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HOW EFFECTIVE ARE PRIZES AS INCENTIVES TO INNOVATION? EVIDENCE FROM THREE 20TH CENTURY CONTESTS

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Abstract

Most work in the economics literature on prizes as incentives to innovation focuses on their comparative incentive effects (e.g. Wright 1983, Shavell and Ypersele, 2001, Gallini and Scotchmer, 2001) or their theoretical design where market failure leaves little alternative to prizes as incentives (e.g. Kremer, 2000; Kremer and Zwane, 2002; Masters, 2003), in an effort to predict the economic effects of prizes. Our approach differs from this work by taking a case-based retrospective view. The paper explores the role and incentive effects of prizes in three twentieth century innovations where prizes were important – motorized flight, human-powered flight, and energy efficient refrigerators. We review the historical evidence in light of the current theoretical contributions, and suggest possible areas of future investigation.

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How Effective are Prizes as Incentives to Innovation? Evidence from three 20th century contests

1. Introduction

Several years ago, the World Health Organization and the World Bank proposed the use of prizes to induce the innovation of vaccines that would otherwise not be developed or distributed widely enough (Kremer, 2000). Others have suggested the use of prizes to promote innovation to increase Third World agricultural productivity (e.g. Kremer and Zwane, 2002, Masters, 2003). In 1990, the $100,000 Loebner prize was offered for the invention a computer whose responses to questions cannot be distinguished from a human's. The Foresight Institute (in memory of physicist Richard Feynman) has sponsored a grand prize worth at least $250,000 to spur scientific and technical progress in nanotechnology. The $10 million "X Prize" was created in 1996 to stimulate the innovation of a new generation of launch vehicles to carry passengers into space (National Academy of Sciences, 2000, www.xprize.org.)

These developments have been accompanied by heightened economic interest in prizes as incentives. Most of this work is comparative, analyzing the economic effects of prizes in relation to patents, procurement contracts, and government subsidies (e.g. Polanvyi, 1943, Wright 1983, de Laat, 1996, Chiesa and Denicolo, 1999, Llobet, Hopenhayn and Mitchell, 2000, Shavell and Ypersele, 2001, Gallini and Scotchmer, 2002). Other studies analyze the hypothetical design of future prize systems in areas where it is clear that market failure leaves little alternative to prizes as incentives to innovation (e.g. Kremer, 2000; Kremer and Zwane, 2002; Masters, 2003).

Our approach differs from this work by adopting a case-based, retrospective view. We explore the incentive effects of prizes in three twentieth century innovations where prizes played a substantial role: (1) motorized flight, (2) human-powered flight, and (3) energy-efficient refrigerators. Rather than seeking to predict how prize design will affect the innovator's behavior in untried areas such as vaccines or agriculture, we ask: how has the design of prizes in the past affected contest outcomes?

Our paper is organized as follows. Section Two briefly explores the nature of prizes as incentives, and introduces some of the central theoretical "puzzles" discussed in the economic literature on prizes. Section Three presents three case studies which illustrate key differences in the dynamics of innovation in areas where

prizes were deemed necessary. These cases are often mentioned in the economic analysis of prizes (e.g. Kremer, 2000), but not further explored. We believe that these experiences can add new understanding to the analysis of current prize initiatives.

Section Four investigates the implications of our findings for theoretical work on prizes. We consider what insights our case studies might provide in relation to discussions of determining the value of the prize, resource duplication, sequential innovations, spillovers and reputation signalling effects, and simultaneous prize and patent competitions. We find evidence of all five effects. Particularly important are the spillover and reputation signalling effects accruing to both sponsors and winners of prize competitions. We then explore the implications of our findings for three further questions related to contest design: how to ensure buyer commitment, determine who should compete, and specify what criteria should be used in choosing the winner. The conclusion indicates areas of possible future research interest.

2. Theoretical background

2.1. What is a prize system?

While prizes are often mentioned in the economic literature, few works have analyzed their incentive effects on the basis of case studies. Adding to the confusion, the term "prize" is applied in different contexts. In work on patent races, for example, the first firm to take out a patent might be seen as winning a prize (e.g. Grishagin *et al*., 2001). Prizes may reward previous work, like the Nobel or Pulitzer Prizes,[1] or promote future achievement. A distinction must also be made between *ex ante* R&D prizes (where the outcome is unknown) and related incentive systems like "patent buy-outs" (e.g. Kremer, 1998) and "rewards" based on *ex post* sales data (as described in Shavell and Van Ypersele, 2001).

In the economic literature, three basic forms of *ex ante* prize systems are described: intra-firm incentives,[2] pre-bidding signaling devices in procurement and

[1] The U.S. Atomic Energy Act of 1946 set up a Patent Compensation Board to reward militarily valuable innovations in atomic energy (which could not be sold commercially). The former Soviet Union often rewarded individual innovators for valuable ideas, sometimes as a percentage of the cost savings achieved (Shavell & Ypersele, 2001).

[2] The use of prizes within a firm – such as awards promised for cost-saving ideas from the shop floor – are often an important means by which firms can reward creative engineers and "signal" the direction in which management wishes to go. Prizes can also be awarded to individual employees (see e.g. Bognanno, 2001, Rosen, 1985, and Fullerton et al., 1999).

other contracting systems,[3] (3) *ex ante* "grand prizes" to stimulate R&D. As regards the first two, the use of prizes is well-recognized, but prizes are not (necessarily) employed to motivate invention and innovation. The third use is the focus of this paper. In an *ex ante* R&D prize system, the sponsor of the prize defines a problem to be solved, a reward for solving it, and the terms of the contest. The sponsor evaluates the different entries and determines the winner. The reward is often a large cash payment, but it may also, as in the case of Kremer's (2000) analysis of the WHO/World Bank proposal, consist of credible commitments by future buyers to purchase a given quantity of a product that satisfies specified criteria.

