The incentives and disincentives of innovation prizes: A survey of the dropout teams from Progressive Insurance Automotive X PRIZE

by

Bharat Bhushan

Submitted to the System Design and Management Program
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Engineering and Management

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ABSTRACT:

Technological innovation is driven by incentives. However, our understanding of how incentives actually work "on the ground" to change the level of activity of innovators or to shape the direction of their innovation is relatively limited. This thesis contributes to this understanding by focusing on innovation prizes (as applied to the energy industry). It aims to examine how prizes provide a useful but also a limiting incentive for companies in a particular arena of R&D. Specifically, the thesis involves a survey of the teams that dropped out from a highly publicized prize competition to learn about their motivations and perspectives about the competition. How companies/teams understand and evaluate the technologies that they promote involves as much understanding of the technologies as of the economic models of incentives. This thesis uses a survey based methodology to explore the impact of a particular incentive structure – prizes – on a group of teams who initially participated in the prizes and then later decided to drop out. By selecting the drop out group we were able to explore the details of the prize as an innovation mechanism in more detail. The survey results reveal that the dropped out teams believed the prize to be an opportunity to raise money for their projects. Their inability to raise enough funds and eventual dropping out did not decrease their excitement about prizes as an ideal incentive to bring about radical change even though, the dropped out teams judged the specific prize competition as less than ideal. As a consequence, the thesis concludes that the prize incentive has a close relationship with and hence extends the financial infrastructure of a society.

Thesis Advisors: Prof. Fiona Murray, Dr. Erika Wagner

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Prof. Alan McCormick and Prof. Elaine Beckman helped me with the design of a survey questionnaire that is the essential part of this thesis. I am very thankful to them for their help.

Central to the experiment of this thesis is the X PRIZE foundation and I have been fortunate to receive some information from them that only they could have provided. I am eternally grateful for their support in my endeavor. I was also part of the X PRIZE lab at MIT, that researches on various aspects of prizes in practice. My understanding about prizes is greatly enhanced by the interactions in that group. The group interactions have influenced my thesis and I am thankful to all the members of the lab.

I would like to thank my friends from the SDM program and across MIT for enriching my experience the last two years.

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Contents

1. INTRODUCTION

Motivation and Significance

Creativity and innovation are very important for economic growth of a society (Rosenberg, 1972) . The industrial revolution enabled millions of people to attain a level of prosperity that existed only in the topmost echelons of societies before the 1500's (Clark, 2007). It is useful to define for the purpose of this thesis, two kinds of innovations – incremental and radical. The distinction between the two is made by their impact. While incremental innovations would be improved upon very soon, radical innovations create a dramatic improvement on existing products or processes such that it would take relatively longer to improve upon. Societies that attain radical innovations first, get a head start and an edge over other societies as was the case with innovations that started the Industrial revolution. For example, those societies that engaged in the invention and subsequent utilization of the wheel, steam engine, the digital computer, the watch created foundations for a whole set of later incremental innovations. Thus we need to find incentives to encourage not only incremental innovation but also radical innovation.

The growing need for energy in the world demands innovation of radical proportions because the largest source of energy, fossil fuels, will run out in about 60 years (Administration, 2007). . Added to the increasing demand is the constraint to be sustainable because current major sources of energy threaten to make the planet earth unlivable in the areas that are currently habitable (United Nations Environment Programme, 2009). As the developing countries, such as China and India, raise their standards of living, growth in motor vehicles and only incremental efforts to improve fuel economy will certainly result in severe consequences for oil use and CO2 emissions(Huo, et al., 2007). Hence, transportation and energy offer a compelling domain for studying modern innovation.

Perhaps even more interesting are the incentives that we, as a society, have in place to encourage the radical breakthroughs needed in the domains of energy and climate change. There is money to be made in the market by selling more efficient cars, local and organic produce, and other "green" products, as is proven by the existence of a few niche players in these markets. The market incentives entice entrepreneurs to undertake innovation in these domains. However, market incentives have not been enough to forestall the environmental consequences of global expansion, as the rate of technological and policy innovation in the

energy domain has not kept pace with increase in demand, decrease in reserves and other challenges such as climate change. There are incentives offered through government grants and government policies to develop new technologies and create markets for them. Besides these, now in the modern society, there are various and unprecedented number and kinds of financial institutions - banks, stock markets, venture capital, etc. - whose existence has made it easier for those who can productively use money to meet those who have funds available. In fact, the evolution of credit and debt has arguably been as important as any technological innovation and social institution such as patents in the rise of civilization (Fergusson, 2008).

Patents or statute of monopolies, are incentive schemes that are widely credited with facilitating radical innovations in the past (Scotchmer, 2004). There is yet another incentive scheme that is claimed to be especially well suited for compensating radical innovations, as opposed to incremental innovations. It is so unique in the way it works, that I am going to argue later in this thesis that it is equivalent to a new financial institution. These are the incentives of a prize. Incentive prizes are a time-honored mechanism for driving radical breakthroughs. Prizes are offered by an individual or an institution to solve a specific problem that has remained unsolved due to lack of enough interest in it. Well-designed prizes can reach across national and disciplinary boundaries to attract intellectual and financial capital required to achieve breakthroughs.

Despite the wealth of historical experience with prizes, many questions as to whether prizes are indeed a good incentive for the development of the radical solutions in general and specifically, in the domain of energy. What kinds of people are attracted to competitions whose winning purse is a huge prize? What kind of unintended (maybe even perverse?) incentives do prizes create? What are the limitations of the prize model in general and some of the currently offered high-profile prizes in specific? How does an individual decide to form a team to compete in a prize competition, and why do some of the individuals and teams drop out eventually? What role do group dynamics and demographics play in making a team a worthy competitor? Who is best positioned to offer and sponsor a prize? Should governments use taxpayer money to offer prizes? There exists literature on prizes as a theoretical model; a few case studies of the effects of some prize competitions of the past; how entrepreneurial teams are formed; what kind of teams find success. However, there is very little literature available on the aspects of prizes that I mentioned. While I can't possibly address all of these questions in a master's thesis such as this, these questions served a good fodder for the mind for us to start. My modest aim, through

this thesis, is to shed some more light on these related issues and to assist a bigger research on the topic of efficacy of prizes.

I am fortunate to have a relatively larger access than most, to an active prize competition —the Progressive Insurance Automotive X PRIZE (PIAXP). PIAXP aims to award radical improvements in automobile technologies relating to efficiency and environmental cleanliness. The prize challenges competitors to build road-worthy, marketable vehicles that get at least 100 miles per gallon, or its energy equivalent. While much will be made of the successes of any prize competition, the challenges faced by the slate of potential competitors are interesting because they highlight what some prizes are unable to achieve in practice, despite being capable of them in theory. Bridging the gap between the theoretical model and the practice of prizes would be of relevant interest to any prize administrator. Hence, this thesis aims to document challenges of the prize as seen from the perspective of early participants who decided to drop out of the competition. The lessons learned from studying this single X PRIZE may not be applicable to all prizes in general, but I hope this effort will begin to improve our understanding of how prizes are perceived by the innovators at whom they are targeted.

Summary of Dissertation

This thesis is divided into six chapters. Chapter 2 contains a brief history of prizes and their effectiveness. Chapter 3 contains the details of our empirical context. Chapter 4 contains an overview of the methodology and experiments. Chapter 5 contains the review of our survey findings and finally Chapter 6 contains the analysis of the data collected in our research and some conclusions. It also contains the overarching theme as understood from the research and a direction for future research in similar areas.

2. BACKGROUND TO PRIZES

Prizes may be classified by their time of formulation as one of two kinds: ex-post prizes and ex-ante prizes. Ex-post prizes are given on the basis of criteria defined after the fact, typically in recognition of some great work, such as the Nobel Prize, Academy Awards, and US Medal of Honor. The ex-ante prize, on the other hand, follows the model of: set prize then innovate (Stiglitz, 2007). For the purpose of this thesis, my focus is in understanding the usage of ex-ante

prizes only and when I refer to "prizes" hereafter in this thesis, I mean ex-ante prizes exclusively.

Existing research on prizes ranges from studies on the theoretical justification for a prize model for a certain kind of problems to documentation of empirical results from prizes of the past. This chapter contains a brief summary of existing research on prizes. This literature attempts to answer a few key questions relating to why prizes are a distinct and viable compensation model and for whom. More importantly it exposes a gaping hole regarding the perspectives of the radical innovators that are expected to participate but do not.

2.1 Prizes, in theory

It is well known that a very competitive market with little barriers to use of information fails to provide socially optimal level of R&D expenditure (Romano, 1989) and (Arrow, 1963). In fact in a perfectly competitive market there will be no investment in R&D. To promote R&D, widely used incentives are patent protection and R&D subsidization. Often preceding an innovation is a body of research and development (R&D) work. Governments and corporations (Both are considered as administrators of the research in this text) employ various means to promote inventions through research by their citizens. Most commonly known incentives include patents, prizes and research contracts. Wright's research (Wright, 1983) describes parameters that can be used to differentiate various incentive schemes –

1. Amount of information asymmetry, between the researchers and those who are funding, and related to cost and benefit of research;
2. The probability of success of the research effort;
3. The amount of research already going on in the domain, also referred to as the supply side of the research market.

Wright's research on these R&D incentives led to a formal economic model to evaluate the efficiency and follies of those incentive schemes. Wright treated research objectives as a given amount of undiscovered "pot of gold" (much like a prize purse!) and researchers as the agents of discovery. The model predicts that the supply of inventors and their probability of success affect the choice they will rationally make between the incentives at hand. As shown in Figure 1, patents are optimal only when elasticity of supply of research is high, i.e. for long shot research areas with low aggregate probability for success.

