	InnoCentive	No	Yes
Open Architecture Community Prize	2010	Architecture for Humanity	No	Yes
Open Architecture Safe Trestles	2010	Architecture for Humanity	No	Yes
Netflix Prize	2011	Netflix	No	Yes
Steel Corrosion Inhibitor Prize	2009	InnoCentive	Yes	—
Zinc Corrosion Inhibitor Prize	2009	InnoCentive	Yes	—
Compressed Cotton Materials	2010	InnoCentive	Yes	—
Sustainable Packaging in Developing World	2010	InnoCentive	Yes	—

As Table 1 illustrates, many prizes do not require winners to transfer their patent rights to the prize sponsor. However, a number of these prizes require the winners to license their IP to the prize sponsor. One possible explanation for offering prizes with subsequent licensing of IP to the sponsor is to facilitate additional revenues when the prize purse does not provide enough of an incentive to pursue the necessary R&D. To the best of our knowledge, the typical transfer is nonexclusive, with fees not publicly available. An exclusive transfer with no fee would mean that the prize is the sole incentive for the innovation. An exclusive transfer with a positive fee would mean that the total prize is essentially the nominal prize plus the expected fee; if the fee is specified in advance, it just becomes part of the prize. It also may be relevant if the transfer (with or without a license fee) is made to a for-profit funder or to a government or nonprofit funder. If the latter, the transfer may be a precursor to free or low cost distribution by the government, making the prize more like a patent buyout. Why patent buyouts are not the same as patents is the subject of the following section.

3. Prizes Are Not Patent Buyouts

As noted above, the leading way to distinguish between patents and prizes is to view a prize as a lump sum buyout of a patent. This approach is particularly attractive to economists concerned with providing drugs in poor countries at very low marginal cost rather than allowing much higher patent-protected prices to make the drugs effectively unavailable (Kremer 1998; Hollis 2008).¹⁵ Shavell and van Ypersele (2001) supported this view, finding that the likely advantage of the patent system in being able to exploit the private information of the innovator regarding value is balanced by the average gain in efficiency from using what they call “rewards,” which in this vein are similar to prizes. Weyl and Tirole (2010) have designed a mechanism combining an allowed fraction of monopoly rents to exploit that private information and an up-front prize to reward innovation to reduce the deadweight losses from monopoly rents. Earlier, Kremer (1998) proposed a prize-like scheme for lump-sum buyouts of patents to avoid wasteful effort by rivals to compete for patent rents.¹⁶ Shavell and van Ypersele (2001, 530–31)

¹⁵ Mowery et al. (2010), citing Newell (2007), suggest that the importance of broad global action to fight climate change similarly justifies making climate-related innovations available at lower prices than innovators might obtain under a patent.

¹⁶ Hopenhayn et al. (2006) proposed a mandatory buyout scheme to reduce distortions the patent system imposes on incentives for successive innovations; see also Encaoua et al. (2006).

found that allowing the innovator to choose between keeping a patent and taking a buyout “unambiguously” dominates using patents alone.

There are four primary reasons why the patent-buyout theory prevalent in the literature does little if anything to explain prizes.¹⁷ First, prizes generally do not require transfer of a patent. When government prizes allow the winning innovators to retain patent rights, removing market distortions of patents is apparently not a leading motivation. Patent buyouts do not seem to be in the interest of the private donors who fund many of the prizes noted in the introduction—the winners of the X Prizes typically do not have to transfer patents to the donors—perhaps with the exception of prizes for vaccines and treatments to prevent the spread of diseases plaguing the poorest parts of the globe.¹⁸ For commercial prizes, such as the Netflix prize, Netflix surely obtains the rights to use any patented processes coming from the search for better methods of predicting movie preferences, but the patent and any attendant monopoly profits do not disappear.

Second, prizes in practice seem to be implemented only in very specific contexts. As Kalil (2006, 20) has noted, they are adopted only in contexts where one can specify precise “victory conditions.” To prevent litigation and bureaucratic abuse, as described by Abramowicz (2003) in his critique of patent buyouts, one needs clear criteria for winning the prize. These criteria can be either the first person or team to meet a specified goal, or the person or team that performs the best by a date certain, where performance can be defined without ambiguity. This emphasizes the informational hurdles in attempting to replace the patent system with a buyout program: patents reward innovation that may never have been imagined, much less amenable to reward estimation, by anyone other than the inventor.

The third reason why the patent-buyout theory does not explain the prevalence of prizes relates to the difficulty of implementing a reward system in place of patents. As alluded to above, the patent-buyout story holds in two circumstances: First, as in Shavell and van Ypersele (2001), the patent system could be preempted by a reward system that provides the inventor with the expected surplus from the invention, where the expectation is taken over the distribution of possible demand curves for a successful invention. Second, as Kremer (1998) and Shavell and

¹⁷ A fifth may be that the private sector offers prizes, while government would purchase patent rights to make a good available to the public at large at marginal cost. Private parties could have similar motivations on charitable grounds, as discussed in the section on idiosyncratic reasons for prizes.