Historically, R&D "grand prizes" have led to important innovations. Perhaps the best known is the series of prizes offered in 1714 by the British government to the inventor who could design an accurate method to measure longitude. Many methods were proposed, but the top prize of 20,000 pounds was won by John Harrison for his chronometer (Sobel, 1995).[4] In 1775, the French Academy of Sciences offered an award of 12,000 francs for the development of artificial alkali. Nicholas Leblanc developed a process using the known reaction of sulfuric acid on common salt, ultimately leading to the growth of the 19th century inorganic chemical industry. A third important 18th century prize stimulated the development of food canning.[5]

The main benefit of a prize system is to focus innovative efforts on problems for which solutions otherwise do not seem to be forthcoming (such as medicines for

[3] Here, firms compete in the pre-contractual bidding round for a procurement contract (or another type of contract), several "winners" get a "prize," consisting of money to develop their proposals further, and the final contract is awarded the most successful winner. Such contests allow firms to "signal" their abilities, and thereby qualify for serious consideration. The "prize" conveys otherwise unavailable information about a firm's capacity to perform R&D. A more recent, non-military, instance of such a prize was arranged by the U.S. Department of Energy and the American Institute of Architects. Inventors were asked to create a solar architectural and technological landmark to cover the south wall of the Energy Department's building in Washington, D.C. The top prize of $20,000 was awarded to a design involving both hydronic and photovoltaic solar panels to maximize the use of the sun's energy throughout the year (Aveni, 2001).

[4] Most interest centered on methods to gauge longitude from the position of the stars. But John Harrison, an amateur clockmaker, insisted that it was possible to design precise timepieces that, by accurately telling the time at Greenwich, enabled a comparison with local time, and thus of the ship's location at sea. Over time, he developed timepieces of increasing accuracy, "chronometers" sufficient robust to withstand battering at sea, yet exact enough eventually to qualify for the top prize, according to tests by the Royal Navy.

[5] A prize of 12,000 francs was offered in 1795 by Napoleon's Society for the Encouragement of Industry for a method of food preservation usable by the French military. It was awarded in 1810 to Nicolas Appert, the inventor of food canning. The process utilized heat treatment of food in sealed champagne bottles (Wright, 1983, p. 704).

Third World diseases). Yet prizes also impose costs. Due to problems of asymmetric information, it may be difficult to set the appropriate size of the reward, and/or to pick the most qualified contestant. Rewards may also be arbitrary, influenced by political positioning (see Davis, 2004).

2.2. Central theoretical issues

2.2.1. Implications of prizes for social welfare

In the literature on the incentive effects of prizes, five issues in particular have been the focus of interest. Drawing mainly from theoretical work by Gallini and Scotchmer, 2002, Shavell and Van Ypersele, 2001, and Kremer, 2000), these may be briefly described as follows:

(1) Determining the value of the prize. It is generally conceded (Gallini and Scotchmer, 2002) that the deadweight welfare loss due to monopoly pricing under the patent system need not occur in the case of a prize. There are caveats to this finding: that the prize winner resigns patenting rights, that the prize-winning innovation must have a social value, and that social value must be properly calculated by the prize sponsor. The social value of a patented invention is its market valuation (assuming perfect markets). In a prize system, the valuation set by the prize sponsor substitutes for the market mechanism. To be socially efficient, the size of the prize is important. If it is too small, the prize will attract less than the socially optimal amount of resources. If too large, it will divert resources from other more efficient uses. While there is nothing which theoretically inhibits a sponsor from finding the socially correct price (prize) for an innovation, this is fact can be quite a complicated exercise, in that the social value of the prize may only be revealed *ex post*.[6]

(2) Duplication of effort. Different firms have differing cost estimates, differing technologies, differing preferences. Thus they cannot accurately read signals from each other with regard to investment choices, leading to inefficient investment and duplication of effort, with the consequent welfare losses. This raises the following

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[6] Thus the effectiveness of a vaccine cure for AIDS may appear very promising for a period of years, but may subsequently wane as new variants of AIDS appear. Similarly, an innovation which accomplishes the prize objectives in the laboratory, may upon commercial upscaling prove to be useless. In this respect, one might claim that the *ex post* valuation of the innovation, due to the nature of the patent system, might make patents superior to prizes, in that the value of the innovation would be adjusted either upwards or downwards, depending on the innovation's market performance.

questions. Firstly, to what extent might the nature of information exchange among prize contenders at times be different from that for other incentive mechanisms (for example, patents)? Secondly, might it be possible to design a prize competition which eliminates most of the waste arising from duplication of effort?

(3) Spillovers and reputational gains. While the spillover effects of patents (e.g. Griliches, 1984, Caballero and Jaffe, 1993), procurement contracting (e.g. DeGrasse, 1984, Melman, 1986, Rosenberg, 1986) and subsidies (e.g. Goolsbee, Klette, *et al*, 1998, Katz and Ordover, 1990) are relatively well researched, we have found no systematic account of the spillovers characteristic of prize contests. A related issue has to do with the reputational gains associated with prize contests. In accordance with Sutton's logic (1991), one might contend that sponsoring or winning a prize constitutes a sunk cost signal to consumers. This is a form of advertising effect that both sponsors and winners can use to their advantage, both with respect to the prize-winning performance or prototype, and with respect to their other activities.

(4) Sequential innovations. Given the sequential nature of innovation, the question of when to award the prize becomes critical. If a prize is given prematurely, a subsequent superior invention will not be adequately rewarded. Why should firms continue to invest in improving an existing product or inventing a new one, if the profit rate is not sufficient to justify such an investment? But the prospect of this occurring may negatively affect inventors' initial incentives to invest. Prize systems can be set up so that the definition of what is most worthy is not specified in advance. But as Gallini and Scotchmer (2002) have pointed out, where innovation is cumulative, administering the system becomes particularly cumbersome.

(5) Competition between patents and prizes and firm strategic choice: the problems of co-existence. Very generally speaking, the majority of publications on patents and prizes have tended to be formal analytical comparisons of the two systems, either in terms of their incentive effects, or in terms of a common problem such as that of sequential innovators (see sources cited above). Some proposals specifically require that the prize-winning invention be bought up (in a one time payment) and put directly into the public domain, to avoid the subsequent use of patents to protect prize-winning inventions (e.g. Masters, 2003). Yet this might also create a disincentive to firms to invest in R&D in the first place. What has been lacking here, in our opinion, is a closer analysis of firm strategies given an

environment where both patents and prizes are available. Two issues seem particularly relevant.

Firstly, how can individual firms combine the two systems to maximize the return from their innovative efforts? Neither patents nor prizes are awarded in a vacuum. How do the incentive effects of prizes affect the incentive effects of patents (and vice versa) in terms of firm strategy and, ultimately, the social direction of innovation?

Secondly, the ability of a prize winner to patent his innovation arguably deprives the prize of its major advantage over the patent, since the patent will give the prize winner monopoly rights over his discovery. As it is precisely the absence of such monopoly rights which makes prizes attractive (see the comments above), such a dual incentive system may be unnecessarily costly in social welfare terms.