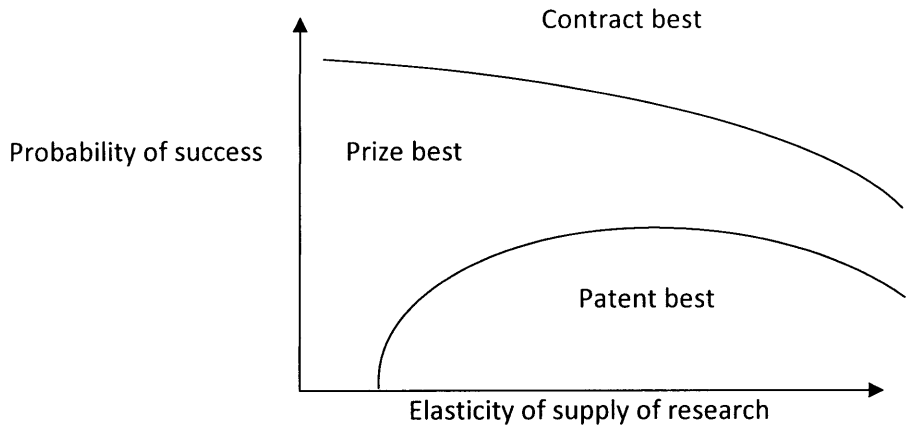


Figure 1 The optimal choice of invention incentive. [Source: (Wright, 1983)]

Hence, patents are an extreme that provide a lot of incentive to the inventor but may not be optimally beneficial to the society if the inventor holds more information about the benefits of the invention. Research contracts are forms of R&D subsidies that are less of enough incentive but are socially inexpensive. Prizes tend to be a compromise between the two and trade off for the best of both the extremes (Stiglitz, 2007). Prizes are best for research areas with intermediate success probabilities and for all areas where supply is inelastic. When the probability of success is very high, contracts offer the most efficient incentive. The model also hypothesizes that when the cost of research is shared by many while benefit is accrued to few, in this case namely researchers or product developers, more decentralized incentives of prizes and patents are less attractive.

Wright also mentions that the relative merit of each incentive does not change if the administrator has exclusive information about costs and benefits of the research. It is only the *private* information among researchers that affects the choice between incentives. The special advantage of patents arises only from ex-ante researcher information relating to the value of an invention. On the other hand, if the administrator cannot monitor the effort of researchers, the two more decentralized options have an advantage over contracts by allowing self-selection and self-supervision of researchers. Contracts are inefficient from a cost-control perspective because there is a lack of monitoring of expenses by the administrator and lack of incentives for the researcher to be cost-efficient. Patents and prizes on the other hand provide ample incentive to the researcher to be cost-efficient because costs eat into profits.

Hence, Wright believes that theoretically, prizes are the best compensation for R&D work that is believed to be achievable (i.e. probability of success is neither very high, nor very low) but is not

being achieved at quite the expected speed (i.e. supply of researchers is constricted, perhaps due to some policy or market failure?). Also, prizes would be better suited than patents if specific research inputs are available already.

In order to effectively design prizes for breakthrough innovations in the energy sector, we must identify markets with these characteristics in mind.

2.2 Prizes, in practice

While the model presented above distinguishes between patents and prizes as exclusive incentives, in practice, modern prizes often contain a prize purse as well as retention of intellectual property (IP) with the researcher.

Patents were granted by the Greek city governments as far back as 500 BC(Scotchmer, 2004). Patents gradually evolved into "Statute of Monopoly" in 15th century England for "projects of new invention" only. Scotchmer's book *Innovation and Incentives* notes that patents evolved into prizes around the Industrial Revolution to promote innovation in areas of research whose results were a matter of public good. The British Longitude Prize, which was announced in the 18th century and is one of the best known historical prizes, provides insight into the use of prizes prior to the advent of government-sponsored research agencies.

There is a long history of prizes spanning from the 18th Century Europe to the X PRIZE Foundation of current times. It has been shown that in all these prizes, what needed to be achieved was of greater importance than how it was achieved, Hence, as is clear from the following few examples, prizes often welcomed participants from diverse backgrounds. Following are examples of some successful prizes. More details on historical prizes can be found in **APPENDIX B: Additional Detail on Historical Prizes**, which also contains examples of some prizes that may not be considered as successful.

Longitude Prize (Sobel, 1996)

As people began making transoceanic voyages from Europe in the 16th century, sailors encountered a major obstacle in their inability to tell longitude when out of sight of land, resulting in consequent loss of life and trade. It was in government's interest to create safe seas for easy

trade. A well funded Navy ensured protection from pirates but not from being lost in the sea. Determining longitude on land was far easier than on sea - a stable surface to work from, a comfortable location to live in while performing the work and the ability to repeat determinations over time made for great accuracy. Solutions that calculated longitude inaccurately existed at the time and hence what was required was accuracy improvement by radical proportions. The British government established the Board of Longitude in 1714 to make awards for demonstrating a practical method for determining the longitude of a ship at sea, with multiple prize purses for solutions of increasing accuracy. These prizes, worth millions of dollars in today's currency, motivated many to search for a solution.

Prior to the British prize, the governments of Spain, Holland and France also offered smaller Longitude prizes, making navigators and scientists in most European countries aware of the problem and engaging many in finding the solution. Given the international effort in solving the problem and the scale of the enterprise, it represents one of the largest scientific endeavors in history.

In the end, one of the winning realizations was that "time is longitude". If the navigator knew the time at a fixed reference point, the difference between that time and his apparent local time would give him his position relative to the fixed location. The winner was John Harrison, a cabinetmaker who devised a chronometer that could keep accurate time, even while at sea. However, because chronometers were expensive, the lunar distance method (whose inventor was also rewarded by the Board) continued to be used for some decades. The Longitude Prize highlighted the ability of prizes to draw interest from broad areas.

Orteig Prize (Lindbergh, 1953)

In 1919, a self-made New York millionaire, Raymond Orteig, offered a $25,000 reward to the first Allied aviator(s) to fly non-stop from New York City to Paris or vice-versa. He was influenced by his idol, Eddie Rickenbacher, who was an ace pilot and whose speeches involved visions of Franco-American friendship. Several famous aviators made unsuccessful attempts at transatlantic flights before the relatively-unknown young Charles Lindbergh won the prize in 1927 with his aircraft, *Spirit of St. Louis*. In total, nine teams spent $400,000 in pursuit of the $25,000 Orteig prize, a leverage of 16-fold. Lindbergh was the first solo pilot to cross the

Atlantic non-stop in a fixed-wing aircraft (rather than an airship). His flight was followed by a boom in public interest in air travel and aviation stocks skyrocketed.

This prize showed the potential of buzz created by a high-profile prize to jumpstart an industry that was just waiting for some significant event to raise it from its slumber.

DARPA Grand Challenge and Urban Challenge (DARPA, 2007)

While the sponsors of early prizes were largely governments, most modern prizes have been offered by private individuals or organizations. However, lately, government agency sponsored prizes have been staging a comeback. Through the National Defense Authorization Act for fiscal year 2003 the US Congress authorized the Defense Advanced Research Projects Agency (DARPA) to offer prize money of $2 million for the first Grand Challenge to facilitate robotic development, with the ultimate goal of making one-third of ground military forces autonomous by 2015. In response, DARPA instituted a series of challenges with the goal of developing autonomous navigation for unmanned vehicles. These challenges focused on university-sponsored teams, had staged funding levels with review gates that had to be passed to graduate to higher levels, and saw successful completion of the DARPA-designed obstacle course after the second year of the competition. With the initial off-road challenge completed, the program was rolled into an Urban Challenge, with the same basic task (autonomous vehicle navigation), but in a far more demanding environment (a dense city-like landscape).

A team from Carnegie Mellon won the 2004 Challenge and a team from Stanford University claimed the first prize in 2005. In the much tougher 2007 Urban Challenge, where the cars also had to obey traffic lights and be able to merge with other traffic, the top four places were taken by university teams, with Carnegie Mellon winning, Stanford University in second place and Virginia Tech and MIT taking third and fourth places respectively.

The DARPA Grand Challenge is an instance of modern prize offered by a government agency that has a specific focus on university research, showing the power of prizes as an incentive that can be targeted to a very specific group of researchers, if required.

Super-Efficient Refrigeration Program (SERP) (IIEC)

In 1990, the US Environmental Protection Agency (EPA) championed a collaboration with Pacific Gas & Electric (PG&E), the US's largest investor-owned utility; the Natural Resources Defense Council (NRDC); the American Council for an Energy-Efficient Economy (ACEEE) and the Washington State Energy Office, along with 20 other utility companies. in order to pool $30 million dollars in the Super Efficient Refrigerator Program (SERP). SERP sponsored a contest to award the manufacturer who could build and sell the most efficient CFC-free refrigerator at the lowest cost. In 1994, Whirlpool won the Super-Efficient Refrigerator competition with a 22-cubic-foot model that uses as little as 561 kilowatt-hours per year. To pocket the prize, Whirlpool had to sell 250,000 super-efficient fridges by July 1997. But sales were low -- reportedly 30 to 35% below the target -- and Whirlpool discontinued that model before the clock ran out on the program. Company spokesman Mike Thompson explained that consumers would not pay extra for a highly efficient product, raising a question about the structure of this particular incentive.

Despite the fact that the purse was never awarded, with very modest taxpayer money, EPA and its partners leveraged a much larger private sector investment in energy efficiency and pollution prevention. The approach is an important model for Federal leadership in promoting advance technologies. EPA played a leadership role, primarily by selling the idea of cleaner technologies to the manufacturers, marketing SERP to the prospective utilities and assisting SERP in obtaining Department of Justice assurance on compliance with antitrust laws.

X PRIZE Foundation

In past 20 years or so, since the advent of information age, the rate of innovation has increased rapidly. The faster flow of information has led to coming of age of the venture capital industry, which identifies and funds innovations that could lead to next set of radical breakthroughs. In such a world, the stakes for prize-driven innovation are even higher, and hence, prize design now requires an increasingly higher level of expertise. A sign of increasing professionalization in prize design is the creation of the X PRIZE Foundation. Founded in 1995, the X PRIZE Foundation focuses on using the prize incentive to solve problems in various domains and has so far offered four prizes for commercial human spaceflight, genomic sequencing, private lunar exploration, and high-efficiency automobiles (the focus of this thesis). Thus the foundation has ushered in an era of professionally administered prize incentive scheme for solving even bigger challenges.(Company, 2009). An indication of that fact is that starting with the Ansari X Prize,

there has been a sharp increase in the absolute numbers and aggregate value of prizes that offer more than $100,000.

