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A theory of grand innovation prizes

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ABSTRACT

The past decade has witnessed a resurgence in innovation awards, in particular of grand innovation prizes (GIPs) which are rewards to innovators developing technologies reaching performance goals and requiring breakthrough solutions. GIPs typically do not preclude the winner also obtaining patent rights. This is in stark contrast with mainstream economics of innovation theories where prizes and patents are substitute ways to generate revenue and encourage innovation. Building on the management of innovation literature which stresses the difficulty to specify ex-ante all the technical features of the winning technologies, we develop a model in which innovative effort is multi-dimensional and only a subset of innovation tasks can be measured and contracted upon. We show that in this environment patent rights and cash rewards are complements, and that GIPs are often preferable to patent races or prizes requiring technologies to be placed in the public domain. Moreover, our model uncovers a tendency for patent races to encourage speed of discovery over quality of innovation, which can be corrected by GIPs. We explore robustness to endogenous entry, costly public funds, and incomplete information by GIP organizers on the surplus created by the technology.

1. Introduction

Economists have long recognized the crucial role played by innovation in economic growth and – at least since Arrow (1962) – have considered channels that might cause under-investment in innovation relative to the socially optimal level. How to avoid such under-investment and how to provide greater innovation incentives are a central question in the economics of innovation literature. The patent system is the most important institution developed by policy-makers to spur innovation. Patents provide temporary monopoly rights as an incentive to innovation. However, it is well understood that patents come at a cost, since monopoly leads to inefficiencies. The natural alternative, prizes that come through money rather than monopoly rights, are viewed as difficult to implement in a way that generates appropriate incentives; proper incentives require that the prize be awarded only to genuine innovations, and in proportion to their usefulness. Prizes have nonetheless been growing as a way of rewarding innovation, both publically and privately. In the United States, former President Obama's Strategy for American Innovation strongly encouraged the use of innovation prizes and the America Competes Reauthorization Act of 2011 provided all federal agencies with power to offer innovation prizes (Williams, 2012).

This paper studies grand innovation prizes (GIPs), which are a prominent class of innovation inducement prizes. GIPs are defined as large monetary rewards for innovators reaching a pre-determined set of performance targets (Kay, 2011; Murray et al., 2012). Critically, a GIP does not preclude the winner from also obtaining patent rights. This is different from the usual view of prizes and patents in the innovation literature where the two are viewed as alternative ways to generate revenue to encourage innovation, and the only reason patents are preferable to prizes is because of information or contracting frictions that prevent the prize from being sufficiently tied to success to be an effective incentive.

Our model of grand innovation prizes provides an explanation for this coexistence of prizes and patents. Our setting departs from traditional models of innovation contest by assuming that the characteristics of the technology target can only be partially specified by the GIP organizer. Performance targets can be described but a full description of a solution is unavailable. We model this as the innovation having two dimensions. On one dimension, the performance goals for the prize to be awarded can be well specified and verified ex post. On another dimension, they cannot.

The use of prizes is not limited to the public sector, and their use in the private sector can be informative. Our multi-dimensional approach is consistent with existing descriptions of GIPs in the private sector. Often not much more is known than that a successful product requires significant research effort and breakthrough ideas. Since technical specifications are difficult to describe, GIPs differ from smaller-scale

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competitions as software development contests requiring more limited resources and for which the solution can be typically described in great detail (Boudreau et al., 2011).[1]

A number of case studies analyzed in the literature support the idea that specifying ex-ante the technical features for the winning technologies is the most challenging aspect of GIPs. For example, Murray et al. (2012) describe the Progressive Insurance Automotive X Prize for the development of "*viable, super fuel-efficient vehicles that give people more car choices and make a difference in their lives*." The broad objective of the prize was the development of vehicles able to revolutionize the automobile industry through a new generation of fuel efficient cars. Translating such broad aim into precise requirements for the contest is very hard. While technical metrics are required to set a target for the prize, the future impact of the technology may be related to characteristics that are difficult to specify ex-ante with unambiguous criteria. For example, the Progressive Insurance Automotive X Prize required vehicles to meet an efficiency standard of 100MPGe with CO_2 emissions equivalent to < 200 g/mi. However, statements from the X-Prize Foundation indicate that the overall impact of the technology on consumers and follow-on innovation was unlikely to depend on fuel efficiency alone. Other dimensions related to the manufacturing process and consumer desirability would also be very important component of the welfare generated by the innovation.