¹⁸ For more on donor-supported prizes, see McKinsey and Co. (2009).

van Ypersele (2001) consider, the government is prepared to purchase the patent at a price at least as great as the profit the patent holder would expect to get from the exclusive right to sell the product or license the process at the profit-maximizing price, presumably above marginal cost.

However, these mechanisms forego the advantages of the patent system in that the effort and reward relies on privately held information regarding expected benefits and costs, as Encaoua et al. (2006) point out and Adler (2011), in an article generally supporting prizes, recognizes. The difficulties with instituting prizes as fixed-price substitutes for patents are akin, and in some ways worse, to the related problems with substituting lump-sum taxes for per unit or ad valorem taxes. For the tax comparison, although lump-sum taxes eliminate the distortions associated with commodity or sales taxes, structuring them so they are revenue equivalent on a per-taxpayer basis requires knowing what the taxpayer would have paid under the relatively inefficient tax structure. If the lump-sum taxes do not take actual payments into account, there will be distributional consequences. If they do, they replicate the distortions they were intended to eliminate.

We can apply this analogy to the choice of public patent buyouts over privately held patents, but with the added wrinkle that a discrepancy between an ex ante reward and an ex post patent value creates its own set of deadweight losses. The problem is not merely distributional. As Wright (1983, 691–92) pointed out in his initial formal analysis of the benefits of patent buyouts:

It is further necessary to specify that the terms of the award must be fixed before this information imbalance [between the patent holder and the government providing the reward] is resolved, if it can ever be economically resolved. Several arguments for this assumption are presented ...; if it does not hold, any rationale presented here for choosing patents over other incentives with lower excess burden collapses.

Shavell and van Ypersele (2001, 535–37), who otherwise largely supporting a reward system, found that a patent system could outperform a reward system because a reward will induce too much investment in low-value patents and too little investment in high value patents.

Abramowicz (2003) notes practical difficulties if the rewards are provided after the innovation takes place. In his view, leaving discretion on the size of the awards to government agencies invites the well-known disparities between political and economic optima associated with bureaucratic discretion. He suggests that the government could take patents with just compensation, but that leaves determination of the prize to courts, where neither certainty nor

expertise may be ensured.¹⁹ He also points out that trying to estimate the value of a patent is problematic because in many cases, a patent is not a product with a particular demand curve but an input used in conjunction with many other patented products. Even for pharmaceuticals, where the patent protects a specific product, Wei (2007) points out that estimating a demand curve in advance to figure out the right prize will be difficult.

A useful analogy may be a fixed-payment system substitute for copyright. In theory, making information available at its marginal cost, essentially zero, increases its distribution throughout society with perhaps a variety of noneconomic benefits, as well as efficiency gains. However, having an agency or court decide which authors, filmmakers, and songwriters should get funded seems a process likely to be fraught with error. The similar advantage of patents over a buyout system or prizes is that intellectual property is largely content neutral; other than the market, one does not have a gatekeeper deciding which projects merit funding and which do not. The example of copyright supports another observation by Wei (2007) that a patent buyout reduces the incentive to expand the market for the patent after the reward or prize has been received, although Hollis (2008) addresses this issue through disbursing the prize on the basis of quantity supplied.²⁰

Fourth and most fundamentally, the argument for looking at prizes as a form of patent buyout rest on the assumption that a patent buyout, if perfectly implemented, is distortion free. All these arguments ignore the distortions in the taxes necessary to generate the revenues needed to fund these patent buyouts. In some circumstances they may be less distortionary than patent markups, but this is not obviously the case, particularly given preexisting distortions in the economy and the size of taxes needed to reproduce the rewards provided by the patent system.²¹ Moreover, as Wei (2007) and Kremer (1998) exemplify, much of the interest in patent buyouts

¹⁹ Still, attracted by the elimination of deadweight losses in an ideal patent-buyout system, Abramowicz (2003) proposes to deal with bureaucratic efficiency by having Congress appropriate funds for this purpose and set up an agency that would not go into effect for 10 years. Abramowicz suggests that those choosing to begin a research effort today will be unable to predict the particular bureaucratic bias in an agency ten years from now and thus will have no incentive to distort their research efforts to exploit that bias.

²⁰ An even more general argument may be Hayek's (1945) on the informational advantages of decentralized markets over central planning.

²¹ A useful comparison may be taxes to internalize externalities associated with climate change. Parry and Williams (2011) find that such taxes increase aggregate economic welfare only if the revenues are used to reduce income and payroll taxes because carbon taxes, by raising the price of goods, exacerbate the reduction in labor income under the existing tax structure.

arises from considering the health and social benefits of being able to distribute pharmaceuticals at marginal production cost rather than have them priced out of reach by monopoly mark-ups. The demand for drugs to treat serious health conditions is likely to be at least as inelastic as the supply of labor, financial capital, and other items that would be taxed even more to cover the cost of these rewards.

In short, if one is looking for an explanation for prizes over patents, such an explanation will have little if anything to do with the putative efficiency properties of publicly provided lump-sum payments for the rights to use innovations at marginal cost. The inability to design a practical system of patent buyouts suggests that the purpose of prizes is not simply as an alternative payment mechanism within the patent system. One alternative explanation is that prizes are employed when patents themselves may not perform very well, if at all. We review some of the particular reasons why private and public enterprises have turned to prizes in the next two sections.