2.2.2. The problem of contest design

The most influential recent work on issues of contest design is Kremer's (2000) discussion of the WHO/World Bank proposal proposal to give pharmaceutical corporations the incentive to develop new vaccines against malaria, tuberculosis and HIV, and to distribute them to people in need. Two problems in this regard – setting the prize size, and discovery sequencing – were discussed in the previous section. Three further issues are pertinent in this context (see also Kremer and Zwane, 2002, and Masters, 2003). As Kremer (2000) argues, impartial, transparent rules are necessary to ensure that buyers are committed to purchasing successful vaccines, to specify who is eligible to compete, and to establish the criteria by which the different entries are to be judged. These are briefly outlined below.

(1) Ensuring buyer commitment. Kremer emphasizes that in the case of vaccines for the Third World, a prize system must be designed to convince pharmaceutical firms that potential buyers are committed to purchasing a vaccine that has not yet been developed. If firms are unable to sell their vaccines at a high enough price, they will lack the incentive undertake the costs and risks of R&D.

(2) Who should be eligible to compete? A contest can be completely open, or restricted to particular types of contestants. Kremer, for example, emphasizes the importance of ensuring that vaccines developed by imitators are not candidates for awards, to provide real incentives to engage in R&D.

(3) On what criteria should the contestants be judged? Kremer analyzes at length the thorny issue of selecting a winner. The conditions for winning (in the case

of vaccines: safety, efficacy, and applicability to Third World conditions), he emphasizes, should be clearly stipulated. But how can the prize sponsors know who should get the prize? (One aspect of this question, as noted above, is that even if a successful candidate is found, awarding the prize to this vaccine might preclude the development of an even better vaccine in the future.) Should bonuses be awarded for vaccines that exceed specifications? How can potential buyers choose among multiple candidates for the vaccine?

3. Three 20th century innovations where prizes were important

3.1. Motorized flight

3.1.1. Prizes as incentives to R&D

More prizes have been offered for achievements in aviation in the past century – by newspapers, business interests, individuals, and governments – than in any other technical area (National Academy of Sciences, 2000). Sponsor motivations have included a fascination with flying, along with a desire to spur innovation and reap the reputational advantages (and profit-making opportunities) of being associated with dramatic flying feats.

At the beginning of the 20th century, for example, wealthy petroleum magnate and aviation enthusiast Henri Deutsch de La Meurthe sponsored the Deutsch prize of 50,000 francs, for the first person to fly around the Eiffel tower within a half hour (this was won by the Brazilian Santos Dumont in 1901). In 1904, Ernest Archdeacon, a prominent Parisian lawyer and founder of the Aero Club of France, established a series of prizes, starting with a silver trophy – the *Coupe d'Aviation Ernest Archdeacon* – for the first person to fly a motor-powered airplane 25 meters. The Aero-Club de France put up a prize of 1500 francs for the first aviator to fly 100 meters. Archdeacon Deutsch de la Meurthe also announced the 50,000 franc *Grand Prix d'Aviation* to reward the first to fly a one-kilometer circle. The London *Daily Mail* offered a 1,000 pound prize to the first to fly across the English Channel. Many adventurers competed to win these prizes.

But the first pilots actually to fly an airplane – Wilbur and Orville Wright, on December 17, 1903, at Kitty Hawk, North Carolina – were not among them. At first, the news of the Wright brothers' feat did not attract much attention. This apparently suited the brothers, who had always been quite secretive, fearing that others would copy their invention. During the next five years, they refused to enter any contests or

demonstrate their invention publicly, focusing on patenting it both at home and abroad, improving it, and negotiating with interested military and/or civilian parties for its further development. In 1906, their U.S. patent application was finally approved. They licensed out the patent rights to companies in France and Germany to manufacture and sell their aircraft. The U.S. army signed a $25,000 contract with the Wright brothers in 1909.

Meanwhile, in the United States, different entrepreneurs became involved in airplane manufacture, including motorcycle manufacturer Glenn Curtiss, and Alexander Graham Bell, inventor of the telephone. One of their first projects was to build a small glider patterned after the Wright design, based in part on information provided by the Wrights. When Curtiss won a prize with a later aircraft (a contest in which the Wrights had again declined to compete), the brothers reminded Curtiss they had freely shared information with his company. Curtiss could use the patented control system for experimentation, they added, but not the patented features of their machines for exhibitions or for commercial gain. Apparently undeterred, Curtiss further developed his airplane, achieving worldwide fame in 1909 by winning the Gordon Bennett Cup Race and the *Prix de la Vitesse*. His company continued to grow.

After 1908, the Wright brothers became involved in patent lawsuits both in the United States and Europe. In the U.S., they sued Curtiss for using a stabilizing device, the aileron, on his plane, which they insisted was their own patented invention. In France, they sued the flier Henri Farman for patent infringement. In 1912, the brothers suffered a major defeat when a German court ruled that their patent should only be recognized in terms of how it involved the coupling of the rudder and wing warping in simultaneous movement (separate wing warping was judged to be common knowledge), eventually leading the Wrights to give up their presence in Germany.

Further prizes contributed to the development of the international airline industry. In 1919, the London *Daily Mail* offered a prize of 10,000 pounds (worth roughly 300,000 pounds today) to reward the first person to fly non-stop across the Atlantic Ocean. The Australian government offered a similar prize for the first flight from England to Australia, the longest flight ever made. Both were won later that year. The $25,000 Orteig Prize, offered by New York hotel owner Raymond Orteig for the first non-stop flight between New York and Paris by a pilot flying alone, was finally claimed by Charles Lindbergh in 1927. (For further details, see Ackman, 2003,

www.charleslindbergh.com, www.militarymuseum.org, www.libraries.wright.edu, www.nasm.si.edu/wrightbrothers, www.first-to-fly.com, www.centennialofflight.gov)

3.1.2. How effective were prizes in inducing innovation?

What were the Wright brothers' incentives to invent? The major prizes for flying motorized craft, as noted above, were announced *after* their successful 1903 flight. Initially, the brothers sought to protect their invention through secrecy and patenting, and by negotiating for a military contract. They also appear to have been motivated by the sheer love of invention. Only when potential buyers insisted on public demonstrations did they agree to do so.