The allocation of intellectual property rights in GIPs appears particularly in contrast with the microeconomic literature on innovation prizes (Wright, 1983; Scotchmer, 2004). The economics of innovation literature has treated prizes and patents as substitutes, and stressed that a prominent feature of prizes is the removal of the monopoly deadweight loss generated by patents. In the choices of the private sector, things appear very different: patents and prizes are viewed by GIP organizers as complements and GIP rules tend to allow participants to keep the IP rights on their technologies. Murray et al. (2012) report the following quote from an XPrize organizer: "*We have a standard for any XPrize that we have no interest in taking IP from teams with the exception of media rights to tell the story of the competition. It is not in our best interest to claim IP … we need to allow teams to pursue their business in whatever way makes sense to them.*"

We argue that the informational motivation for the private use of GIPs might also be a rationale for their use by public policy makers. There may be additional reasons why it may be useful to allocate patent right by GIP rather than simply a patent. For instance, if rents from a patent are low, but either consumer surplus or externalities from the innovation are high, additional subsidy is valuable. Papers in the prize literature, such as Kremer (1998) or Galasso et al. (2016) emphasize replacing monopoly rights with prize revenue in such cases. When patent rights are not excessively costly and benefits are high, the policy maker might want to use both.

We begin our analysis with a simple model in which there is only one innovator. The planner wants to maximize welfare by rewarding successful innovation and has full information on the marginal benefit and marginal cost of innovative effort. A standard result in the innovation literature is that in the presence of full information prizes dominate patents generating larger welfare and innovation incentives. Because research effort in our model is multi-dimensional and only one dimension is contractible, this result does not hold in our environment.

We compare three different reward structures. The first one is a patent regime in which the innovator is granted a patent which allows him to extract market profits from the innovation. The second one is a prize regime in which the innovator obtains a cash reward if the technology meets a target specified by the prize organizer and the innovation is placed in the public domain. The third regime, that we label grand innovation prize, is a hybrid system in which the innovator obtains a prize if the performance target is met and retains patent rights over the technology which allows him to extract additional revenue from consumers and licensee.

Neither the patent nor the prize regime can generate the first-best level of innovation in our model. In the patent regime under-investment arises because the patentee can appropriate only a fraction of the surplus generated. Prizes can correct the underinvestment by linking the reward to a performance target that maximizes social welfare. Nonetheless, because only a subset of innovative activities can be measured and contracted upon, the inventor has an incentive to disregard the non-measurable dimensions and to invest only on measurable activities. The hybrid GIP system generates larger innovation effort by attacking both of these under-investments. The under-investment in measurable activities that arises with the patent system is reduced thanks to the award that the innovator obtains if the effort target is met. The under-investment in unmeasurable activities that arises with prizes is reduced because the innovator obtains a fraction of the welfare generated, which depends on the entire set of innovative efforts. This result provides an explanation on the joint use of patents and prizes that is observed in grand innovation prizes. Intuitively, the partial surplus appropriability typical of a patent regime combined with the non-measurability of certain aspects of innovative effort generates complementarity between the two instruments. We show that this complementarity implies that, under very general conditions, GIPs generate more welfare than the other two regimes.

We extend the analysis in several directions. First, we consider the case where research efforts along the two dimensions are complements or substitutes. We show that if either strong substitutability or strong complementarity is present, then a simple prize may perform better when compared to a GIP than in the baseline case of no interaction between the two inputs. If the two inputs are strong substitutes, then the under-investment in the unverifiable effort dimension induced by prizes is less problematic than in the baseline case because it is sufficient to induce a high effort in the other dimension for the innovation to succeed overall. If the two inputs are strong complements, then again it is sufficient to induce effort in the observable dimension because complementarity between the two effort levels will provide a built-in incentive for the innovator to exert effort along the non-observable dimension as well.

We consider further extensions to show that our results are robust to features that are standard in the innovation literature. In particular, we show that introducing costly public funds does not change our results qualitatively, and neither does incomplete information about the value of the innovation. Introducing competing innovators (either with a fixed number of innovators or with free entry) does not change the performance of simple prizes and GIPs, so our main comparison results are unchanged. However, patents perform worse with competing innovators than with a single innovator because each innovator may have an incentive to rush to the patent office, and file patents that provide very little improvements over existing products.

The rest of the paper is structured as follows. In Section 2, we provide further literature review. Section 3 sets up the baseline model and provides our main results. Section 4 revisits the baseline model to analyze the case of competing innovators. Section 5 considers the role of incomplete information, and costly public funds. Section 6 discusses the policy implications of our findings. Section 7 concludes. The proofs of all the results are relegated to the appendix.

[1] A 2009 McKinsey report estimates that the total funds available from large prizes have more than tripled over the last decade to surpass $375 million with a large number of philanthropists entering the business of rewarding innovators (McKinsey, 2009). For example, Qualcomm and Nokia have offered multi-million dollar prizes for the development of affordable devices that can recognize and measure personal health information. Similarly, the Gates Foundation has offered an innovation award to immunize children in the poorest parts of the world. Such trend is likely to have been stimulated by the success of the 1996 $10 million Ansari Prize offered by the X PRIZE Foundation for a private space vehicle to launch a reusable manned spacecraft into space twice within two weeks (Kay, 2011; Murray et al., 2012).