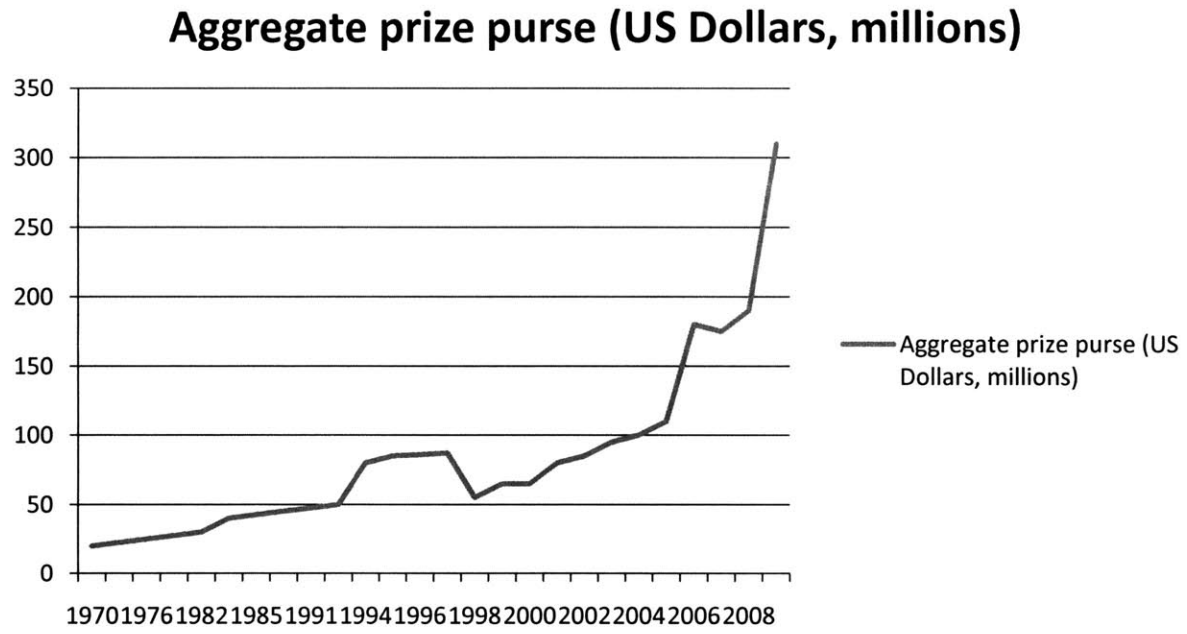


Figure 2 Aggregate prize purse of prizes offered in each year over last 40 years

[Source: Mckinsey dataset of 219 prizes worth $100,000 or more]

Common themes among Prizes of the past

From these examples and myriad other prizes offered in the last three centuries (His), one may see the breadth of formulations and operations for incentive prizes. Prizes may be offered by government (e.g. British Longitude Prize), private individuals (e.g. Orteig Prize), or private organizations (e.g. Google Lunar X PRIZE). Prizes may be offered for technology development (e.g. Ansari X PRIZE) or for technology deployment (e.g. Liverpool & Manchester Railway Locomotive Prize).

As the Longitude Prize showed, the winning technology may come from breakthroughs in an absolutely unexpected domain (e.g., time keeping instead of astronomy). Winners of prizes may come from fields far removed from the prize topic, and be either relative amateurs working on their own time or relative experts with experience in the field (such as the technical university programs with experience in autonomy and robotics from the DARPA Grand Challenge).

Two unique values generated by the prize incentive and both are seen very clearly in the Orteig Prize. Firstly, well-designed prizes generate valuable public relations and "buzz". Secondly, prizes also deliver to the prize administrator a high leverage, i.e. the size of cumulative investment by all the competitors in proportion to the incentives offered (including prize purses and market commitments). There exist unsuccessful prizes such the SERP prize, which is regarded as a failure because the anticipated market reward incentives failed to materialize after the competition.

These observations about historical prizes give birth to questions about what makes prizes work. What kinds of problems are best solved by offering a prize?

2.3 Importance of diverse ideas

Lakhani found that broadcasting unsolved scientific problems to diverse solvers is a more efficient process for solving them compared to assigning specific people to solving those problems (Lakhani, 2007). His analyses show that broadcast search is an effective means of reusing distributed knowledge for solving previously unsolved problems. Diversity in the scientific interests of the potential solvers and their degree of specialization are important predictors of problem solvability. Solvers extensively use their own and/or others' existing solutions to generate their own new solutions. Moreover, successful solvers were more likely to apply existing knowledge from their own field to solve problems in other fields, thus bridging scientific disciplines.

The idea behind Lahkani's research is that openness and free information sharing amongst scientists are supposed to be core norms of the scientific community. However, these norms are not universally followed. Scientific problem solving is often constrained to a few scientists who typically fail to leverage the entire accumulation of scientific knowledge available.(Lakhani, 2007)

Lakhani shows that disclosure of problem information to a large group of outside solvers is an effective means of solving scientific problems. Problem-solving success was found to be associated with the ability to attract specialized solvers with a range of diverse scientific interests. Furthermore, successful solvers often solved problems at the boundary or outside of their fields of expertise, indicating a transfer of knowledge from one field to others.

Hence, prizes differ from other incentives in the sense that they can more readily reach out to passionate people with diverse backgrounds. However, it is unlikely that the complex problems of the modern world will be solved by the efforts of single individuals. Assuming that it takes a passionate team to solve such problems, it is important to understand what kind of teams participate in prize competitions. Prize winning is much less probable than getting compensated for the work through other incentive schemes. So presumably the teams that attempt to win prizes have to believe that they can perform extraordinarily to justify their participation. That begs a question - What are the characteristics of a highly successful team?

2.4 Successful Teams

The level of sophistication of the unsolved problems of today is such that no single individual is likely to demonstrate the solution on her own. The core idea may belong to an individual. However, to deliver an innovative technology based on the core idea likely requires a team effort. Stanford Professor Jim Collins, sums up the kind of excitement that is characteristic of a super-successful team as he defines it:

> "...real people in real companies want to be part of a winning team. They want to contribute to producing real results. They want to feel the excitement and the satisfaction of being part of something that just flat-out works. When people begin to feel the magic of momentum—when they begin to see tangible results and can feel the flywheel start to build speed—that's when they line up, throw their shoulders to the wheel, and push." (Collins, 2001)

Deborah Ancona from MIT uses the term X-teams(Ancona, et al., 2007) to describe such successful teams and noted the following common traits among them:

1. First, to create effective goals, plans, and designs, members go outside the team; they have high levels of external activity and not just internal activity.
2. Second, X-teams combine all of that productive activity with extreme execution inside the team. X-teams develop internal processes that enable members to coordinate their work and execute effectively while simultaneously carrying out activity.
3. Third, X-teams incorporate flexible phases, shifting their activities over the team's lifetime.

The Stanford Project on Emerging Companies (SPEC), launched in 1994, focuses on the links between an organization's employment practices and other aspects of the business. During data collection that spanned 1994 to 1997, SPEC researchers conducted a longitudinal study of nearly 200 young Silicon Valley companies and their founders. Their research (Burton, 2002) shows evidence of the relationship between entrepreneurship and various kinds of diversities in a team – functional, educational and demographic.

However, diverse teams are prone to disintegration. Trimmer's work (Trimmer, 1999) has focused on conflicts within a team, highlighting what often causes teams to disintegrate and not deliver desired results. His research subjects are primarily US corporations but the lessons are relevant anywhere in the modern world where the demographic diversification of the work force and impact of global development require professionals to work with an increasingly diverse population. Demographic diversity refers to the diversity in cultural backgrounds of various team members and includes national, ethnic and linguistic differences within a team. Another kind of diversity studied for impact on team efficiency is the functional diversity which refers to the proficiencies, academics and professions of the team members. Diversity is a double edged sword in the sense that it can lead to better performance if diverse backgrounds are leveraged in a correct way, but it can also lead to conflicts that lead to higher turnover rates.

It is my hypothesis that teams successfully competing in a prize have to be high-performing teams, like Ancona's X-teams, and would most likely be diverse in a variety of ways. Conversely, teams that do not compete in a prize competition, despite being perfectly placed to compete in them, are either not incentivized by prizes or most likely not diverse enough or not cohesive enough. Teams that are not lured by the prize would not show any interest in participating in the prize competition. However, there would still be some teams that are interested in competing for the prize but are unable to do so due to their shortcomings. Such teams may be identified by observing that they show an initial interest in competing but eventually do not follow through completely and drop out. It is such teams that are likely to be homogenous and possibly incohesive. It is this hypothesis that frames the remainder of this thesis.

2.5 Unanswered Questions

The existing literature begins to examine the econometrics and the history of prizes. It also gives us reasons about why prizes are able to solve certain problems much better than other

incentives. Finally, the literature also answers a few questions about how successful teams form and function in various for-profit organizations. It is reasonable to assume that radical breakthroughs require very effective team formations whose team members share passions for a cause that is worthy of a prize competition. Such teams should have the ability to ward off any internal threats to its sovereignty. Hence, it is expected that successful prize teams will have a good track record to meet a tight deadline posed by a highly competitive prize. It is also expected that the team be a close knit group of people.

There does not exist in the literature a formal documentation of the motivations of individuals and teams that compete for prizes. This thesis aims to connect the dots between the prizes literature and the research on teams.

Wright's econometric model, presented in section 2.1 can be used to tell if a given incentive is well placed for certain innovation that the administrator seeks. Using that, one may argue that the prize for a demonstrably achievable efficiency in automobile is perfectly valid. In the domain of energy and technologies for preventing climate change, there are various ideas that exist outside of the big auto companies of the world but are still too risky to be picked up by the venture capital industry. The merger and acquisition activity in the automobile industry in last four decades has been limited to increasing market share, attaining economies of scale and augmenting product ranges (ReportSure, 2004). Very little portion of the total investment in automobile technologies has gone into developing cleaner, more efficient cars and "efforts by both the automotive industry and governments to increase fuel economy have not achieved the significant course change necessary to make a substantial difference" (Mercer, 2006). Among many opportunities in the automobile industry are technologies for more efficient automobiles. Hence, a prize competition for efficient cars is a valid prize. If such is the case, then why would certain teams drop out from the prize competition? This question forms the central point of this thesis. The thesis also addresses the questions relating to the nature of teams and individuals that form and function for a prize competition and how a prize administrator may reach out to innovators that have important ideas. Specifically, the hypothesis that the dropped out teams are a converse of X-teams is tested. A team would be considered a non-X-team if it lacks considerable external interaction, functional or demographic diversity, or enough flexibility to bypass regular team processes, when needed. If teams that are found to be efficient and are expected to be performing, dropout the prize administrators have something to think about.

3. EMPIRICAL CONTEXT

3.1 X PRIZE Foundation

The X PRIZE Foundation is a non-profit organization that designs and manages prizes to solve the grand challenges facing humanity in the domains of energy, education, life sciences, exploration and development. The prizes are worth millions of dollars to draw public's attention towards the goal. The theory behind their model is that prizes, if properly designed, can act as potent incentives for bringing out radical breakthroughs.

Inspired by the Orteig prize, the first prize offered by the Foundation in 1996 was the Ansari X PRIZE, which successfully challenged teams to build private spaceships to open the space frontier. Building on this success, the Foundation has since launched three additional prices: the $10M Archon X PRIZE for Genomics, the $30M Google Lunar X PRIZE and the $10M Progressive Automotive X PRIZE.