As regards the development of the commercial airline industry, the outbreak of World War I in 1914 played a colossal role. Stimulated by government contracts and demands for new aircraft, vast improvements were made in techniques for design and construction. After the war, a large number of aircraft became available at very low prices. Stunt pilots bought them up and entertained the public, maintaining public interest in civilian aviation. In Europe, the first commercial airplane routes were served by wartime pilots flying decommissioned warplanes.

During the 1920s, governments also provided large subsidies to establish national airlines like British Airways, Air France, and KLM. In the United States, the introduction of airmail service required the establishment of a nationwide airport system. In 1925, the U.S. government began to subsidize private carriers to deliver the mail (and in some cases to carry passengers as well). Among these solo fliers was Charles Lindbergh. The four major U.S. airlines, Pan Am, American Airlines, TWA, and Delta, were founded between 1928 and 1931.

Given the importance of patents, government contracts, and subsidies in the innovation of the airplane, what role did prizes play? Clearly, they contributed to these developments. Thus even if the Wright brothers refused to participate in competitions, they still kept a wary eye out as to what was happening in Europe (and actually did participate in several contests, winning the Michelin Cup in 1908). Lindbergh's successful 1927 flight caught the public imagination, further stimulating the growth of the international commercial airline industry. Later, he carried out survey flights for the development of passenger and airmail routes, and thus at least indirectly contributing to the commercial establishment of the U.S. airline industry.

Yet it is difficult to judge how much innovation can ultimately be ascribed to prizes. To what extent, for example, would Glenn Curtiss have gone ahead and

invested in his airplane business, even if he hadn't won a prize? Might not the European contestants (and their backers) in the first decade of the 20th century, even without the opportunity to win a prize, have been goaded into action by the Wright brothers' commercial foray into European markets? Alternatively, if the Europeans had concentrated on patenting their technologies rather than winning prizes, might they not have gained a stronger head start? Finally, there can be little doubt that the advent of World War I, along with heavy government support in the establishment of their national carriers in the 1920s, provided the major stimuli to innovative activity in airplane technology – developments which would never had occurred with prizes alone.

3.2. Human-powered flight

3.2.1. Prizes as incentives to R&D

After the development of the commercial airline industry, aviation enthusiasts applied their imaginations to another area: human-powered flight. A few small prizes were offered in Germany, Italy and the U.S.S.R. in the 1930s for achieving this goal, but were never claimed. Two decades later, the English Manpowered Aircraft Group began experimenting on human-powered flight as a hobby. Among the group's members was the head of a company owned by British industrialist Henry Kremer. In 1959, as the story goes, during a three-martini lunch, the man told Kremer that the group's efforts were not progressing very rapidly. Kremer then offered a £50,000 award for the first human-powered aircraft that could fly around a mile-long, figure eight course. The result was a burst of research into human-powered flight.

After eighteen years, the prize was won by an American, Paul MacCready. Observing the flight patterns of hawks and vultures, he had noticed that as a wing grew larger, it required less aerodynamic lift to keep it aloft. A plane capable of winning the Kremer prize, he realized, did not have to be elegant like a sailplane, or even satisfy the structural-safety margin for a regular hang glider (since it only had to fly once). His entry, the 70 pound bicycle-powered *Gossamer Condor,* built of simple light-weight materials (like Mylar, piano wire, aluminium tubing, and tape), with a 30-meter wingspan, didn't even look like a plane. In 1977, it became the first human-powered vehicle to achieve sustained, manoeuvrable flight. (www.achievement.org).

Kremer then announced a second prize of £100,000 for the first human-powered aircraft to cross the English Channel. To this end, MacCready and his team did not

design a new plane, but reshaped the *Condor* to fly on about a third less power. To finance this venture, MacCready approached the Dupont Company, whose materials they were using – particularly the Mylar skin that covered the plane, and Kevlar (which is by weight five times stronger than steel). In 1979, the *Gossamer Albatross*, piloted by bicycle racer Bryan Allen, successfully made the crossing in 2 hours and 49 minutes.

Kremer then announced a third prize in 1979 of £10,000 for the first non-U.S. citizen to fly the figure-of-eight course (won in 1984 by Gunter Rochelt). In ensuing years, Kremer and the Royal Aeronautical Society sponsored several further prizes, aimed mainly at rewarding new speed records, and inducing the development of smaller, more manoeverable, more practical craft, to give the sport wider appeal. (For further details, see Carlson, 1997, www.achievement.org, wwwww.dupont.com, www.www.nebulasearch.com/encyclopedia/article/Gossamer_Albatross, www.wikipedia.org,)

3.2.2. How effective were prizes in inducing innovation?

What were MacCready's incentives to invent? Clearly, he loved flying: he had built model planes in his youth, trained as a Navy pilot, taken a Ph.D. in aeronautical engineering, and won several hand glider competitions. But his specific reason for competing for the Kremer Prize, by his own account, was financial. He had guaranteed a loan for a relative's business, and when it failed, he incurred a $100,000 debt. In 1976, MacCready realized that the Kremer prize, in which he had earlier shown no interest, was just about equal to the debt he owed. (www.achievement.org).

After winning the prize, MacCready continued to experiment with aircraft and environmentally friendly technologies. By studying energy storage in batteries charged by the pilot's pedaling, his team learned how to make more efficient use of very limited battery power. This contributed to the development of the electric car. MacCready designed several solar-powered craft, not to win prizes, but to publicize the power of solar energy.[7] In 1990, a cooperation with General Motors produced the Impact, an efficient battery-powered electric car that could accelerate from zero to 60

[7] In 1981, his *Solar Challenger* flew 163 miles from Paris to Canterbury, England, reaching an altitude of 11,000 feet. MacCready's Bionic Bat (short for battery) was awarded another Kremer Prize for human-powered air speed. In 1987, to compete in a race across Australia, MacCready built the high-performance solar-powered Sunraycer. In August, 2000, MacCready's solar powered aircraft Helios, built by his company AeroVironment, reached an altitude of 96,000 feet, breaking the high altitude record for an airplane.

mph in eight seconds. Other prizes were offered for innovation in human-powered transport.[8] Data from the *Gossamer Albatross* contributed to several high altitude projects in the United States, like the Pathfinder. Both the Department of Defense (seeking to develop a remote-controlled craft that could stay aloft for long periods of time), and NASA (seeking to create an airborne platform to observe the atmosphere), utilized his designs. There is also a small market for Microlite aircraft (tiny two-seater motorized gliders), which built on MacCready's technology. Thus prizes not only "kick-started" MacCready's business career, they also inspired numerous innovative activities in related technologies, with various spin-off benefits. While human-powered flight never spawned a big new industry, it did lead to the development of commercially viable niche markets, not least the electric car.

