THE HAMILTON PROJECT

Advancing Opportunity, Prosperity and Growth

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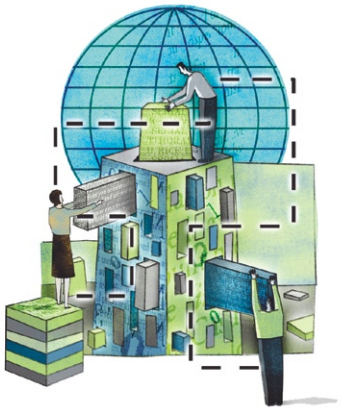
Prizes for Technological Innovation



IN 1919, NEW YORK HOTEL OWNER Raymond Orteig offered a $25,000 prize for the first nonstop aircraft flight between New York and Paris. The conventional wisdom of the day suggested that the winning craft would be a heavy, multiengine airplane with a large crew. In 1927, Charles Lindbergh overturned expectations by crossing the Atlantic as a solo pilot in a single-engine plane, with the world listening on the radio as the flight progressed.

For centuries, governments and individuals have offered prizes to spur innovation. Under the right conditions, prizes have several advantages over traditional funding mechanisms, such as contracts and grants. In a new discussion paper released by The Hamilton Project, Thomas Kalil of the University of California, Berkeley, proposes that the federal government make greater use of inducement prizes in order to encourage more innovative responses to a range of scientific challenges.

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THE CHALLENGE

The private sector and the government both play essential, complementary roles in furthering innovation. Private sector firms account for about two-thirds of total spending on research and development (R&D) and take the lead in developing and finding uses for new technologies that benefit consumers, increase productivity, and raise standards of living. The need for government support of innovation arises because firms are able to capture only a small fraction of the total benefit to society from their innovations—the remaining benefits accrue to other producers and to consumers of products that make use of the innovations. As a result, the private sector invests less in R&D than is justified by the benefits of such investment to society as a whole.

In fiscal 2006, the federal government spent almost $70 billion on grants and contracts that supported R&D by private and academic institutions. Although generally an effective means of supporting R&D, federal grants and contracts have limitations. First, government grant programs typically require administrators to choose between different methods for achieving a particular goal—even when that might exclude nontraditional, yet worthy, approaches. Second, government grants pay for research even when it is unsuccessful. Indeed, since research grants are provided on the basis of predicted success rather than actual results, researchers have an incentive to exaggerate the prospects that their approach will succeed. Finally, grants and contracts are subject to federal regulations and reporting requirements that can discourage the participation of individual innovators who work independently of large laboratories and other enterprises—those who have been responsible for so many of the innovative breakthroughs during the past century.

> Research grants reward predicted success; prizes reward actual results.

A NEW APPROACH

Kalil argues that inducement prizes avoid many of the limitations of traditional funding mechanisms. First, prizes allow the government to pursue a technological goal without deciding in advance which researchers or methodologies are best positioned to meet the goal. Thus, prizes may be particularly suitable for pursuing goals where the objectives are fairly concrete but the means of success are highly speculative (such as the goal of radical life extension). Second, prizes are awarded only in instances of success, eliminating the incentive to exaggerate the prospect of success. Finally, prizes can attract participation by small groups and individuals who otherwise would not do business with the federal government.

Kalil cautions that prizes also have limitations and in many circumstances should not be the policy instrument of choice. For example, since prizes only provide funding after the successful completion of a task, all entrants must raise the funds necessary to compete—yet most individual researchers, and many small- and medium-sized companies, find it difficult to self-finance or raise external funding for R&D. Second, prizes may be of limited use in the case of fundamental research, where the victory conditions for a prize might be unknowable or difficult to quantify in advance. Finally, prizes are more likely than grants or contracts to result in a duplication of research efforts, although Kalil argues that this effect can be mitigated through careful program design.