3.2 Progressive Insurance Automotive X PRIZE

The Progressive Insurance Automotive X PRIZE (PIAXP)The X PRIZE Foundation created the Progressive Insurance Automotive X PRIZE (PIAXP) to "stimulate automotive technology, manufacturing and marketing breakthroughs that radically reduce oil consumption and harmful emissions and result in a new generation of super-efficient and desirable mainstream vehicles that people want to buy" (www.xprize.org).

To this end, PIAXP is focused on breakthroughs in "green" automotive technologies, challenging teams to design, build, and race market-ready vehicles that can get at least 100 miles per gallon or its energy equivalent.

The X PRIZE Foundation began work on the development of a competition to spur innovation in the automotive industry in 2005, a year after the Ansari X PRIZE competition ended successfully. After background research and hiring of some key executives, the prize was announced in April 2007. Progressive Insurance became the official sponsor of the prize by funding the prize purse in 2008 and subsequently it was known as Progressive Insurance

Automotive X PRIZE. The prize's stated goal is to "inspire a new generation of super-efficient vehicles that help break America's addiction to oil and stem the effects of climate change."

The announcement at the official launch of PIAXP mentioned the collaboration of Progressive and X PRIZE Foundation as "two organizations that support innovation coming together in a way that can make a real difference in the world." (Progessive Insurance, 2008)Later, Brian Silva, director of special projects at Progressive, stated that the reason for sponsoring the prize is that Progressive has a:

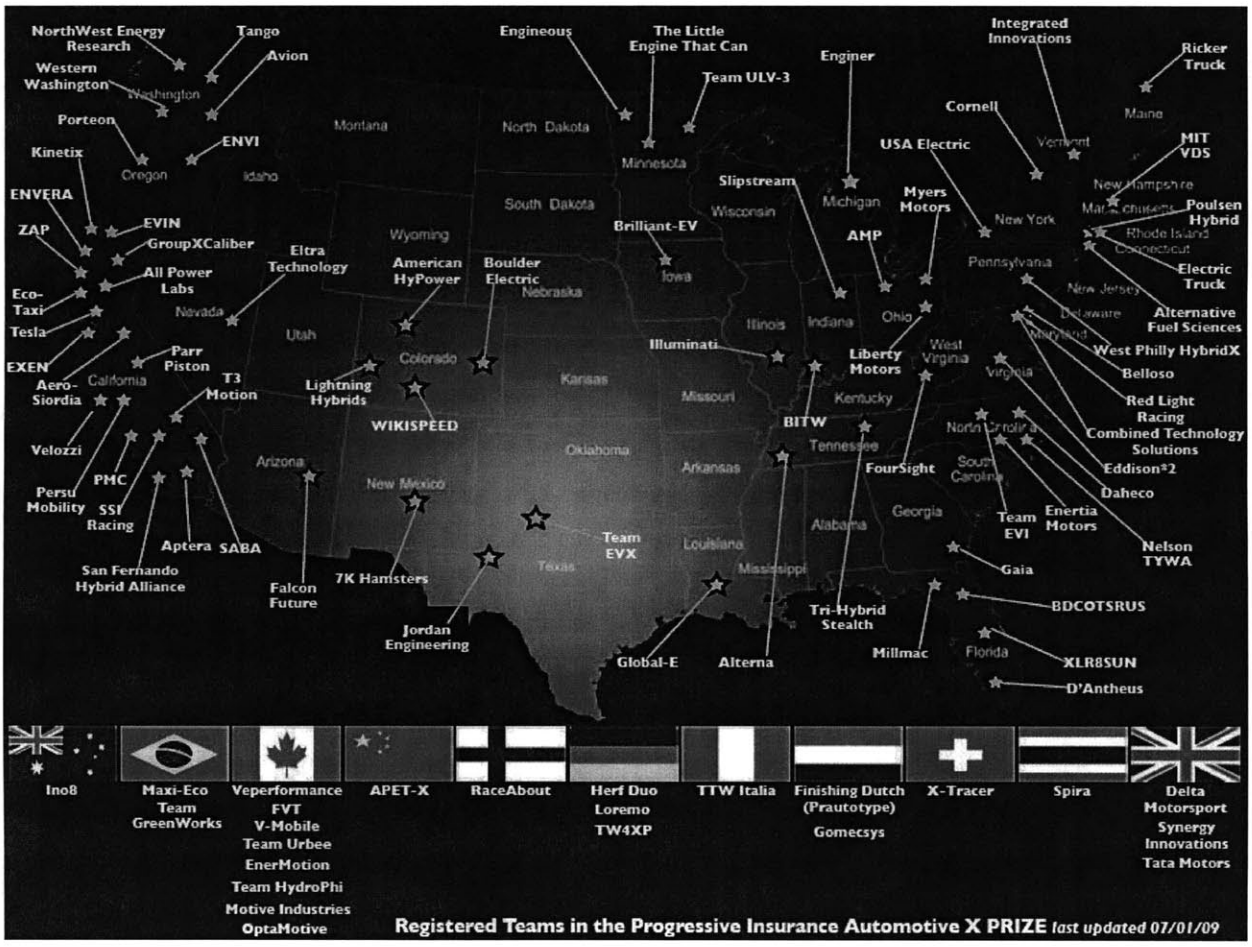
> "...financial incentive for the continuance of the American way of life based on the automobile. If people do not drive cars, [our] business gets smaller. It's going to be an ever-more-restrictive world for carbon-based fuels, and everything we can do to increase the mileage-per-gallon equivalency, the more cars will be driven. And the more cars that are driven, the more [we] get to insure. [We] want to ensure that [we] can continue our love affair with automobiles, It's all about saving driving." (Ecotech, 2008)

The prize has two main divisions – the Competition and the Demonstration divisions. The latter does not carry a prize purse and is for well-established companies that are already selling more than 10,000 units per year, such as General Motors, to demonstrate their efficient vehicles without the strict requirements of meeting 100 miles per gallon equivalent (MPGe). The Competition division carries $10 million in prize purses for two separate competitions: the mainstream class with a prize of $5M and the alternate class with two prizes of $2.5M each for side-by-side seating and tandem seating races. Teams will compete in races that test vehicle efficiency, performance and durability under real-world conditions. Vehicles with the best overall time in the final race while still meeting requirements will win.

An important contribution of PIAXP is the development of the new metric, MPGe. This economy rating is based on the quantity of heat energy that can be obtained by burning a US gallon of gasoline (115,000 BTUs).The equivalent in terms of another fuel is the amount of such other fuel that would produce that same amount of heat. When the term "MPGe" is used by electric vehicle manufacturers and advocates, generation and transmission losses are typically ignored, and the term is taken to mean distance travelled by the vehicle under certain conditions for every "gallon of gasoline equivalent" - 33.7 kWh of electricity drawn from the wall charging outlet. This allows for fair comparison of energy use across a wide variety of vehicles, and has been adopted by Consumer Reports as the new metric for mixed-fleet comparisons

Besides the MPGe requirement, an additional requirement in order to win the competition division is the Green House Gas (GHG) Emissions limit, measuring the equivalent grams of CO_2 emitted per mile of vehicle driven, including all contributions from fuel extraction, production, distribution, and consumption. To estimate GHG emissions of a vehicle, standard data generated by the Argonne National Lab of the Department of Energy is used. To win, the vehicle should produce no more than 200 grams per mile of CO_2 or its GHG equivalents. In addition, the vehicle must be designed to meet criteria emissions standards no worse than US EPA Tier II, Bin 5; the race vehicle must meet at least US EPA Tier II, Bin 10 in road testing and Tier II, Bin 8 in dyno testing.

In the first phase of the Competition division, while the rules of the competition were stil in flux, interested teams had to send a letter of intent (LoI) to participate. Around 150 teams [1]sent their LoI, along with refundable fees of $2,000.



[1] "Around 150": Can't be precise because it is known that some teams participated and dropped out anonymously.

Figure 3: Schematic map of participating teams locations (Courtesy: http://www.progressiveautoxprize.org/teams)

In April 2009, a set of more specific competition rules were published, followed by the formal registration of teams. 111 teams registered at this stage and the remaining teams got their refundable fees back. By July 2009, the number of teams competing was down to 94. Figure 3 above shows the geographical description of these 94 teams. Teams from 12 countries across the world have registered, of which 8 countries are from the developed nations of North America and Europe. The remaining 4 countries represented in the list are Australia, Brazil, China and Thailand. About 83% of all the teams are from US and Canada only (which presumably shows the bias X PRIZE foundation introduces by being an organization based in the US).

The PIAXP "suggests" the use of one of the five fuel sources for the automobiles competing for the prize – 87 to 91 octane gasoline, bio-diesel, fuel ethanol, compressed natural gas and electricity. However, the registered teams' automobiles represent 14 different fuel sources. One of the tasks of the X PRIZE Foundation is to create equivalency of mileage metrics for various fuel sources by considering the scale of availability/accessibility of the fuels, their CO_2 footprint and the complexity/weight/bulk etc. of the automobile.

To avoid any "gaming" in the competition and to make sure that the teams stay true to the principles and the spirit of the competition, tests other than the automobile race are also part of the competition. These tests include –

1. Safety, Emissions: Follow the US Safety and Emissions standards (Again, a clear US bias)
2. Manufacturability, Cost: Ability to mass produce at least 10,000 of the vehicle at a benchmark cost of similar vehicles.
3. Features: Consumer orientedness
4. Business Plan: How mass manufacturing and marketing will be actually executed – raising capital, developing infrastructure for the fuel, road to entry in the market etc.

Each of the above-mentioned "softer" metrics will be judged by a panel consisting of representatives from PIAXP and domain experts from commercial, academic, non-profit and government backgrounds. The teams will submit documents explaining relevant details of their design and plan that address the above features. The panel will judge a team as Pass or Fail in

each of these domains (with one opportunity for appeal), and each team must pass all four domains to be able to compete in the competition.

These documents are supposed to ensure that the teams focus not only on the technology but also on the market side of the automobiles. This is an acknowledgement of the fact that many automobiles have shown high efficiency performance in the labs over the years but very few run on the roads. Hence, the goal of the competition seems to be to see a giant leap in the number of high efficiency vehicles that run on the road a few years after the competition. Another aspect of PIAXP that reinforces the goal of seeing high efficiency vehicles on the roads is the introduction of the "Demonstration Division of the Large Manufacturers". The demonstration division of the prize does not have a winning purse but acknowledges the fact that "it is unlikely that Mainstream vehicles in high-volume production by 2010 will achieve 100 MPGe in realistic, typical driving". Thus, the demonstration division is to promote the vehicles and experimental technologies that are most likely to be on the roads in near future.