In this connection, it is interesting to consider what sponsorship of MacCready's endeavors meant for Dupont. Two leading Dupont products, Mylar and Kevlar, due to their strength and lightness, were used for the *Gossamer Albatross*. But neither were developed specifically in relation to the Kremer prize (Mylar was introduced in 1952, Kevlar in 1971). Both synthetics are were trademarked and heavily patented, and are still in wide use today (Kevlar still generates hundreds of millions of dollars of annual sales for the company worldwide.)

So why did Dupont sponsor MacCready's wild scheme? During the flight of the *Gossamer Albatross*, the company's name was featured prominently on the body of the plane. TV exposure generated a stream of favorable publicity. Perhaps Dupont was genuinely inspired by the venture; perhaps it hoped to shed its image among certain groups as a chemical polluter. When MacCready later approached Dupont to financially back the invention of a solar-power plane, the company agreed. In 1983, Dupont itself sponsored a prize for the first human-powered vehicle that could break 65 mph. This was claimed three years later, and itself had a "spin-off" effect: the winner now manufactures bicycles called Easy Racer Recumbents in California. Dupont has additionally sponsored a prize for human-powered watercraft.

3.3. The development of energy-efficient refrigerators

[8] Successful businessman and race car enthusiast Ed Dempsey, for example, has offered a cash prize of $25,000 for the first single-rider human-powered land vehicle to reach or exceed 90 kilometers in one hour. Another example is the Human-Powered Vehicle Association (HPVA), which over the past two decades has sponsored three prizes

3.3.1 Prizes as incentives to R&D

The development of the super efficient refrigerator was the first initiative of the "*Golden Carrot*" awards, sponsored by the U.S. Environmental Protection Agency, in partnership with non-profit companies, utilities and environmental groups. The goal was to provide financial incentives to encourage manufacturers to develop and market more energy efficient appliances (it was thus a voluntary program, as opposed to the regulatory "stick"). Under a Golden Carrot program, several utilities could pool the rebates they offered to customers who purchased efficient appliances, providing a clear market signal (a guaranteed pool of rebate money) for appliance manufacturers to commercialize advanced energy efficient appliances.

In the mid-1980s, several U.S. utility companies, including Pacific Gas & Electric (PG&E), and Southern California Edison (SCE), had been investigating ways to increase energy savings from their refrigerators. Federal regulations, based on the Montreal Protocol, required a phase-out of CFCs. Yet since non-CFCs were less effective coolants, this would *ceteris paribus* decrease refrigerator efficiency. Consumers were reluctant to pay a premium for efficiency. To induce manufacturers to undertake the costs and risks of developing highly efficient, environmentally friendly *and* affordable refrigerators, a powerful new incentive was required.

The result was the formation in 1991 of the Super-Efficient Refrigerator Program (SERP), a non-profit consortium of 24 utilities based in Washington, D.C., representing 21% of U.S. households. The idea was to enable utilities to "seed" a market transformation, and then withdraw, letting manufacturers take over, mass produce and market the product without further subsidization. SERP offered a prize of $30 million to reward the manufacturer that developed and successfully marketed a competitively-priced, CFC-free refrigerator that used at least 25% less energy than existing regulations prescribed.

Each utility would decide how much it wanted to invest in the initiative, based on a calculation of the cost savings it expected to achieve. After the winning contestant was found, each utility would receive a number of refrigerator units proportional to its investment. To deal with potential problems of free-riding, when SERP refrigerators were sold to customers outside a participating utility's service territory, the utility would be compensated via the original funding pool.

Contestants had to demonstrate experience with the specific technologies proposed, and present a feasible production, marketing and tracking plan, along with a

delivery schedule to retail outlets. The manufacturer would be responsible for getting the super-efficient units into the retail distribution chain in each utility's service area, at prices comparable to conventional units with the same features. For each unit sold, the winner would receive an "incentive check" according to the sales tracking information provided by the company. Thus the SERP incentive did not involve the up-front funding of R&D, but would be disbursed as payments for each refrigerator distributed by the manufacturer. To enter the contest, a company had to have manufactured at least 100,000 refrigerators annually for the previous four years.

The SERP board had chosen a "winner takes all" program in the belief that this would spur strong competition to stimulate manufacturers' technologies, with the most cost-effective results. Yet potential entrants faced an extra risk. Manufacturers typically release a new product to a limited test market, allowing them to iron out the bugs before broadly distributing the product. This test market period was completely eliminated for the SERP refrigerator.

Safeguards were established to protect confidential information during the bidding and pre-production phases, to encourage manufacturers to be forthcoming with their technological, marketing and tracking ideas. Representatives of the manufacturers were not permitted to serve on the SERP board, attend advisory committee sessions or participate in the initial program design. The manufacturers' input and submissions were not disclosed to their competitors, or the public. The contest designers ensured that program did not conflict with antitrust regulation.

In July, 1992, SERP distributed its Request for Proposals to all potentially interested manufacturers. Fourteen manufacturers submitted bids. Two semi-finalists were chosen, and asked to produce prototypes and submit final offers. In June, 1993, the winner was announced: the Whirlpool Corporation. Its design did not involve developing a radical new technology, but represented a refinement of its most efficient current technology. The refrigerator was CFC-free, and used some 30% less energy than required by the 1993 federal energy standards. In 1995, Whirlpool improved its own technology to be 40% more efficient than the 1993 Department of Energy standards. (International Institute for Energy Conservation, 2004). To realize its winnings, Whirlpool had to sell 250,000 super-efficient refrigerators by July, 1997.

Nevertheless, as energy prices fell in the 1990s, no large market developed for the refrigerator. Sales were reportedly 30-35% below the target. Whirlpool ceased production of the appliance, before the deadline had expired. Consumers were

apparently unwilling to pay for highly energy-efficient products. In addition, the American Home Appliance Manufacturers trade group had lobbied successfully to delay the adoption of the new standards, from 1998 to 2001. Whirlpool reportedly quit the association in protest.() (For further details, see International Institution for Energy Conservation's report on the Super *Efficient Refrigerator Program*, accessed January 16, 2004, available at sol.crest.org/efficiency, www.ecomail.com, along with www.ecomall.com/greenshopping/icebox2.htm, www.gcrio.org, homeenergy.org, and www.whirlpoolcorp.com.)