4. Idiosyncratic Advantages of Prizes

The specificity and rarity of prizes relative to patents and the related operational limits to the patent-buyout rationale suggest other reasons why prizes may be adopted. Before proposing a framework for comparing different means of technology inducement based on the ex ante knowledge regarding the potential innovation and the optimal allocation of risk, we look first at some particular advantages prizes may have in some contexts over patents.

Publicity

A mundane but not dismissible consideration is that, as George Carlin observed, people like to win prizes and be known as prize winners. It can be fun to win a contest. This rationale may pertain when a prize could be won by coming up with an idea in one's spare time or building a prototype in a garage with inexpensive materials. The private value of prizes can attract those who might not otherwise consider commercial efforts, expanding the pool of potential innovators (Kalil 2006, 7; McKinsey and Co. 2009, 23–24). These benefits may show up in spending, for example, in that the contestants for the Ansari X Prize for suborbital flight

reportedly spent \$100 million to claim a \$10 million prize.²² This may also be the case when winners of the prize get not only the satisfaction of winning as such, but also any satisfaction from contributions their invention may make to solving a significant social problem, as for example the student teams participating in the Department of Energy's Solar Decathlon contest to come up with the best design for an affordable, completely solar-powered house.²³

However, it does not seem reasonable to count on intrinsic publicity or a sense of contributing to the social good as generally sufficient to encourage efficient investment. The willingness to spend what it takes to participate in a contest to produce a car that gets 100 miles per gallon of gasoline or fly someone into suborbital flight twice in two weeks is not likely to be sustained by the satisfaction of winning alone. One would then want to look at commercial benefits. Publicity can serve a commercial informational function similar to advertising. As McKinsey and Co. (2009, 19) observed:

Well-designed prizes carry a strong element of theater that makes them newsworthy and media friendly. This messaging and brand-building potential is attractive to corporations looking to burnish their image or wealthy donors seeking to signal their arrival.

Penin (2005) argued that patents serve as signals of ability and capacity for innovative thinking; a highly publicized prize seems an even clearer signal. Because the publicity value of prizes depends on their relative infrequency, some observers have noted the potential for "prize fatigue," reducing the willingness of potential innovators to participate in any given prize competition (Hill 2004).

Reward Flexibility

The patent system has only a "one-size-fits-all" solution to induce innovation: it provides the first inventor with an exclusive, transferable right to produce the invention or use the process (Scotchmer 2004, 117). A prize, on the other hand, can be designed in any number of ways to induce innovation. In the qualitatively similar context of inducing workers to exert effort to

²² X Prize Foundation, "Ansari X Prize," n. 2 *supra*. Of course, this could also be evidence of waste in the design of the prize contest as well. Adler (2011) refers to getting a greater investment in research than the prize itself as "leverage."

²³ US Department of Energy Solar Decathlon, <http://www.solardecathlon.gov/competition.html>, accessed March 25, 2011; Templeton (2007).

achieve a goal, Nalebuff and Stiglitz (1983) emphasize flexibility as the primary advantage of prizes, tournaments, and relative compensation schemes over simple piece-rate or fixed-salary compensation. The Netflix Prize embodied this flexibility. Along with the \$1 million prize for the first prediction algorithm meeting its criteria, it awarded annual \$50,000 “Progress Prizes” until there was a grand-prize winner to the team that had improved the most on the best result in the prior year.²⁴

With Nalebuff and Stiglitz’s (1983) analysis of worker contests as a model, the flexibility of prizes relative to patents may be manifested along other dimensions. One can give prizes to contestants coming in second or other positions to provide more encouragement. This strategy is particularly useful when participants view winning as a low probability because either the number of contestants or the chance that no effort will be successful is large.²⁵

One could also award the winning prize only if there is a substantial gap between the first and second place finisher’s performance. This design can induce more effort by reducing the chance that winning is a matter of luck. More generally, the prize could be based on relative performance, not just on whether someone won but by how much better they did than their competitors. Taking advantage of these last possibilities in an innovation prize contest would require a clear measure of how the gap will be measured, supporting either a “best-in-class” approach, where all entries are evaluated at a prespecified date, or a substantial second prize to keep contestants in the race after a winner has been selected.

Payment Precommitment

In many situations, there will be only one party interested in a desired innovation. Because there is only one buyer, the innovator will not have the ability to set the licensing price high enough to recover the investment costs. Offering a prize creates a minimum payment commitment, without which innovators would be vulnerable to post-innovation opportunism. A prize could be used to finance development costs or provide a guarantee for future purchases of the winning innovation at a high enough price to recoup development costs. The reasoning is similar to why we have quasi-constitutional requirements that utilities, which make significant

²⁴ The Netflix Prize Rules, <http://www.netflixprize.com/rules>, accessed March 24, 2011.