4. THE METHODOLOGY

This study, as noted above, aims to provide more detail regarding perspective of the participants of a prize competition. Specifically, how do the participants view a prize opportunity and what makes them compete or not compete? How do they conduct their own cost-benefit analysis of participating (or not) in a prize competition?

To answer these questions, I decided to survey the teams participating in the PIAXP, with a focus on those teams that dropped out of the competition prior to the first design review milestone.

Preliminary Analysis

Pilot interviews were conducted with four teams: Avion Car Company, Aptera Motors, TriHybrid Motors and RedLight Racing Company. The interview questions were designed to reveal objective data about the teams (see **APPENDIX G**: Questionnaire for the aborted Survey). We quickly found that formal questions on organizational structure and plans meant little to teams with only a handful of members and no formal hierarchy, no formal HR practices, etc. The characteristics of these teams simply did not fit into any of the usually described characteristics of high performing teams (Ancona, et al., 2007) that were described in section 2.4. These teams did not follow any specific demographic profiles either (Burton, et al., 2007). We realized that many of these teams started working ad-hoc and were almost always driven by passion rather than structure. This level of informal organization necessitated that teams be understood first in a subjective manner, with an aim to capturing lessons learned from stories and other structured feedback.

The final research design focused on those teams that had initially submitted a Letter of Intent, but later dropped out of the competition. This allowed us to explicitly address the following questions and hypotheses:

1. Is there a regional or functional bias inherent in PIAXP?
2. Is there a minimum amount of money that a team must spend to participate in PIAXP?
3. Does a prize purse really hold a lure for the teams to participate in a competition?
4. What are the major reasons for dropping out of a team?
5. Are the dropped-out teams a converse of X-teams?

Additional advantages to this approach included that the teams were:

1. Down-selected to a smaller number
2. Presumably less busy after dropping out than the teams that are still scrambling to meet the PIAXP deadlines
3. Not under non-disclosure agreements with the X PRIZE Foundation.
4. Most likely to share their introspection.

Population

Out of the approximately 150 teams, that sent in their LoI to participate in the PIAXP, about 29% dropped out after the first detailed set of rules were announced by the X PRIZE Foundation in April 2009. An additional 11% of the original count dropped out by July 2009 leaving only 94 of the original teams participating prior to the first design evaluation in August 2009.

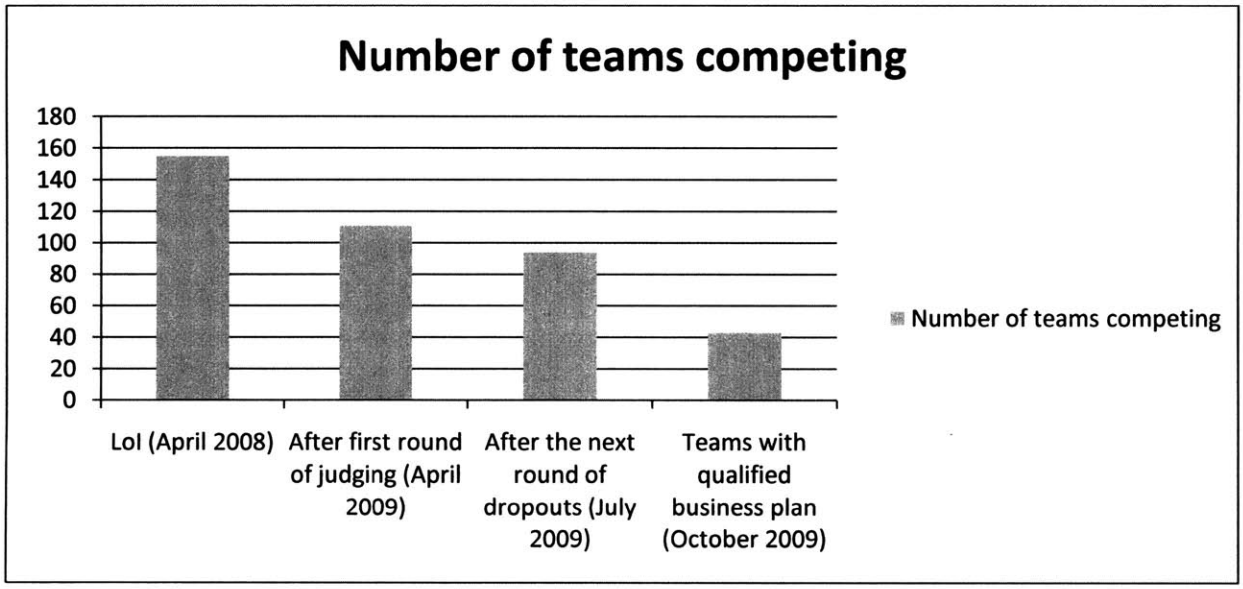


Figure 4 Participating teams at various stages of PIAXP

Out of the 63 teams that dropped out after sending in the LoI, I was able to gather contact information of 44. After initiating contacts with these teams, it was learned than 5 of these were still participating, albeit under a different name, leaving 39 teams available to interview. In the end, a little over 20% of the withdrawn teams that I could get in touch with responded with a willingness to interview (see **APPENDIX C**: Complete list of dropped out teams).

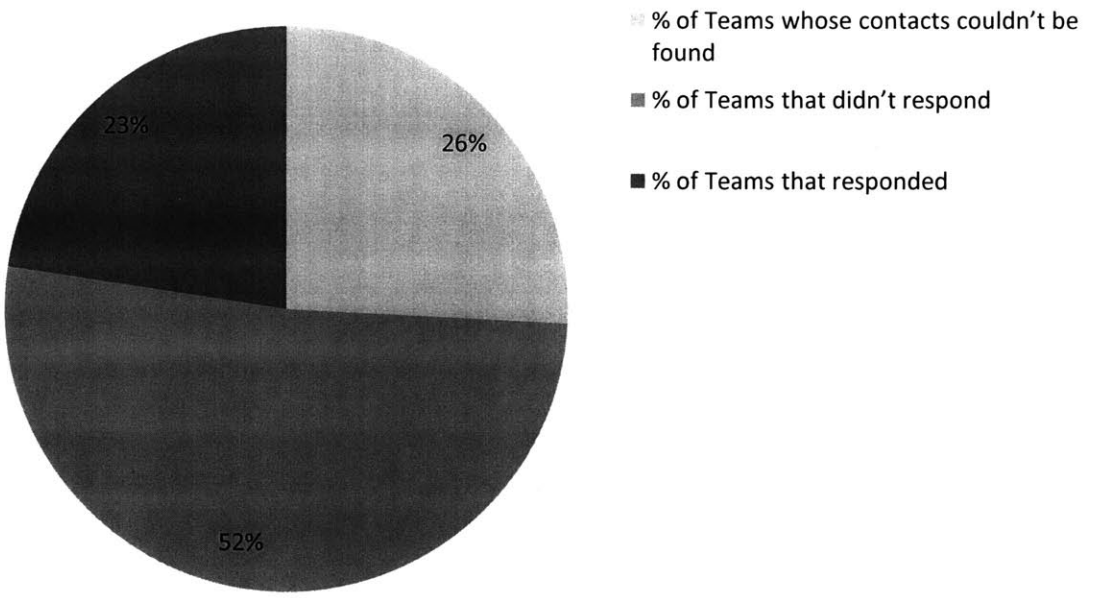


Figure 5: Dropped out teams response

In order to better understand the composition and motivation of teams who had dropped out of PIAXP, we contacted each group via email with a request for interview. Contact was established with 20 teams but in the end only 14 teams granted an interview --13 of the 14 teams agreed for a telephonic interview while 1 agreed to answer the questions through email. The 6 teams that communicated but never interviewed with me did so for various reasons – non-disclosure agreement, reluctance to talk to someone affiliated with X PRIZE Foundation in some way, too much effort and time to interview, etc.

Based on our experience with our pilot interviews, survey questions were developed to capture information about the origins and the motivations of the teams. These questions are listed in **Error! Reference source not found.**. The survey questions are rather open and leave the room for the interviewee to respond subjectively. Objective data gathered through the survey was collected and statistics were generated for some of the pre-defined parameters. The parameters studied for prizes in this thesis have earlier been studied in the context of startups by various studies under SPEC (Burton, et al., 2007). The parameters explore the origins of the team effort, level of diversity and conflict resolution mechanism. The specific parameters studied were:

- Location of the dropout team: This would inform about the inequity in dropouts from various regions of the world and if there is some form of regional bias.
- Year of the beginning of effort: This would tell us if PIAXP actually helped new ideas to originate as opposed to bringing the ideas to the forefront.
- Number of founding members: This along with demographic and professional backgrounds would tell us about the origins of the team and its dynamics and its effect on stability of the team.
- Reasons for participating and for dropping out: Explicitly expressed statements from the dropped out teams
- Amount of money required to participate: This would tell us if most teams needed some minimum amount of resources to be able to participate or could an individual garage owner participate with any realistic chance.

The main aim of this thesis was to find, in some way, the minimum amount of effort or resources, required by a team in order to be a serious contender for the PIAXP. I hypothesize that the teams that dropped out were unable to gather the minimally requisite resources, including money, camaraderie, and/or technology. A team may possess technology in the form of a unique "idea" or an IP. A team's monetary capital may also include the ability to sell this idea to another to generate funds to implement the idea. Finally, a team's camaraderie is more subjective and is evaluated not only in terms of the team's success but also the age of the partnership, defined as the average amount of time a team member has spent being part of a team at a given time. Data was collected to calculate these parameters, and to estimate the level of resources and effort required to compete. A sample transcript of one of the actual interviews is presented in **APPENDIX F:** Transcript of one of the interviews.The results are presented next.

5. RESULTS and DISCUSSION

The survey of the dropped out teams resulted in the following findings about the teams themselves, about the financing of their projects, about their future plans and about what the teams felt about PIAXP and prizes, in general.

About Teams

75% of surveyed teams reported only a single core team member (plus a family member who helped time to time). Among the remaining 25%, none had more than 3 founding members and each had at most one most-active member. This statistic also correlates very well with the inability of the team to raise funds for their project since all the teams that had a single core team member reported lack of funding as their reason for dropping out.

The average age of the dropped out teams that were surveyed was found to be 14 years with a range from 0 to 32 years with a standard deviation of around 10 years. The large standard deviation suggests how varied the ages of dropped out teams are. Hence, there is no specific bias for or against newer or older teams. This also shows that most teams were already working on their ideas even without the incentive of a prize.