3.3.2. How effective were prizes in inducing R&D?

Critical to the decision to use a prize was an evaluation by the U.S. Environmental Protection Agency as regards the potential and cost-effectiveness of various refrigerator technologies:

> It determined that cost-effective technologies did indeed exist and that there were a variety of ways that manufacturers could utilize those technologies. The evaluation suggested that there could be a healthy design competition and that in the end no one manufacturer could corner the market of super efficient refrigerators by owning patents or technologies. (Quoted in International Institute for Energy Conservation, 2004, p. 4).

This indicates that the EPA did not feel the super energy-efficient refrigerator would be forthcoming under the normal market incentive conditions provided by the patent system. In the words of Kremer (2000), the market had to be "created." The stated purpose of SERP, in fact, was to bring about the commercialization of energy-efficient refrigerators ahead of normal market projections. According to the terms of the contest, the winner was responsible for marketing the refrigerator. Whirlpool could mention its product in press releases, but could not feature it as part of a national advertising campaign, since the target market was limited to the service territories of the utilities participating in SERP. Thus there were clear *ex ante* limitations to the market that could be created.

While the design of the winning refrigerator itself was not new, the special tracking system developed by Whirlpool, ExacTrack, a proprietary system, reportedly played a central role in SERP's decision to declare Whirlpool the winner. To ensure that retailers provided accurate details of refrigerator sales, Whirlpool charged a slightly higher wholesale price for the units, but reimbursed the retailers for that amount after they had submitted information on sales: ExacTrack enabled it to keep reliable records in this regard. Thus while Whirlpool could apparently not patent its

invention, it could boast at least one proprietary advantage. SERP benefited as well. ExacTrack provided utility providers, for the first time, with accurate information about where and how the appliances were being used (which could also be used for larger purposes, such as identifying regional markets and market behaviour).

Winning the Golden Carrot award brought Whirlpool considerable national publicity. *Business Week*, *USA Today*, and numerous television news programs carried features about its prize-winning design. A prototype of its model was displayed at the White House and described in a Presidential speech.

An alternative incentive to prizes, in this instance, could have been consumer rebate programs (such as refundable credits for income taxpayers that purchase energy-efficient appliances, and/or deductions that could be employed by all taxpayers that install energy conservation measures). Whirlpool's Program Manager for Refrigeration Technology later noted, in fact, that while the company had enjoyed some spectacular publicity in connection with the award, and even if he would bid on another Golden Carrot if he felt it were in the company's interests:

> He still favored traditional consumer rebate programs over Golden Carrot programs because rebate programs eliminate the need for a sophisticated and expensive tracking system as well as the financial risks of a winner-takes-all contest incurred by manufacturers. Whirlpool thinks that the rebate programs should be standardized across the country and that utilities should limit the rebate requirements to the level of energy efficiency and let manufacturers determine which technologies to use to achieve that level. (Quoted in International Institute for Energy Conservation, 2004, p. 18).

The total costs of this program, in 1990 U.S. dollars, have been estimated at $26.3 million (International Institute for Energy Conservation, 2004). Participating utilities also incurred administrative costs (such as board meetings and program administration), and allocated resources in areas they otherwise might not have considered, possibly leading to the less efficient overall use of resources. Offsetting these costs were the considerable energy savings achieved, and lower environmental pollution.

Several further "spin-off" benefits can be noted. After Whirlpool won the prize, other manufacturers, such as General Electric, Amana and Frigidaire (the contest runner-up) all began to produce super-efficient CFC-free refrigerators. Whirlpool itself has continued to develop and market new energy-efficient appliances.[9] Even so,

[9] This work been honored over the past ten years by numerous awards at the state, federal, and even international levels (for details, see Whirlpool's home page). Even though it discontinued its

the company did choose to discontinue its prize-winning refrigerator. This suggests that a prize, while it can be highly effective in inducing innovation, cannot necessarily sustain the commercial development of that innovation, if the external environment (here, in particular, the regulatory framework) is not conducive to that end.

4. Some implications of our findings for theory

What insights might our historical evidence offer as regards current theoretical understanding of the welfare effects of prizes, and problems of contest design?

4.1. Welfare effects of prizes

(1) Determining the value of the prize. While the issue of prize size does not seem to have been relevant in our cases, it is noticeable that nowhere is there evidence of an *a priori* calculation of the social value of the prize. For example, how did Deutsch de la Meurthe arrive at a figure of 50,000 francs for the first aviator to fly in a one-kilometer circle? What was the calculation behind the *Daily Mail'*s 10,000 pound prize in 1919 for the first person to fly nonstop across the Atlantic? Clearly, to the degree that the sponsors denoted a prize which exceeds or falls short of the social value of the innovation or aviation feat (with its associated innovations) concerned, there would have either been underinvestment or overinvestment in R&D.

(2) Duplication of effort. Our cases provide several interesting insights in this regard. Firstly, the nature of information exchange among the contestants in our early aviation case, if further investigated, may prove to have led them in complementary directions. There was a succession of prizes, each for greater performance and achievement. The contestants engaged in repetitive competitions for these prizes and could reiteratively observe changes in the design and performance of their competitors' machines. In addition, there is evidence that the contestants "borrowed" ideas from each other (both Archdeacon and Curtiss did so, among others). Thus there were apparently two forms of competition: a prize competition where contestants were willing to share information to improve their chances of winning a prize in the short term, at the cost of revealing valuable design information; and a patent

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SERP model, it has introduced a new generation of high performance, energy efficient appliances, using as its benchmark for success the ENERGY STAR rating system, a label developed by the United States Department of Energy and the Environmental Protection Agency to help consumers identify products that save energy and help protect the environment, and that are significantly more efficient than required under current federal standards.

competition in which one major innovator eschewed competing for a prize in the hopes that its patent rights could be successfully defended in the longer term. This raises some interesting questions as to the degree to which the two differing forms of competition affected each other and their over-all effect on innovative efficiency in this growing industry. (One such study, dealing with similar interdependencies at 19th Century World Trade Fairs, is Moser, 2003).

Secondly, the SERP contest for energy efficient refrigerators was deliberately designed to minimize duplication of effort. The sponsors sought to gather all available information as to the capabilities of the different contestants – their technological, marketing, and tracking ideas – through establishing safeguards ensuring that no contest information would be made available to competitors. Based on this information, SERP selected two semi-finalists to make prototypes and submit final bids. These features of the SERP prize winning process are reminiscent of Scotchmer (1999). Further duplication might have been avoided had only one finalist been selected. (The finalist would still have had to develop the refrigerator and sell 250,000 appliances to qualify for the prize).