Harnessing the Power of Prizes

Kalil illustrates the potential of prizes by exploring five key areas in which prizes could be an effective complement to traditional funding mechanisms:

Space Exploration. NASA has identified two principal advantages of prizes relative to grants: the ability to attract a broader range of researchers and entrepreneurs to work on innovation related to NASA's work, and the potential to increase public interest in science and technology. In 2005, Congress passed legislation authorizing NASA to sponsor a prize of any dollar amount and to accept private matching funds. NASA subsequently announced its intention to sponsor competitions for technologies including flexible astronaut gloves, space elevators, unmanned aerial vehicles capable of exploring other planets, and robotic constructions of structures on the moon and other remote destinations. Kalil proposes that NASA also move forward with more-ambitious prizes, such as an Earth-Moon solar sail race and a lunar lander-rover. To fund these and other efforts, Kalil proposes that NASA immediately devote to prizes at least $100 million of its $16.8 billion annual budget, and that NASA gradually increase this amount until it reaches 2–3 percent of NASA's yearly budget.

African Agriculture. Private firms find it difficult to capture the returns to their investments in agricultural R&D targeted toward poorer countries, in part because farmers can take seeds from a first crop and use them in subsequent crops. Kalil observes, however, that such R&D could have enormous benefits for poorer countries and proposes that the U.S. contribute $50 million to $100 million for prizes that would encourage increased R&D in African agriculture. Kalil cites agricultural economist William Masters on the likely efficacy of such prizes: "Since prizes can easily be divided, they offer innovators a strong incentive to collaborate with others in achieving and documenting the impact of their work."

> Prizes offer greater scope for unexpected solutions and for solutions arising from unexpected sources.

Vaccines for Diseases of the Poor. Although AIDS and malaria together cause the deaths of millions of people each year, no effective vaccines exist for these diseases or for certain other diseases that disproportionately affect the poor. In other cases, vaccines exist, but companies have not invested in production capacity sufficient to inoculate the populations of developing countries. Companies in high-income countries have little financial incentive to invest in the development and production of new vaccines for these diseases. Annual global sales of all vaccines total just $6 billion, roughly the size of the market for a single blockbuster drug; the total vaccine market in developing countries is even smaller—only $500 million a year. Kalil proposes that the United States join with other wealthy countries to finance advanced market commitments (AMCs) for vaccines for six diseases—HIV/AIDS, pneumococcus, tuberculosis, malaria, rotavirus, and human papillomavirus—that kill approximately nine million people each year. The AMC would be similar to an inducement prize: It would constitute a legally binding commitment by donor governments to purchase, at a specified price, a minimum number of doses of a vaccine that met certain technical characteristics regarding safety, efficacy, and the like. The U.S. share of this program would be approximately $4 billion. Kalil notes the AMC could include a provision requiring vaccine developers to make additional doses available at a low price, once the AMC had been met.

Key Highlights

Proposed Prizes

- Inducement prizes would be awarded only for successful results.
- Initially, competitions would be run in five areas:
  - NASA would devote at least $100 million of its annual $16.8 billion budget to prizes.
  - The United States would contribute $50 million to $100 million for prizes encouraging increased R&D in African agriculture.
  - The United States would join with other wealthy countries to sponsor advanced market commitments to develop vaccines for diseases of the poor. The U.S. share of program costs would be about $4 billion. A vaccine for malaria would save lives at an estimated cost of $15 per life-year.
  - The Department of Energy would increase its budget for prizes to $100 million to $200 million of its $5.1 billion annual budget.
  - The Department of Education and other funding agencies would devote at least $100 million a year to prizes for the development of learning technologies.

Institutionalizing Prizes

- The president or Congress would direct agencies to identify new areas where prize competitions are likely to be effective.
- Once new ideas are generated, Congress would give additional agencies authority to sponsor prizes.

Design Issues

- Prize designers should clearly specify victory conditions that are neither too difficult nor too easy to achieve.
- Sometimes prizes need only be large enough to command widespread attention, which can engage firms and individuals drawn to the reputational benefits of winning.