75% of the team founders had an engineering degree and or an advanced degree in science or engineering. The remaining teams' founders had the highest academic qualification of high school. One founder with an unusual background described himself as an "artist who makes digital paintings and real life fixtures."

75% of the teams that were surveyed started out their work on the automobile as a part-time effort while they held their day jobs. About 15% of the teams started out part-time but have become full-time efforts after the announcement of the prize. However, even though, the prize announcement coincided with the becoming of these efforts as full-time, the reasons cited by the team members were different. The reasons were more in the lines of – "being able to think about the competition more freely" rather than wanted to spend more time on it.

75% of the founders declared family influences as the reason for being interested in automotive industry. Most of these people grew up in a family in which some family member owned an auto

garage or used to tinker with automobiles. One team's founder's influence had been his parents who were race car drivers themselves. 20% of the founders got interested in the mechanical engineering industry due to their professional affiliation or educational training. Only 1 team reported that their main motivation to be involved in automotive industry is because they are interested in cleaner technologies for the industry.

Among the sources of energy of the cars of the dropped out teams, 50% would have run on gasoline, 18% would have run on solar energy and the remaining 32% would have run on some kind of battery. This suggests that no specific technology was specifically biased against. Even though gasoline based cars seem to be dropping out in higher numbers, there were more gasoline cars participating to begin with.

About 90% of the interviewed teams were from US. This is not surprising as most of the participating teams (about 80%) were from US to begin with. Hence, an equally proportionate number of dropped out teams would also be expected from the US. In addition, since the PIAXP events are most accessible from North America, it is also likely that most teams from other regions from the world would not even send their LoI unless they were more serious about participating than most teams from the US. In other words, the low barriers to domestic participation encourage local teams to enter even without sufficient resources to compete in the ultimate race. Hence, the dropped out teams could be more likely to be from the US than their normal proportion among the participants. Finally, the teams that agreed to interview with us were mostly from the US, likely due to the logistical challenges of an international exchange.

About financing

Our survey of the dropped out teams revealed that 62% of teams dropped out because they could not raise funds to build their cars. About 35% of the teams reported that the new safety rules declared in April 2009 were too restrictive and imposed new costs on building cars that were prohibitive. The remaining team reported both lack of funds and mismatched timelines between the PIAXP and their personal goals as their reasons for dropping out. Hence, inability to generate funds to carry out one's projects seems to be the biggest reason for dropping out. About 85% of the teams surveyed reported no formal ownership of any relevant patents. In addition, lack of patent ownership and inability to generate funds, very closely correlate in our data.

None of the teams mentioned that the current financial crisis of 2008-2009 has caused drying up of financing. Only one team was candid enough to admit that the reason why funds might not be available is because many teams have imagined unrealistic chances of their winning while their projects are not competitive enough. "It is easy to claim you have the best idea. It is difficult to prove that, and it shows" – said the team in the interview.

Average amount of money invested into the teams by various funders of the teams that dropped out was found to be around $150,000 with a range from $10,000 to $500,000. Standard deviation was found to be close to the average $150,000 suggesting that people dropped out at various stages of investments. Most teams mentioned that the amount of funds they needed to compete would be of the order of $5 million.

About dropping out

Among the 35% teams that dropped out due to rules they found reasonable, most blamed the involvement of special interest groups. New safety requirements were declared on April 15th 2009, almost 18 months after the prize was first announced. Some teams complained that a race for gas-mileage and clean technology should not have safety requirements as those tend to increase the cost of a car and require more kinds of expertise than an inventor interested in efficiency, could handle. Among the new requirements from each team were 3-dimensional rendering of the entire automobile, details of electrical connections, specific insulation requirements for battery box and race car driving license.

> "…They (PIAXP) sent out new rules on Apr 15th. 45 pages. There was absolutely no way I was going to be able to comply with all of them in time. Suddenly it occurred to me that its got to do with politics of safety rather than engineering a high mileage engine. They took the wind right out of my sails. The emphasis is on battery protection than on driver protection."

One interviewee lamented that it was unfortunate that an insurance company sponsored the competition because they have an inherent interest to further their agenda. He mentioned that -

> "…Progressive Xprize sponsored by insurance company was a conflict of interest. {my company} reduces the number of vehicle interactions coz they go through guide ways. North-south guide ways and east-west guide ways don't intersect. That will decrease the number of collisions and with speeds around 25mph, number of fatalities will plummet

too. How's an insurance company gonna make more money that way? {My solution} would actually shrink the auto-insurance industry."

10 out of the 12 teams surveyed, about 85%, had not changed the level activity on their projects after sending in the LoI. Most of their effort since sending in LoI was in seeking funding to proceed. The teams that had been involved in car-making even before the competition was announced did not report a change in direction of their development due to the competition even though all of them complained about the new safety requirements in the competition rules unveiled in April 2009.

About 60% of the dropouts really thought that, had they participated, they would have won the prize. The remaining 40% thought being exposed to the world was enough incentive for them to participate.

Despite leaving the field of competition, about 60% of the teams are continuing with their efforts. The remaining 40% have aborted their efforts. Of the teams that are continuing their efforts, 90% of the teams are those that started their efforts at least 5 years before the prize competition was announced. In fact, all the teams that started their efforts before 2003 are still continuing their efforts. The ones that aborted their efforts were unable to generate funds for their projects.

None of the dropouts really changed their effort or focus after the announcement of the prize. The ones who started after the announcement of the prize started full time work on their car.

About PIAXP

All the teams interviewed mentioned that they believed an Electric car (not a hybrid car, a conventional gasoline car or a car with other sources of energy such as solar) will win the final prize. Most of them also mentioned that if that indeed happened, they felt it would not be a good thing because "the technology of the future is not electric", as one of the interviewees put it. The reason electric would win, most opined, is because "they have the most funding". Most teams favored Aptera Motors or Tesla Motors to win as they have "deep pockets".

80% of the teams surveyed said that they would be willing to help another team after they dropped out. The remaining 20% said that they were disillusioned with the process of XPRIZE

Foundation and hence will not have anything to do with them. Part of their disillusionment is with the involvement of special interest groups.

> "..I don't know. I think I am done. I am disappointed with xprize. There are many things. Like they said they don't want to have anything to do with govt grants but then they come and say they want to use govt standards of safety and they used govt officials to put the rules and it just got too big. Too many opinionators, too many lobbyists. My favorite saying is that America is gonna go broke on too much safety coz no one knows how much we need. I think xprize has gone way beyond what its original goal. It was supposed to be contest about innovation in high mileage rather than innovation in safety rules"

Most teams, almost 90% teams, had not thought of what they would do with the money if they won the prize. Our initial hypothesis was that an important measure of stability of a team is the formal process for conflict resolution. However, most of the teams surveyed were single-person teams and hence there was no question of any process to divide up the earnings, if they materialized. Most teams stated that the hypothetical situation of winning would lead to investment into their projects and reimbursing the investors.

Every surveyed team agreed that prizes are a great idea for challenges like high efficiency automobiles because Prizes give visibility to crazy solutions.. Most teams, however, lamented that X PRIZE had deviated from the ideals of prize competition – which the teams held should be to have as few rules as possible. 20% of teams also mentioned that it would be better if X PRIZE could help foster easy financing of ideas also in addition to being a platform for the new ideas.

None of the teams mentioned that money was the major reason for any team participating in the competition. The lure of a maximum of $5M prize was not enough for any of the teams. In fact most teams mentioned that the minimum investment required to be able to participate competitively would be around $5M. Hence, monetarily, it would be an irrational decjsion to compete. However, for most teams prizes offer some intangibles that direct market does not. 45% of the teams mentioned that prizes offer a forum for "crazy" ideas to come out in the open so that they could be recognized.

> "...I think the prize is a focus point where people who already have ideas or stuff to show or idea that hasn't had an ignition point comes. It doesn't create new cars but it will give

initial point to start it. Because competition for new car companies is pretty stiff. Hence prize becomes the focal point for new ideas…"

About 35% of the teams said that they were participating for free publicity of their idea so that they could reach out to people who might be interested as investors or buyers.

"I think most of the contestants are in it for the advertising. Look at the big guys participating in it. They have no intention to get into 100 mpg, they are in it for advertising. For them it's a great venue to go out and promote their vehicle and say they are high mileage. They are not 100mpg high mileage."

The remaining 20% mentioned that prizes are unique in that they define a concrete goal to go after when it is not very clear. Prizes are a great way to create a clear direction of invention

"…I developed and patented it all myself and it all started before xprize. Well, it became more defined for me. Prior to the that I had some specific things in my mind but there was no money involved besides what I was spending there was no prize money and so no specific requirements. It did make a diff. I did find some other people who had interest in competing, obviously xprize gave it more exposure than what you could do on your own and for me, the single biggest piece was me getting known so people would be willing to help, I had a website on which I mentioned the Xprize. Xprize played the role of creating awareness and creating level field for people to compete in this arena. The announcement did not change the technology because xprize doesn't have any clue about new technologies – they just wanna inspire people to develop next leap in innovation. They want a stretch from 35mpg that's the current generation's car efficiency. Pretty lofty thought. I never dreamed that I was gonna get 100mpg. My aim was get to preliminary contest where 67mpg…"

DISCUSSION

As was clear from PIAXP data, most teams are from North America which shows a likely bias of the PIAXP as they might not be able reach out teams from rest of the world as conveniently. On the other hand, it is also possible that regional bias in participation is a genuine indicator of a regional interest. North America, after all, has traditionally been the largest automotive market in the world, in per capita terms.

Most of the drop-out teams interviewed were individuals without teams. Given my initial hypothesis that successful participation would require "effective teams", this finding is unsurprising. Additional data on the teams remaining in the competition is necessary, however, to determine whether this is truly correlative.

Most teams cited monetary problems as the reason to drop out. That is natural since most of these drop outs were individuals. Ed Roberts's research on entrepreneurship (Roberts, 1991) reveals the link between team size and its success in high technology fields. The research uses the argument that it is very unlikely for a person to convince a financier when the champion of an innovative idea is unable to convince even one other person about the feasibility of the idea.

Just looking at the list of all the teams that are participating, none of the big auto companies of the world are participating despite the fact that they have most funds to be able to compete. The reason for this goes back to what the surveyed teams called the "actual prize" in a prize competition – which is the buzz. An established firm stands to lose a lot of its reputation for not being able to deliver in the final race against the new ideas and hence, they choose to not participate. However, since most mentioned that the teams most likely to win are Tesla or Aptera, who have "deep pockets", it can be inferred that most believe that some minimum level of resources are important to compete and some reasonably high level of resources make some teams favored. Thus, the teams low on funds can not go far and teams with the deepest pockets do not prefer to participate. This is reminiscent of the Wright's econometric model (Section 2.1), which expects prizes to be most attractive for medium levels of risk.