²⁵ Multiple prizes could also replicate the gains from having multiple innovations, where the second has some value but less than the first, etc.

investments to serve a single specific state “buyer,” have a fair opportunity to earn a just and reasonable return on investment.²⁶

Contestant Management

Those holding contests for prizes have ample opportunities to maximize the benefits of cooperation and minimize duplication by managing the contestants. As noted above, they can hold entry auctions to recapture potential surplus from setting the prize too high and, more important, limit the competition to contestants with the largest expected chance of success. To reduce the duplication of effort—also a problem with patents; hence the term “patent race,” as described in Baye and Hoppe (2003)—contest holders can encourage information sharing and consolidation among research teams. They are in the best position to balance the risks that information sharing will impede competition by dissipating advantages to private parties and the gains from the possibility that information sharing would increase the likelihood or speed of meeting the objective.²⁷

Learning from Failure

Not all prizes contests produce a winner, but they still may be valuable because information may be gleaned when a prize is not awarded. Failure to win suggests at some gross level that the offered prize was insufficient to stimulate the necessary investment for the desired outcome. Contestants who almost win reveal the state of the art. As a result, prizes allow one to trace out a supply curve, or at least a few points on it, and thus provide information for the contest holder about innovative capacity to solve the problem at hand. One may be able to make similar inferences from failure to develop patents in a particular area—for example, orphan drugs—with either too few potential beneficiaries overall or too few with sufficient income to be willing to cover the cost of development. Prizes, however, allow one to put a specific number on a value insufficient to stimulate successful solutions to an identified problem.²⁸

²⁶ The standard case citation for this legal principal is *Federal Power Commission v. Hope Natural Gas Co.* 320 US 591 (1944).

²⁷ For its prize, Netflix provided a discussion board where competitors could and did share information regarding their progress in finding algorithms to improve predictions of movie preferences (Thompson 2008).

²⁸ On the other hand, patents reveal the value of the innovation in the market and thus may provide signals regarding demand for additional innovations, akin to Demsetz’s (1964) argument for charging positive tolls for bridges even when the marginal cost of using them is zero, to garner information as to how valuable the bridge is.

Nonpatentability

From the contexts in which prizes have been implemented, the most striking if not crucial idiosyncratic difference between prizes and patents is that prizes can be and are employed for all sorts of achievements, where patents can be granted only to what is patentable under the law. Under US patent law, a patent can be obtained for “any new and useful process, machine, manufacture, or composition of matter, or any new or useful improvement thereof.”²⁹ To meet this test, “the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would [not] have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.”³⁰ With some variation for designs or pharmaceuticals because of the time it takes for US Food and Drug Administration approval, the exclusive right granted by a patent extends 20 years from the date of application.³¹

Determining whether the subject matter proposed for a patent is “new and useful” and nonobvious to someone with ordinary skill in the prior art is the task of the examiners in the US Patent and Trademark Office. Most relevant to prizes, however, is the determination of whether something is a “process, machine, manufacture, or composition of matter.” In 2010, the US Supreme Court in *Bilski v. Kappos* affirmed a Federal Circuit Court of Appeals ruling that to be patentable, the subject matter must be connected to something tangible, specifically that it either be “tied to a particular machine or apparatus” or transform “a particular article into a different state or thing.”³² This overturned the Federal Circuit’s 1998 *State Street Bank* ruling that something need only “produce a ‘useful, concrete, and tangible result’” to be eligible for a patent.³³ *State Street Bank* led to the patenting of a range of business processes, most notoriously

²⁹ 35 U.S.C. 101. In the EU, the novelty is required to be “absolute” in that it cannot be part of the state of the art, defined as “everything made available to the public by means of a written or oral description, by use, or in any other way, before the date of filing.” European Patent Convention (EPC), Article 54(2). This is a stricter requirement than that in the US, in that in the EU any information disclosed about patent can reduce the chance of getting a patent (RSW 2002 at 1.2).

³⁰ 35 U.S.C. 103(a).

³¹ 35 U.S.C. 154(a)(2). Note that this reinforces the argument that patents are a “one-size-fits-most” approach to inducing innovation, while prizes can be customized to fit the situation at hand.

³² *Bilski v. Kappos*, 561 US 8 (2010), available at <http://www.supremecourt.gov/opinions/09pdf/08-964.pdf>, upheld a Federal Circuit Court of Appeals decision invalidating a patent for an algorithm to hedge weather-related risk. The Federal Circuit is the part of the judicial branch that handles patent cases, through courts with specialized judges.

³³ *State Street Bank & Trust Co. v. Signature Financial Group, Inc.*, 149 F. 3d 1368 (1998).

Amazon.com's "one-click" online ordering (Stobbs 2003, 10–17). Prior to *State Street Bank*, business methods were difficult if not impossible to patent; failed attempts included drive-through windows in fast food restaurants and drive-in movies (Stobbs 2003, 4–10).