(3) Spillovers and reputational gains. There were significant spillover effects in the early aviation contests, since the participants could observe each other's aircraft design and performance. (One reason the Wright brothers refused to compete was ostensibly their fear that their patent pending warped wing design would be copied). The prize-winning technology developed by MacCready and his team spawned advances in battery technology and contributed to the emergence of niche markets like Microlite aircraft and the electric car. It also led to design improvements in craft desired by the US Defense Department and NASA.

A somewhat different kind of "spillover" may occur to the degree that the competition for a patent could cause weaker competitors to exert pressure on the prize sponsor to change the rules of the contest, or otherwise affect the economic fortunes of a winning design. The "factoring in" of such industrial strategies might be seen in the fate of the SERP refrigerator contest. Since most contestants were eliminated from this contest early on, they had an incentive to lobby (successfully) to delay the new energy efficient standards from 1998 to 2001, the very standards which were to make it possible for Whirlpool to sell the required number of refrigerators and collect its

prize. To be successful, prize designers must be aware of how contestants factor the contest into their over-all competitive strategies.

Well-publicized prize contests can signal prize winner and sponsor reputation in a manner few patent races can. That Curtiss won both the Gordon Bennett Cup Race and the *Prix de la Vitesse* contributed to his nascent firm's later success. The human powered flight prizes certainly highlighted Dupont's Kevlar and Mylar products, giving Dupont the incentive to sponsor yet another MacCready venture. This also undoubtedly established MacCready's reputation as an entrepreneur. Even Whirlpool, despite the failure of its prize-winning machine, enjoyed the reputational benefits of becoming the sole qualifier for the prize. Thus the impact of prizes on reputation, we feel, is a much overlooked phenomenon. They alone can provide the economic justification for a sponsor to design the contest and for contestants to enter.

(4) Sequential innovation. The incentive problems associated with sequential innovations (as described in Section 2.2.1.) were found in our cases as well. A complicating factor is that one motive for the prize sponsor might be that her prize would enable subsequent discoveries or improvements without the hindrance of a patent thicket or other economic barriers to discovery. The problem would be that given the low cost of the unpatented discovery, only potentially major breakthroughs or improvements on the first discovery would be worthwhile investing in, even if the breakthrough was patentable.

A possible solution would be to have a prize scale, so that discoveries or inventions subsequent to the first prize winner would also be rewarded. In our cases, examples of this include the sequence of prizes awarded for aviation feats, and the sequence of Kremer prizes for human-powered flight.

(5) Competition between patents and prizes and firm strategic choice: the problems of co-existence. Prizes can be used where patent protection for an innovation proves impossible to obtain, should the innovation not fulfil the criteria of patentability (novelty, non-obvious, and industrially useful). A prize system can reward firms that combine known technologies to solve a given problem, but also hinders firms from spending millions in developing patentable technologies for the same purpose. There is evidence that in the SERP contest, Whirlpool did not engage in any significant new innovation, but worked off technologies already proprietary to the company. To the degree that the combination of these technologies did not involve an inventive step, the Whirlpool design would not have been patentable. As far as we

have been able to determine, MacCready's aircraft did not embody any new, patentable inventions (though certain of the materials used, such as Mylar and Kevlar, had been patented years earlier).

Moreover, "pure" prize systems (that do not entail *ex post* patenting of winning entries) fail in one critical respect: To the degree that they are based on performance alone, winning the prize provides no guarantee that the invention will be further developed. In fact, given the increased costs of commercialization and marketing, the winner has no such incentive. A related example here is the discovery of penicillin by Alexander Fleming. Although famous for his statement "Can one patent the sun?," Fleming's unpatented discovery, perhaps the most significant in medical history, went undeveloped and unimproved for years. It was not until 1939-40 that a group of Cambridge scientists, using university laboratory equipment (at university cost) refined penicillin to the degree that it was useful. To guarantee that a winning innovation is commercialized, the prize sponsor must either (like SERP) specify a marketing goal as a prize criterion, allow the invention to be patented, or otherwise support the winner. The proposed scheme for new vaccines (Kremer, 2000), for example, involves recipient government co-payment arrangements for the prize winners as a form of guarantee that the winning vaccines would in fact be used.

4.2. The problem of contest design

(1) Ensuring buyer commitment. In all three cases, this problem did not appear to be important, perhaps because the prizes were offered for quite narrowly defined feats, perhaps because there was not too great a gap between the costs of investing in R&D in these technologies, and the marginal costs of production. While the Wrights did find their investment was copied, it was not because the prize sponsors refused to pay, but because their patent position proved relatively weak.

(2) Who should be eligible to compete? An intriguing aspect of the story of early aeronautics concerns the "nationalistic" role played by prizes. After hearing rumours of the Wright brothers' successful flight, Ernest Archdeacon responded not only by commissioning the construction of a flying machine inspired by the Wright craft, but also by sponsoring a series of prizes to induce inventive activity in Europe, especially France, with its long history of aviation experiments. These French prizes were, indeed, mainly won by Europeans (along with the Brazilian Santos Dumont). But was this because the Wright brothers refused to participate? In the U.S., the Aero

Club of America and *Scientific American* magazine, aware of how prizes had spurred European flying, sponsored their own contests. Apparently they hoped to induce the Wright brothers to compete (they refused) – even so, the first winner of this prize was another American, Glenn Curtiss. To what extent, then, were prizes used to promote national glory, and to what extent inventive activity more generally?

In the case of human-powered flight, it would seem that Kremer intended for the prize to be won by the English group that originally inspired the prize. His third prize was specifically targeted for a non-American. This raises the question: what would have happened if Kremer had simply subsidized the English group? Further, without the prospect of winning the prize, would MacCready have gone into debt (and never recovered enough to engage in his later innovative work)? Or would he have found some other backing?

Finally, in the case of super-efficient refrigerators, the contestants all had to be experienced manufacturers. They had to market their refrigerators in the service areas covered by the prize financiers, and accurately track sales. This effectively excluded any start-up companies that might have wished to compete – companies which (at least hypothetically), being unburdened by past technologies and staff expertise, might have been able to devise an even more innovative, cost-effective solution.

(3) On what criteria should the contestants be judged? In our cases, as noted above, the criteria for winning were well-defined. The aeronautical prizes were offered for specific feats, such as flying across the English Channel; in the refrigerator contest, entrants had to surpass regulatory requirements by a given percent. Thus there could be little ambiguity as to who was the winner.