On average, dropped-out teams spent around $15,500 for each year of their operation. Since most of the dropped out teams we interviewed were single-person teams, the average expense per year suggests a hobby-like interest of the team members in the field of automobiles as opposed to a professional interest. Additionally, most of these teams started off as part-time efforts, which reaffirms the hypothesis. The reason most of the surveyed dropped out teams did not change their effort level after the announcement of the prize may be attributable to the fact that they could not raise sufficient funds. Most teams claimed that had they raised funds, they would have hired more people and put in more serious hours into the car.

This suggests that most teams use the competition as a means to raise funds. Teams think of a prize competition as a forum or a social institution that, along with their idea, grants legitimacy to their claim to funds. Without the prize announcement, their idea is just a technology in isolation

without any hope for finding its place in the market. However, with the prize, the innovator is able to see a possible market and hence starts to raise funds for professionalization of his efforts. The fact that many of them do not get sufficient funds to carry out their projects is likely due to the riskiness of their projects, which is high even for a prize competition. As one team put it –

> "...They (investors) thought that XPRIZE was more like gambling, theres no guarantee, no independent oversight body judging so putting investment into was just risky...."

Thus, the PIAXP is helping in professionalization of various independent efforts, thereby finding or creating markets for technologies that are not mainstream yet.

6. CONCLUSION

While not complete in any sense, this study is an important step in understanding the backgrounds of some teams that were at one time interested in participating in a prize but for some reasons dropped out. This is important to know for the prize designers who do not want to discourage some ideas that hold real potential. This is also important for prize designers because this tells them the kind of publicity they need to do to reach out to the kind of innovators they seek. In order to tap into a broader set of innovators, it would be advisable for X PRIZE Foundation to make it easier for such competitions to be accessible to people from other countries. This could be facilitated by creating standardized test conditions so that the test could be done in home countries of the teams and having marketing campaigns in various parts of the world. Also, it might be helpful to facilitate an arm that helps financers match the innovative ideas.

It seems prizes are viewed as a social institution much like banks, stock market. And maybe they are, in some way, like those institutions since they tend to bring out in open hidden talent and make available the money to them. Prizes are an institution that merges media with venture capital. Media identifies the section of the society that needs "equal opportunity" and VC needs to find a station to park its money in trusted hands.

Related future studies that could complement my findings include an in-depth study of the actual participants, as well as a more rigorous treatment of those players in the industry that might have been expected to send in a LoI, but never did. These studies will also tell the organizer how to reach out to innovators that are currently not incentivized by the competition.

APPENDIX A: Final Interview Questions for the dropped out teams

1. How did your project start? What was the history and impetus behind it? Really, what is the story behind the origins of your work?
2. Who was involved? Was it you alone or did you work with others?
3. How much of your time was this – full time, part time, weekends etc.
4. What was your specific technical focus? What was your approach?
5. Why were you doing this?
6. Assuming this was before the prize, how did the prize announcement impact you if at all?
    a. Did you put in more or less effort?
    b. Did it change the direction of your effort and if so by how much and in what ways?
        i. Optimize around prize metrics, market opportunities or
        ii. to showcase your technology
    c. Did it change your time line?
7. What were your estimates of chances of winning before deciding to participate and how had you planned to divide up the prize winnings?
8. Why did you not register, finally?
    a. (If based outside of US), if the X PRIZE competition was held in your country, would you be more likely to have participated?
    b. Would more teams from your country have participated?
9. What are you doing on the project now? Is it continuing along the same direction as before the prize, in the prize direction but on a different time line or not at all? What is happened to the level of effort? What about resources?
10. Even though you didn't register, do you think prize for this problem is a good idea? Why?
11. Who do you predict will win?
12. Will you collaborate with a participant if invited?

APPENDIX B: Additional Detail on Historical Prizes

Napoleon Food Preservation Prize

In 1795, Napoleon's Society for the Encouragement of Industry offered a 12,000 franc prize for a method of food preservation to help feed Napoleon's army. Nicolas Appert devised a solution using champagne bottles in 1809 and was awarded the prize in 1810 on the condition that he publish his methods. The discovery marked the beginning of the canning industry.

Montyon Prizes

In 1820, the French Royal Academy of Sciences began offering large monetary awards after a private donor established the Montyon Fund for prizes in medicine. The Montyon prizes were designated for solutions to pre-specified medical challenges, with reward amounts intended to be "proportional to the service" of the innovator. The Academy struggled with applicants' failure to disclose negative results, while some suggested that the Academy itself was corrupt as there was little transparency in awarding the prizes and un-awarded funds reverted to the Academy's coffers. Nonetheless, an unprecedented 283,000 francs in prizes were awarded between 1825 and 1842. In 1860, a young Louis Pasteur was awarded a Montyon prize for his work in physiology, and the winnings subsidized much of his subsequent groundbreaking research. In the mid-1800's, private contributions to the French Royal Academy lead to the establishment of dozens of additional monetary prizes. These included the Jecker Prize, established in 1851 "to accelerate the progress of organic chemistry" and the Breant Prize in 1858 offering 100,000 francs for a cure for cholera. Charles Friedel was among the winners of the Jecker Prize for his now famous Friedel-Crafts reaction. The main Breant Prize was never awarded, though it propelled more research on infectious diseases that was rewarded with subsidiary prizes. Pierre and Marie Curie received multiple prizes from the Academy between 1895 and 1906. The French Royal Academy gradually transitioned from offering prizes to grants in the late 19th and early 20th centuries.

U.S. Patent Compensation Board

In 1946, the U.S. Patent Compensation Board was established to provide an incentive for private innovations in atomic energy that were no longer eligible to be patented for security reasons. The Board considers the cost and usefulness of inventions in determining how much

to reward inventors, but reward amounts have been criticized for being too low; Enrico Fermi received only $300,000 for his patented process for the production of radioactive isotopes. The Compensation Board remains in place today, but largely fails to stimulate private sector innovations in atomic energy.

Turbine Prize

In 1826 the French Society for the Encouragement of Industry offered a prize of 6,000 francs for the development of a large-scale commercial hydraulic turbine. The prize was won in 1833 by Benoît Fourneyron, who had applied for a patent in 1832. By 1843, there were 129 plants created or improved in France, Germany, Austria and Poland thanks to his design, which also helped to power the burgeoning New England textile industry, and was installed as a generator on the US side of Niagara Falls.

The French Society for the Encouragement of Industry regularly awarded technological prizes. For example in 1896, they awarded 3,000 francs for the best motor to run on commercial oil, 3,000 francs for a more efficient steam engine, 2,000 francs for a motor suitable for housework, and 2,000 francs for an incandescent small scale electric lamp. A 12,000 franc prize offered by the same society in 1795 for a method of food preservation usable by the French military led to the commercialization of food canning.

Liverpool and Manchester Railway Locomotive Prize

English engineer George Stephenson built the locomotive named Rocket in response to a challenge by the Liverpool and Manchester (L&M) Railway Locomotive Company in 1829. The challenge was to demonstrate a freight-hauling locomotive engine below six tons that could take load of 20 tons at ten miles per hour speed. The prize purse was 500 pounds. Ten teams entered the competition; of which only one met all the requirements on the testing day. Stephenson's invention was one of the factors behind the sudden increase in railway construction that helped the spread of the industrial revolution in Britain.. After the competition, L & M purchased the design, which served as the basic template for future locomotive designs for the next half-century.

Chicago Herald-Tribune Prize for Motors

On Thanksgiving Day, 1895, the Chicago Times-Herald offered $5,000 in prize money for a race of self-propelling road carriages through the streets of Chicago. At the time, American public

opinion held that automobiles were unlikely to ever become mainstream and little attention was paid to developments in the then-nascent industry. Originally scheduled for July 4, the competition was postponed until the following Thanksgiving so that the largely underfunded competing teams (76 in total) could prepare their vehicles. Describing how his team came to be, Frank Duryea, chief engineer of Duryea Motor Wagon Company and driver of the winning car said: "The other men active in our company...were not of great wealth or too wide business experience. But they had the courage and the first prize of $5,000 was worth going after..."

When race day arrived, there were four inches of snow on the ground in Chicago. The Times-Herald decided not to postpone again, since a successful car race in snow would prove the superiority of automobiles over bicycles. Six teams were willing and able to brave the weather for the race, including the winning Duryea car, the only gasoline-powered domestic entry.

In his book, *Carriages without Horses*, author Richard P. Scharchburg characterizes this prize as creating a "thrill [that] swept the United States," due in part to the contest's appeal to the elements of the American character that prized travel and were always "seeking to conquer distance," as well as the elements that relished it when Americans "triumphed over foreign competition," as happened during the race. The winning of this prize served to make automotive technology mainstream in the United States, to establish the gasoline engine's dominance over electric motors, and to create millions of future customers for the automobile

Automobile Clubs' Prize for a Cheap Alternative to Gasoline

In 1913 in Paris, the International Association of Recognized Automobile Clubs announced that they were offering a prize of $100,000 for the best fuel, other than gasoline, capable of being used in internal combustion engines. The prize was an effort to address the rapidly increasing price of gasoline by interesting chemists in the development of "a fuel which cannot be rigged or cornered by any nation or combination of national interests.