More generally and less controversially in legal terms, the idea of solving a problem is not patentable. One cannot patent the *idea* of a solo flight to Europe, suborbital flight, fuel efficiency of 100 miles per gallon, rapid sequencing of human genomes, and recovery of spilled oil—all subjects of prizes described above—only a particular process or device to do them.³⁴ The winners of the prizes for these activities may well have patented machines or processes along the way that will allow them to exploit their particular solutions. But unlike a prize, a patent system cannot provide a monetary incentive just for solving the task alone. Consequently, developers may not have been able to patent the prediction methods rewarded by the Netflix Prize, although *State Street Bank* was controlling law at the time.³⁵

A number of circumstances may prevent IP rights from providing adequate appropriations to justify the R&D investment. For areas that could be characterized as “big science” areas with significant spillovers (e.g., access to space), or uninternalized externalities (e.g., climate change abatement), the value that the innovator is able to appropriate from their IP may not be enough to overcome R&D costs even if the social welfare gain is large enough to justify the investment. As a result, innovations will be undersupplied. In these cases, prizes that allow innovators to retain their IP rights could be used to encourage further investment in innovation

Enforcement Differences

Finally, even if countries have similar standards of and terms for patentability, they may differ regarding enforcement policies. Specifically, they may differ in terms of criteria for infringement, the likelihood of enforcement, and monetary and other criminal penalties. In the other direction, different countries may have different rules, standards, and procedures for

³⁴ Similar arguments regarding underfunding and non-patentability apply generally basic research. Erkal and Scotchmer (2009) also suggest that rewards for innovation be increased in contexts where “ideas are scarce” apart from development resources; this could justify prizes as a supplement to patent rewards. In terms of prizes as patent supplements, it is also worth keeping in mind the aforementioned possibility of positive externalities from the innovation that a patent holder could not capture, e.g., from innovations that facilitate reductions of greenhouse gas emissions, as advocated by Newell and Wilson (2005), Newell (2007), Mowery *et al.* (2010) and Adler (2011).

³⁵ It would be interesting to know if Netflix had any expectation of patenting the result.

private parties to challenge the validity of a patent. As a consequence, those who obtain patents in different countries may have different views regarding the credibility that the patent right will be respected and retained, and thus its monetary value. In jurisdictions where patents are not enforced or may be easily challenged, a prize may provide a relatively greater incentive to innovate—assuming that inventors in those countries lack similar doubts about the credibility of a government’s promise to award the prize or to enforce a promise from a private prize funder to do so.

5. The Model

These idiosyncratic advantages of prizes, unlike the potential theoretical advantages of patent buyouts, provide considerable insight into why and when prizes might be preferable to patents for fostering innovation. However, recognizing two fundamental differences between prizes and patents may not only improve our sense of when one might be preferred to another. They also suggest a framework or matrix in which they can be compared with other methods for inducing innovation and procuring goods and services generally.

A few researchers have analyzed prizes and similar instruments, but these studies have not addressed the distinction between prizes and patents. Nalebuff and Stiglitz (1983) discuss prizes—not in contrast to patents but in the broader and somewhat related context of whether to base worker compensation on absolute or relative performance. Fullerton and McAfee (1999) examine using an entry auction to restrict participation to the most efficient contestants for a prize to avoid fixed-cost duplication; Giebe (2010) looks at entry auctions where increasing the number of participants increases the expected number of innovations. To provide an incentive to increase output over the monopoly level, Hollis (2008) proposes an “advance market commitment” under which a government or other funder would distribute the prize in the form of a per-unit premium over the price the winner charges for its patented product, in his case a new drug meeting a “technical product profile”.³⁶

³⁶ Specifically, the firm would be guaranteed a price per unit P^* from the funder, giving it a premium of $P^* - P^o$ per each unit sold, where P^o is the price the prize winner charges users for its product. The winner can collect a maximum of K , which means the funder could obtain the premium on up to $K/[P^* - P^o]$ units of output. The condition for winning the prize is that the winner would continue to charge P^o for the product even after the prize K is exhausted.

The first difference involves specificity. The patent system is intrinsically wide open. Although patent law includes some provisions for pharmaceuticals, plants, and biotechnology, it is essentially equally open to any new, useful, and nonobvious process or machine. Prizes, on the other hand, are employed only for achieving a highly particular goal. This is not only a matter of choice by the holder of the prize competition, but is a requirement for having a prize. A clear set of “victory conditions,” as Kalil (2006) put it, is necessary to provide ex ante assurance to contestants that they know what they have to accomplish to win the prize and avoid ex post litigation over the winner.

The second difference involves risk bearing. Those undertaking research initiatives that may lead to patented products bear risks on both sides of the profit equation. On the cost side, they bear the full expense of developing a patentable process or machine and the risk that they will not win the patent race. On the benefit side, they bear the full risk regarding the eventual demand for and economic value of the innovation. Unless up-front costs and future profitability are highly correlated, having to bear both adds to the risk potential inventors bear relative to bearing one or the other alone. With prizes, on the other hand, one side of the risk, the benefit risk, is shifted to some degree away from the potential inventors to the prize funders because some return—the prize—is guaranteed, along with any ancillary or indirect benefits of winning. Relative to patents, then, the risk associated with research effort is reduced with prizes, in that both require persuading private investors to support that effort, although with prizes, the return is known in advance rather than left to the vagaries of the market.³⁷