Our story of human-powered flight underlines a little noticed aspect of such competitions: the prize can be won by an entry that seeks specifically to satisfy the conditions of the prize, but that otherwise has no practical applicability. MacCready's victorious craft were built to last for only one flight, using piano wire and tape, among other things, to ensure structural integrity, something which would never be permitted on any "real life" flight. The commercial importance of this flight, thus, seems to have had little if anything to do with the winning design, but with related technologies and other "spin-off" technologies, as recounted above. This raises an important question with regard to prize design: Should this prize have been designed differently – perhaps specifying explicitly that the result also had to be capable of sustained flight (this, for example, is a criteria of the current X-prize for manned space vehicles).

5. Conclusion

The prize systems in our cases represent a variety of motivations and outcomes. The early aviation contests stimulated the innovation of bigger and better aircraft, as fledgling firms competed to achieve ever increasing performance goals (thus a prize to cross the English Channel was followed fifteen years later with a prize for the first trans-Atlantic flight). Thus prizes contributed to the development of two huge industries: aircraft manufacture, and international air service. The prizes for human-powered flight provided no immediate commercial gain, but did stimulate related innovation in environmentally friendly technologies, and provided inputs into military and space programs. Finally, the prize for energy efficient refrigerators is valuable for what it demonstrates about the use of incentives to achieve the most efficient prize outcome (if not for its successful commercialization). What areas of future investigation are suggested by these results?

First of all, our findings demonstrate a need to investigate more closely the spillover and reputation signaling effects from prize activities. Whirlpool's development of ExacTrack benefited the utilities sponsoring SERP. Dupont reaped sufficient reputational gains from the *Gossamer Albatross* that it backed MacCready's later solar powered aircraft. To return to Kremer's analysis of the vaccine proposal, the marketing costs of new drugs can run into the hundreds of millions of dollars. A biotech firm that wins a widely recognised prize for a anti-AIDS vaccine might reap many millions in saved marketing costs and extra sales, not only for the vaccine concerned but for other products also identified with the prize winning firm.

Thus prizes have important positive externalities for their sponsors. For one thing, prizes promote innovative activities of sponsor interest and divert societal resources towards these ends. For another, prizes signal a "sponsor profile" to the world at large. A major theme in the technology management literature concerns the puzzle of how utilise scarce R&D resources to maximise corporate R&D returns. This literature ignores the possibilities for augmenting existing R&D efforts with prize contests, in a sense "outsourcing" R&D. Through designing contests aimed at non-core R&D activities, a firm can draw on outside resources while reducing internal R&D overheads. Such a strategy might not yield significant R&D savings, but, depending on the nature of the contest design, give the firm's R&D managers access

to a wealth of informative material which otherwise might not be obtainable, even should the prize never be awarded.

In a period where advertising, branding and trademark budgets are running into billions of dollars, it is clear that a well-advertised prize rewarding an innovator for a product or service widely acknowledged as being in the public interest can promote sponsor advertising as well. This positive externality could conceivably more than defray sponsor costs of contest design and the prize itself. Similarly, one can claim that successful prize winners also enjoy a reputation effect, as evidenced in the Goasamer Albatross case. Here, MacCready's success paid off in his finding sponsors to other lucrative innovations.

Several further points might be made. One concerns the combination of prizes with alternative methods of appropriability and/or incentive systems, and how these affect firm choices. Firms can appropriate rents from their investments in R&D by the use of patents, secrecy, other legal methods, lead time, and complementary investments in sales, services and manufacturing (e.g. Cohen *et al.,* 2000). The Wright brothers, for example, eschewed prizes for patents and secrecy. MacCready combined prizes with lead time (when Kremer's 100,000 pound contest officially opened, the *Gossamer Albatross* had already been flying for six months, see Carlson, 1997). Whirlpool combined prizes with complementary investments in sales and services.

In addition to patents and contracts, further incentives to supplement a prize system include subsidies, partnerships with university researchers, and tax incentives. The Wright brothers, for example, preferred patents and military contracts to prizes. Other permutations are exhibited - or suggested – in the cases. Thus to promote the development of energy-efficient refrigerators, consumer rebates might have been preferable to prizes (according to Whirlpool's Program Manager, as cited above). Possibly, a combination of subsidies, rebates and prizes would have been superior to prizes alone. This indicates that the incentive effects of prizes will vary considerably, according to which combinations are permitted (in terms of contest design), and can occur (depending, for example, on the nature of the resulting invention).

A related implication is that the terms of the contest *per se* may be less important than is often assumed in the literature. In our case studies, the winning inventors saw prizes as one of a range of possible inducements to engage in innovative activity. Where prizes suited their purposes, they competed for them, but rarely was the prize *the* motivating factor. Many of the early fliers were spurred by a taste for adventure.

Whirlpool was motivated by a general commitment to environmentally friendly appliances; might not the company have invested in this research anyway? How important were the presence (and later weakening) of federal regulations?

In seeking to assess the impact of prize on innovation, reference can also be made to an interesting empirical study (cited above) of the innovations displayed at the Crystal Palace Exhibition in 1851 London and the 1878 Philadelphia Centennial Exhibition, which suggests that strong patent systems tend to change the "direction of innovative activity rather than on raising the number of innovations (Moser, 2003, p. 1)." Given that the incentives to enter a prize competition are much like those of entering a 19th century exhibition, it is quite likely that our prize systems have had that effect – that they have changed the direction of innovation. If this is true, and if welfare arguments for a specific prize contest are sufficiently strong, this "change of direction" argument must remain an important justification for prize contest design.

Finally, a prevailing assumption in the economics literature is that R&D prizes are offered by governments. Due to the presence of asymmetric information, it is argued (e.g. De Laat, 1996, Shavell and Van Ypersele, 2001, Gallini and Scotchmer, 2002), patents will be relatively more efficient than prizes, since private investors will have better information about the market for the innovation (and about their own capabilities) than the government. If the invention is not profitable, private investors will be punished by the market. Our cases demonstrate that, in practice, prizes are more frequently sponsored by private parties (from wealthy entrepreneurs to non-profit foundations to newspapers). Among recent prizes, while proposals to stimulate innovations suitable to Third World conditions are government-sponsored, others – such as the Loebner prize, the Foresight Institute prize, and the X-prize – are all private initiatives. This indicates a further line of analysis that might be pursued in assessing the effects of prize incentive systems for social welfare.

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