Energy and Climate Change. The Energy Policy Act of 2005 gives the secretary of energy the authority to award prizes for "breakthrough achievements in research, development, demonstration, and commercial application" that are related to the Department of Energy's mission or that reduce our dependence on foreign oil. Kalil recommends that Department of Energy increase its use of prizes, investing at least $100 to $200 million a year (out of a $5.1 billion annual budget for nondefense R&D) on energy-related prizes, such as for fuel-efficient cars and renewable energy. Kalil notes that, for certain energy-related prizes, it may be desirable to reduce the value of the prize over time to encourage companies to move quickly, and to award the prize on a sliding scale as different thresholds are passed. Kalil also observes that a challenge of energy-related prizes is to define the victory conditions in such a way as to make the technology's adoption feasible from a cost perspective. (A prize awarded for more-efficient solar cells made of rare and expensive materials, for example, would have little commercial relevance.) Kalil believes that, in addition to eliciting technological change, prizes can help generate widespread public interest and participation in increasing energy efficiency.

Learning Technologies. While the resources devoted to U.S. K-12 public education increased significantly during 1980–2000, the average performance of 17-year-old students showed only modest gains. Kalil argues that learning technologies could play an important role in improving student performance. He recommends that the Department of Education and other funding agencies devote at least $100 million a year to prizes for software that teaches reading, or for games and educational software that improve student performance in math or science. Kalil argues that a prize could stimulate additional investment in such software by philanthropic and corporate interests.

> Prizes can spur investment far beyond the award itself: the $10 million X Prize stimulated at least $100 million in private investment.

Institutionalizing Prizes

In order to make prizes a regular feature of government support for R&D, they must be institutionalized as policy.

Generating Ideas for Prizes. The first step in institutionalizing prizes is to generate a stream of additional specific ideas for prizes. Kalil proposes that the president or appropriate congressional committees direct federal agencies to identify areas where inducement prizes or AMCs could be an effective method of meeting agency goals and advancing the public interest. Agencies would be directed to designate at least one program manager to lead the hunt for ideas. Managers would be given a modest budget to charter working groups of outside experts (potentially partnering with organizations such as the X PRIZE Foundation) to help with design issues, and to establish an interagency forum for program managers from different agencies to come together to exchange ideas and lessons learned.

Legislative Authority. Once agencies have generated compelling ideas for prizes and AMCs, Congress would authorize agencies to proceed with setting up competitions. Congress could either pass legislation on an agency-by-agency basis, as it has done up to this point, or it could enact a broader legislative change, granting all agencies the authority to support prizes and AMCs. Kalil proposes that such legislation enable and encourage agencies to partner with nonprofit and private sector entities that could take the lead on logistical planning. The legislation also would require that the government's prize program be evaluated periodically by a credible third party such as the National Academy of Sciences.

Designing Effective Prizes

Kalil identifies a number of design issues that agencies should consider when developing prizes.

Victory Conditions. Prize sponsors should have a specific objective and a clear definition of victory. Articulating effective victory conditions can be difficult. For example, Nobel laureate Richard Feynman attempted to promote nanotechnology in 1959 by offering a prize of $1,000 to anyone who could build an operating electric motor that was no larger than one-sixty-fourth of a cubic inch. The next year, an engineer figured out how to do so using jewelers tweezers and other conventional tools. The engineer thereby met the conditions of the prize, but failed to advance nanotechnology.

Victory conditions must be specified with appropriate precision. Victory conditions that are too ambiguous can reduce the number of participants or lead to litigation about the outcome; victory conditions that are too specific can limit the creativity of the contestants or inadvertently foreclose promising technological options. Prize designers must decide whether to award the prize to the method judged most effective at achieving a particular goal or to award the prize to whichever method is the first to achieve the goal. Finally, designers must decide whether to award one or multiple prizes: On the one hand, allowing for multiple winners can increase the probability that any single participant will achieve some success and thereby increase the willingness of individuals and firms to participate; on the other hand, multiple winners will reduce the amount of the award received by each winner.

> Prizes hold promise in areas as diverse as space exploration, African agriculture, vaccines, energy and climate change, and learning technologies.

Stage of Innovation. Prizes can be offered at different stages of innovation. White paper competitions that encourage people to describe their ideas for promising research directions or goals are an inexpensive, yet effective, use of prizes at the earliest stage of the innovation process. At the later stage of invention, when innovations are still far from commercial application, sponsors also would be able to attract interest for relatively small prizes.