A simple model can illustrate the effects of risk sharing and ex ante knowledge of a funder’s preferred innovation on the funder’s choice to offer a prize or rely on the patent system. Suppose that there are two potential innovations, *X* and *Y*. Assume, without loss of generality,

Leaving aside the distortions associated with raising revenues to fund the prize, Hollis’s mechanism can be designed in principle to achieve the efficient level of service by setting K equal to the maximum of monopoly profit or the fixed cost of innovation (plus epsilon, to break any ties) and setting $P^* = MC + K/Q(MC)$, where MC is the marginal cost of the product and $Q(MC)$ is the demand for the product at a price equal to marginal cost. Because K exceeds fixed costs or the monopoly profit, whichever is bigger, the firm will choose to take the advance market commitment rather than the patent monopoly. By setting P^* as described, the firm will have an incentive to charge a price equal to marginal cost to maximize the profits it can obtain when the funder gives it $P^* - MC$ per unit up to K . In this regard, Hollis’s mechanism may be better thought of as a way to induce marginal cost pricing from someone who has obtained a patent rather than as an alternative mechanism for inducing innovation.

³⁷ This is contrary to Adler’s (2011, 18) suggestion that a “potentially significant drawback of prizes is that researchers must obtain funding for their research in order to compete.” Prizes, however, will be riskier than grants in which the government or funder puts up the money; these are briefly discussed below as part of the matrix.

that the funder's decision will be whether to offer a prize for X or to let the expected returns from a patent guide the innovator's choice between X and Y . An innovator has private knowledge of what the net expected value of a patent might be, respectively \underline{V}_X and \underline{V}_Y (underlining indicating expected value).

To minimize notation, the net values are net of the cost of undertaking the innovative effort to come up with Y ; we offer more detail into the determinants of \underline{V}_X below. The innovator is uncertain regarding the distribution of actual values of the returns to innovating in X , but to minimize extraneous notation, we assume that V_Y is known with certainty to the innovator and the funder. One could regard \underline{V}_Y as the risk-adjusted net return from the best outside option or, alternatively, the opportunity cost of foregoing working on Y in order to develop X ; accordingly, we assume that $\underline{V}_Y \geq 0$.

To focus on the cost of risk associated with producing the potential prize innovation, we do not explicitly describe any risk-related effect that determines \underline{V}_Y , but we model the cost to the innovator of uncertainty regarding the returns V_X to X . These returns are the difference between the revenues R_X from selling X and the cost C_X of producing X . The expected return \underline{V}_X is $\underline{R}_X - \underline{C}_X$, the difference between expected revenue and expected costs. If both R_X and C_X are uncertain, then the variance of in \underline{V}_X , notated as σ_X^2 , will be given by

$$\sigma_X^2 = \sigma_R^2 + \sigma_C^2 - 2r_{RC}\sigma_R\sigma_C. \quad (1)$$

where σ_R^2 is the variance in revenue, σ_C^2 the variance in cost, and r_{RC} is the correlation coefficient between revenue and cost; $1 \geq r_{RC} \geq -1$.

We describe the cost of this risk to the innovator as $K\sigma_X^2$, notated as σ_X^2 is the variance of the value of X , and K is the cost from that variance to the innovator, based on her risk aversion, invoking constant absolute (or, taking V_X as constant, relative) risk aversion regarding the returns to that innovation. In the absence of a prize, the innovator will choose X (Y), based on whether

$$\underline{V}_X - K\sigma_X^2 > (<) \underline{V}_Y. \quad (2)$$

We assume that the funder does not know whether (1) holds, in order to open up the possibility that the funder has to consider whether X would be developed without a prize. Let T be the probability that in the absence of a prize, the innovator would have chosen to do X ; the probability of choosing Y is thus $1 - T$. T depends on \underline{V}_X , \underline{V}_Y , and $K\sigma_X^2$, all exogenous parameters; we can assume that the funder's uncertainty is over V_X , the expected return to the innovator from producing X .

The funder has to choose whether to let the innovator select X or Y , or to intervene to influence the innovator's choice by offering a fixed prize, P to replace the uncertain R_X as the return for the innovation. If so, the only variance is on the cost side, and the value of pursuing X to the innovator now becomes

$$P - \underline{C}_X - K\sigma_C^2. \quad (3)$$

For a prize to be large enough to increase the return to developing X , (2) and (3) imply

$$P - \underline{C}_X - K\sigma_C^2 > \underline{V}_X - K\sigma_X^2 = \underline{R}_X - \underline{C}_X - K[\sigma_R^2 + \sigma_C^2 - 2r_{RC}\sigma_R\sigma_C],$$

or

$$P > \underline{R}_X - K[\sigma_R^2 - 2r_{RC}\sigma_R\sigma_C]. \quad (4)$$

Having the funder absorb the revenue component of risk could increase the risk that the innovator bears. This will be the case if the expression in the brackets in (4), the difference in risk without or with the prize, is negative, which holds when the correlation coefficient exceeds half the ratio of the standard deviation of revenue to that of cost:

$$r_{RC} > \frac{\sigma_R}{2\sigma_C}. \quad (5)$$

If revenues and costs are sufficiently correlated, decreases in revenue will be hedged by decreases in costs. If revenue risk is small relative to the cost risk, the loss of this hedging benefit will outweigh the removal of the revenue risk, making the pursuit of X more risky for the innovator.

So, offering a prize need not involve reducing the risk left to the innovator. We will assume that it does, that is, (5) does not hold. When reducing revenue risk reduces overall risk, (4) shows that the prize P could be less than the expected revenue \underline{R}_X the innovator would achieve absent the funder's intervention; it need only exceed the value adjusted for the risk the innovator would otherwise absorb regarding uncertainty about X 's value.

In guaranteeing P for developing X , the funder removes the revenue risk $K\sigma_R^2$ from the innovator. To guarantee that the innovator develops X , the prize has to be sufficiently large to cover the opportunity cost of pursuing Y , that is,

$$\begin{aligned} P - \underline{C}_X - K\sigma_C^2 &> \underline{V}_Y, \text{ or} \\ P &> \underline{V}_Y + \underline{C}_X + K\sigma_C^2 \end{aligned} \quad (6)$$

Absorbing the risk $K\sigma_R^2$ will come at a cost to the funder; we describe that below.

The choice between a prize and a patent in this setting comes down to whether the funder would be willing to offer a prize of at least this magnitude sufficient to induce X rather than leave the choice to the innovator. To investigate when this, we need to describe the importance of specificity, which here is magnitude of the funder's ex ante preference for X . This entails comparing the funder's expected welfare if it funded a prize compared to if it did not. Letting U generally refer to that funder's welfare, we will need three things:

- $U_X|X$ is the value of X to the funder given that the innovator would have chosen X over Y , absent a prize.
- $U_Y|Y$ is the value of Y to the funder given that the innovator would have chosen Y over X , absent a prize. If the funder makes no effort to change the innovator's decision, this is what its welfare would be if the innovator were to choose Y .
- $U_X|Y$ is the value of X to the funder if the innovator would have chosen Y over X , absent a prize.

The difference between the last two of these will be our measure of how much the funder would want X when the innovator would have chosen Y instead.

If the funder elects to rely on the patent system to provide incentives, its expected utility will be

$$T[U_X|X] + [1 - T][U_Y|Y]. \quad (7)$$

If the funder chooses a prize P to ensure that the innovator chooses X , absorbing any revenue risk from the development of X , its expected utility in (7) is reduced by the cost of the prize and that risk, given here by

$$T[U_X|X] + [1 - T][U_X|Y] - P - SK\sigma_R^2, \quad (8)$$

$SK\sigma_R^2$ is the cost to the funder of absorbing the revenue risk otherwise borne by the innovator. Risk sharing benefits here can be represented by having S between 0 and 1; greater benefit from risk sharing—risk absorption in this simple model—shows up as a smaller S .

S can be small for at a number of reasons. The funder may have present or longer-run hedging opportunities not available to the innovator, who may not be able to pursue a number of innovations simultaneously. The funder may be relatively sure how much X is worth to it, while the innovator's ability to capture value may depend on vagaries in the market for and bargaining over access to X if it gets a patent for it. This latter effect is likely to be particularly important if the funder is the only likely buyer of X . Any revenue risk to the innovator that may come from

uncertainty regarding the post-innovation outcome of bargaining between it and the funder no longer pertains if the funder pays a fixed up-front fee in the form of a price.

The funder will choose to offer a prize P that satisfies

$$[1 - T][U_X|Y - U_Y|Y] - SK\sigma_X^2 > P. \quad (9)$$

The expected difference in the value of X over Y to the funder, given that the innovator would have chosen Y , times the chance the innovator would have chosen Y , has to exceed the size of the prize plus the cost of absorbing the innovator's risk. If that difference is small, or if Y is unlikely to have been chosen, the funder will not be willing to offer a large prize.

In this setting, one would see a prize only if it is less than what the funder would be willing to offer, but large enough to induce the innovator to choose X over Y . From (6) and (9), the condition for this to occur is

$$[1 - T][U_X|Y - U_Y|Y] - SK\sigma_R^2 > P > \underline{V}_Y + \underline{C}_X + K\sigma_C^2. \quad (10)$$

This condition illustrates the risk sharing and specificity factors that determine whether the funder will choose a prize over a patent. The more specificity matters to the funder, $U_X|Y - U_Y|Y$, the more likely it is that there the funder will find it worthwhile to offer a prize rather than rely on a patent. The larger the gain from shifting risk, represented by a smaller S to indicate the reduction in the cost of risk when the funder takes it on, the more likely the condition will be satisfied, i.e., that the funder will be willing to offer a prize greater than the difference in the expected return (net of risk cost) to the innovator of choosing Y over X .

It may be useful to look at two simple special cases of (10). First, the simplest, assume that absent a prize, the funder knows that the innovator will come up with X without a prize ($T = 1$). In that case, the expression on the left hand side of (10) is negative. The funder will never find it useful to offer a prize for something that it knows will be invented, regardless of risk.