Distributed Innovation. Kalil proposes that agencies consider establishing prizes "that leverage the small efforts of the many, as opposed to the large efforts of the few." They could do this by offering prizes for incremental advancements that are used by research or industrial groups, or by using online marketplaces that match scientists and inventors with companies facing specified scientific challenges.

Size of the Prize. If the prize is too small, no one will compete for it; if the prize is too large, it will lead to overinvestment and a duplication of effort. Kalil describes three possible methods for determining prize amounts. Some prizes only need to be large enough to command attention, since contestants sometimes are willing to enter for reputational benefits and philanthropists sometimes decide to bankroll contestants. For example, when the X PRIZE Foundation established a $10 million prize for the first unmanned space flight, Microsoft cofounder Paul Allen spent $20 million to back the winning team. A second approach is to determine how large the prize would need to be to attract private investment by profit-maximizing firms, and then calculate whether this would be a cost-effective intervention. For example, the Center for Global Development estimated that it would cost $3 billion, an amount equal to the average revenue from a new drug in developed countries, to entice firms into developing an effective malaria vaccine. Finally, Kalil notes that prizes can be set equal to some fraction of the estimated social benefit of a desired innovation.

Eligibility Requirements. Among the eligibility issues that prize sponsors must consider are whether foreign companies or researchers may compete for the prize, whether national labs or government employees are eligible, and whether to conduct qualifying events to winnow down the number of contestants.

Intellectual Property Rights. The prize designer must decide whether the winner of the prize will also keep property rights in the innovation. Agencies may choose simply to leave all rights with the entrants. Alternatively, agencies can vary the licensing of rights depending on the goals of the competition. If the goal is to encourage the development of a private sector capability that can be purchased by the government or others at some future date, most or all of the intellectual property would remain with the contestants. Alternatively, competitors might be required to grant the agency a license to use the innovation, while retaining rights for all other applications.

Budgeting for the Prize. Contestants need to be assured that prize sponsors will honor their commitments to award a cash prize or to make an AMC. Governments and other sponsoring organizations must budget for prize money that may end up being awarded ten to fifteen years in the future. Prizes can be funded in full at the start of a competition; funded through periodic contributions; or funded as a contingent liability to be paid when success is

achieved. For example, the legislation that allows NASA to offer prizes requires that NASA have all of the funding in hand (from either the private sector or congressionally appropriated funds) before announcing the prize.

Widespread Interest in the Prize. Kalil argues that decisions about whether to use a prize to achieve a particular goal should consider the ability of a prize to generate widespread interest. A prize that generates interest from potential competitors, cosponsors, and the public is more likely to be timely and worthwhile. Media attention would make it more attractive for competitors to win the prize and for cosponsors to be associated with it. In a broader sense, publicity surrounding the prize could encourage more young people to pursue careers in science, engineering, and high-tech entrepreneurship.

CONCLUSION

Kalil envisions prizes as a useful complement to, rather than substitute for, traditional grants and contracts that support technological innovation. Kalil regards prizes not as a quick fix or universal remedy, but rather as a currently underutilized tool for stimulating innovation.

Kalil provides useful starting points for the design and implementation of inducement prizes and AMCs in a number of areas, including space exploration, African agriculture, vaccines for diseases of the poor, energy and climate change, and learning technologies.

In order to institutionalize the use of prizes, Kalil proposes that the president or Congress, or both, direct agencies to identify new areas where prize competitions are likely to be cost effective, and that Congress give additional agencies authority to sponsor prizes. As the government expands the use of prizes, careful attention to design considerations will be critical to the ultimate success of the program.

Learn More About This Proposal

This policy brief is based on the Hamilton Project discussion paper, *Prizes for Technological Innovation*, which was authored by:

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  Technological progress has accounted for a large and increasing share of U.S. economic growth. The Hamilton Project's strategy calls for strong new policies in the areas of education, research and development, and intellectual property.

- **Investing in the Best and Brightest: Increased Fellowship Support for American Scientists and Engineers**
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- **Aligning Patent Presumptions with the Reality of Patent Review: A Proposal for Patent Reform**
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