A more interesting special case is when the funder knows that absent a prize, X will not be developed ($T = 0$). Add to this the simplifications that there is all the risk in developing X is on the revenue side ($\sigma_C^2 = 0$) and that the net economic profit from alternative activities indicated by \underline{V}_Y is 0. Then, condition (10) becomes

$$[U_X|Y - U_Y|Y] - SK\sigma_R^2 > P > \underline{C}_X.$$

The net value of X to the funder, less the cost of the risk it absorbs, has to exceed the cost of producing X .

6. The Matrix

Our patent vs. prizes model suggests a matrix of possibilities for procuring innovations, based on specificity of the innovation sought (columns) and the degree to which the solicitor of the innovation, public or private, would reduce uncertainty-related costs by bearing some of the risk (rows).³⁸ So far, we have:

	Unspecified objective	Known objective
All risks borne by potential innovators	Patents	
Risks shared with innovation solicitor		Prizes

The blank regions in the matrix invite consideration of what might go in them. For the lower-left box, a good candidate would be grants in response to requests for proposals from a general research support agency, most likely but not necessarily public. For those, the objective is relatively unspecified, in the sense that research teams have the flexibility to propose potential research ideas, at least within reasonably broad categories.³⁹ The solicitor shares the risk, not on the benefit side as with prizes, but by covering all or a substantial fraction of the costs of the research. Mowery et al. (2010) discuss the successes grant funding and similar research support policies in agriculture, biomedical research, and information technology.

The blank box on the upper right lacks, so far, an obvious institutional arrangement that fits. It describes a setting in which the solicitor knows what it wants done but the potential suppliers absorb all the risk. To clarify what it might mean, it is useful to subdivide the “Known

³⁸ The placement of prizes in the “known objective; shared risk” box is consistent with Rogerson’s (1989) characterization of cost-plus rewards in defense contracting.

³⁹ This contrasts with Adler (2011, 29) who argues that prizes have an advantage over grant funding because, with grants, “decisions about projects or efforts to fund are centralized, limiting the range of promising ventures that may receive funding and increasing the risk that research funding will not result in useful technological innovations.” As noted here, a particular disadvantage of prizes is that they have to be highly specific so contestants know the criteria for winning, whereas competitions for grants typically leave open the specification of the research goal itself.

Objective” column into two. One covers settings in which the solicitor knows the objective it wants to achieve but does not know or have a technological solution. The second covers circumstances where the solicitor knows what it wants and also how to solve the problem. The amended table, filling in the lower left box with research grants, is:

	Unspecified objective	Known objective	Known objective and solution
All risks borne by potential innovators	Patents		
Risks shared with innovation solicitor	Research grants	Prizes	

If the solicitor knows what it wants and how to get it, and the risks associated are best borne by the suppliers, then it can simply purchase solutions to its problems “off the shelf;” that acquisition method can go in the upper right box. If the market risk in supplying those solutions needs to be shared, it can purchase those goods through a procurement contract specifying terms of purchase and delivery; that goes in the lower right box.⁴⁰ This leaves the upper middle box, which would seem to fit most a setting where the solicitor with a known objective makes that objective known to the market, perhaps with the expectation that suppliers are willing to bear the risk because of the potential gains from any subsequent patents or market opportunities. This may be labeled, perhaps for lack of a better term, “Market solutions.” The complete matrix of innovation acquisition method thus becomes:

⁴⁰ Mowery et al. (2006) suggest that obtaining a procurement contract is tantamount to winning a prize.

	Unspecified objective	Known objective	Known objective and solution
All risks borne by potential innovators	Patents	Market solutions	Off-the-shelf purchases
Risks shared with innovation solicitor	Research grants	Prizes	Procurement contracts

This suggests a potential formal approach to the general question of innovation procurement based on the model in the previous section comparing prizes to patents, based on the relative knowledge the solicitor or customer knows about its objective and the technological means for addressing it, and second, the relative cost of risk to the solicitor and the potential innovators.

7. Conclusions

Prizes have long been a method for encouraging innovation and have recently become more prominent. Economic models generally fail to explain why they would be chosen over other methods for encouraging innovation, particularly patents. The effect of patenting on innovation is modeled as if patents were prizes, so those models cannot identify advantages of one over the other. Other models have analogized prizes to patent buyouts, but that analogy fails. Theoretical analysis of the putative advantages of lump-sum payments for innovation neglects the distortions in other market necessary to raise the funds to make those payments. Patent buyouts also would be difficult to implement because the government is unlikely to have adequate information to come up with appropriate compensation that would stimulate optimal investment.

Prizes have a number of idiosyncratic advantages over patents, especially their design flexibility and ability to cover nonpatentable achievements. A potentially fruitful approach to understanding the difference between patents and prizes builds on a matrix of methods to induce innovation based on the degree of knowledge the solicitor has regarding the objective and how to meet it as well as the degree to which the solicitor should share in risk bearing. Our aspiration is that future work will develop a formal model of these relationships and clarify the reasons for choosing between patents and prizes. Such a model may be helpful also for understanding more broadly the choice among these and research grants, procurement contracts, and the wide variety of instruments that may be used to induce innovation.

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