APPENDIX C: Complete list of dropped out teams

1. IaeN'O
2. Valentin Technologies
3. AirShip Technologies Group
4. Mann Research & Development
5. CKE Technologies, Inc.
6. Lydell Industries LLC
7. Roane Inventions
8. Team Fire Fly
9. Alpha–Core/Poulsen Hybrid
10. ARKAS Automotive
11. Automotive Development Engineering Productive Technologies (ADEPT)
12. Bios Fuel
13. Desert Fuel
14. Dragonfly Technology LTD
15. Hybrid Electric Vehicle Technologies, Inc.
16. Istanbul Teknolojik Ar-Ge Merkezi Ltd
17. Kepler Motors
18. Kuttner Doran
19. Miastrada Company
20. Michigan Vision
21. Miles Electric Vehicles –
22. MotoTron Corporation
23. New Leaf -
24. Opera Zero
25. Phoenix Motorcars
26. Porteon Electric Vehicles, Inc.
27. Revolution Motors
28. S.C.E.V.
29. Society for Sustainable Mobility
30. Spirit One
31. HP2g
32. HyKinesys –
33. Industrial Designers GMBH
34. Tilting Vehicle Australia [TvA]
35. C&N Performance
36. Eastern Technologies Romania
37. Electric Revolt
38. Esterer Engineering
39. gPod
40. Green Energy Conversions
41. Gunn Team
42. Hybrid Technologies
43. Hyper Automotive
44. Prometheus Systems
45. Rare Earth Labs (RELEC)
46. The Standard Joule Company
47. Turner Motors
48. Adiabatic Gas
49. Cloud Electric Racing
50. Goodwin-Young "Linc Volt"
51. GotPower
52. Innovative Environmental Energy Concepts
53. Kinetic Vehicles
54. MDI / Zero Pollution Motors
55. Millennial Powers Motors Corporation (http://www.millennialmotorsinc.com)
56. NgEK
57. Pegasus X
58. Physics Lab of Lake Havasu

59. Pinwheel GT
    (http://www.pinwheelgt.com/)
60. Revolución Motors
61. Team Tejas
62. Utopia

APPENDIX D: List of teams interviewed

Each of the following teams entered the PIAXP by sending their LoI in April 2008.

Team	Headquarters	Vehicle type	PIAXP end date
laeN'O	Marshall, North Carolina	Hybrid Electric	April 2009
Valentin Technologies	Milwaukee, Wisconsin	Hydraulic Hybrid	April 2009
Airship Technologies Group	Lake Oswego, Oregon	Biodiesel + Magnetic levitation	April 2009
Mann Research and Development	Benton, Kentucky	Internal Combustion Engine	April 2009
CKE Technologies Inc.	Montreal, Canada	Continuously Variable Power-Split Transmission (Radial engine)	April 2009
Lydell Industries LLC	Erie county, New York	Combustion Chamber Quenching Minimization Technology	April 2009
Roane Inventions	Austin, Texas	Triangular Monorail	April 2009
Team Fire Fly	Washington	Compound hybrid drive system	April 2009
HP2G	Ohio	E-85 powered V8 Engine	April 2009
TvA	Kilburn North, Australia	Tilt angled vehicle controlled through special steering technology	April 2009
Hykinesys	Rolling Hills Estate, CA	Conventional E85 engine	April 2009
Pinwheel GT	Atlanta, Georgia	Compressed air/Electric hybrid	July 2009

APPENDIX E: Survey Data

Team	Total money invested (in $)	Team's average age (in years)	Effort (part-time or full-time)
1	10,000	4	Part-time
2	500,000	21	Full time
3	375000	14	Part-time
4	60,000	32	Part-time
5	180,000	21	Part time
6	120,000	29	Full time
7	250,000	3	Part time
8	10,000	11	Full time
9	25,000	5	Part-time
10	20,000	2	Part-time
11	100,000	10	Part-time
12	150,000	15	Full-time

APPENDIX F: Transcript of one of the interviews

In deference of the team's request, the following text tries to hide their identity. {L} refers to the team respresentative that we talked to. {W} refers to one of the interviewers. All the identifying references have been replaced by XXX

{L}: So you run the Xprize lab?
{W}: Ya, so we do teaching and research on prizes and are studying among other thing the auto xprize
L: I wondered how a student at MIT knew, not that I was in the auto xprize contest but that I am contemplating dropping out of the contest.
W: We have the official list of teams that are finally competing
L: That's all right but I think I am still on the list?
{W}: On the final list?
L: Yeah. I looked at it the other day
W: Hmm. Lucky catch then?
L: Yeah
W: We appreciate you giving us some time chat. So as we explained in the email we are trying to understand what makes people compete, how do teams form and the iterative challenges and how do xprizes affect the innovation landscape and this phase of interview...all who originally decided to compete...Tell us your story, how did you get involved
L: We are XXX Team...I am trying to remember. See I have been working on high mileage cars since much before XPRIZE came along. As far as energy efficiency goes, not just automobiles, but green technologies such as solar panels, windmills, those kind of things since the 70s. My first patent automobile related for high efficiency motor was in 1984.
Being a few years older than you are, I took an early retirement from being a VP at a hospital doing engineering and architectural work so thats my background – architectural engineering - to work full time on high mileage vehicle but 6 months after I retired is when I learned that this is really nifty. At that time they didn't have a number on the prize – how many millions how many miles per gallon – regular car or sports car or the mileage, I wanted a real car with 70-80mpg...and so when Xprize came along I said this matches my goals because the timing was right, preliminary release was going to be just next fall (now its next spring) and final race a month or two after that...for a long time the timeline of Xprize really fit well with my schedule. They came out with their list of rules – their need to keep the rules simple, to create level playing field, the need to make it affordable but specifically to find the kind of people. I identified with the kind of people they wanted – I am not a normal automobile company. I do have extreme interest in competing in contest for high mileage and maybe my ideas can go mainstream and maybe some automobile company can pick it up. See, my idea was never to produce 10000 cars a year not that lofty. Mine was 75-85% of the design was mechanical design and 20% or so was aerodynamic design. I didn't see reason to design my car from ground up since many of those things were already done I just wanted to work on mechanical aspect and squeeze more mileage out of gasoline.
W: So this technology, patented technology of Third cycle engine, that you worked on, is fully developed by you before Xprize came along? And how did you effort change when xprize came along?
L: Yah, I developed and patented it all myself and it all started before xprize. Well, it became more defined for me. Prior to the that I had some specific things in my mind but there was no money involved besides what I was spending there was no prize money and so no specific requirements. It did make a diff. I did find some other people who had interest in competing, obviously xprize gave it more exposure than what you could do on your own and for me, the single biggest piece was me getting known so people would be willing to help, I had a website on which I mentioned the Xprize.

Xprize played the role of creating awareness and creating level field for people to compete in this arena. The announcement did not change the technology because xprize doesn't have any clue about new technologies – they just wanna inspire people to develop next leap in innovation. They want a stretch from 35mpg that's the current generations car efficiency. Pretty lofty thought. I never dreamed that I was gonna get 100mpg. My aim was get to preliminary contest where 67mpg
W: So it was a publicity tool for you and were not really hit the start line on race day?
L: That's correct and the reason for that is when you read through the list, 80% of the them and I have talked to people also, 80% of them you don't worry about them at all because they don't have deep pockets and the ones that have deep pockets have chosen electric rather than mainstream class. My problem is that if a person has enough money, you put $40,000 worth of lithium ion battery in your car because there is no specific cost element just like there is no specific speed element in the list of requirements, they have never defined the actual cost of the car except that it has to be "affordable".
W: Interesting.
L: Part of the requirements is pollution control and emissions control. We have to go through the same dynamometer as the one in Ann Arbor ones go through EPA. We gotta meet the new pollution standards but they never specified the speed or cost.
W: Gaping hole in the rules?
L: No I think that was pretty smart of them to do that.
W: Did you get other people involved during the time you were competing
L: No, even before the contest, I had some family members and other people that I bounced my ideas from time to time and we realized there isn't going to be any single revolution that is going to get us to 100mpg. We will have probably 15 different drive-train assembly and engine innovations. We will have computer driven efficiency program combined with mechanical efficiency....I worked on Ford Focus earlier (now on Honda Civic) to see how many gallons per hour were we using and we found it was around 2 gallons per hour which makes sense since its doing 30mpg and also the computer showed and brought the engine to same speed (60mph) while in neutral in the lab and it said u r using 0.85 gallons per hour. What that tells you is that you are using half the gasoline just to run it on the road.
W: I take it you are an engineer by training.
L: Yes. But I like to call myself an inventor. Theres a big difference between the two. First you come up with how you wanna have the efficiency you want and then you can engineer your engine to do that.
W: So do you have an engineering degree
L: No
W: So this is all self-taught
L: Yes
W: Do you have a background in any other field?
L: Architecture. In the hospital I worked, at least half of my work was designing new buildings, structurally, space planning etc but the principle of how to make anything more efficient stays the same in architecture and in engineering
W: What part of you time did you spend on this project?
L: Well I retired 3 yrs ago so I worked on it full time since then. In between I was working on some hospital stuff 4 hrs a day, 4 days a week. All of the rest of the time – weekend and all – I spent on this. I think I have just shy of around 8500 hours on this project, myself. I have a little machine shop where I do 90% of all my work, my engine is my own, so is my hybrid system, my transmission is my own. I have taken help from a couple of advisors and I have used a couple of companies to manufacture somethings for me once in a while
W: In terms of your software skills, do you do your own website? Marketing etc.
L: No you're correct. I have a couple of people I sometimes call in favors from. Some PR person at the hospital that I worked at said he'd do PR work for me but I said I'd rather keep a low profile and

get the patents secured and go through preliminary contest. The reason is I have been in this long enough to know that people with deep pockets, if they get to know of a good idea, they just go and take it. I hold just 1 patent so far. I do provisional patents coz they are cheaper and that gives me the chance to upgrade them. The upgrade costs anywhere around $20k (up from $1k).
W: So then what happened? Why'd you drop out?
L: They sent out new rules on Apr 15th. 45 pages. there was absolutely no way I was going to be able to comply with all of them in time. Suddeny it occurred to me that its got to do with politics of safety rather than engineering a high mileage engine. They took the wind right out of my sails. First they want 3D renderings of my entire automobile. Nothing wrong with that but then they wanna get under my car – under the hood, get into my knickers a bit. Its none of your business whats under my hood. The original rules said that – we don't wanna know whats under your hood – Not our business. Suddenly they made it their business.They want pictures and very detailed wiring diagrams, details of fuel systems, monitor what I am doing in my drive train, wanna know the amps, the volts, to see if you are electric or hybrid, brake position etc. And I said I cant do that. Julie (from Xprize) said that each of us has signed confidentiality agreement and I said if that's the case then why do you need the information? I felt very invaded.
W: Looks like lot of burden on you and some challenge for your IP too. Rubbed you the wrong way then?
L: Yeah. They want me to measure the coefficient of drag and how I got there. And I said who cares about all this as long as you are getting 80mpg. Its just a series of things – a detail description of any abnormal drive train use. I am not going to send them that.
W: DO you think it was part of safety screening.
L: We haven't got to the safety part yet. This was just about IP that they had no business poking around with. I mean this is exactly what I have spent a great deal of my life doing exactly they want me to send in a couple of pages and we promise we wont tell anyone. They were saying that every contestant has to use their 5 gallon gas tank and their steel connection because they are afraid that people are going to try to cheat. I mean, there are many other ways to monitor whether gas is hidden or not. To me they went way way overboard. I don't think there were a whole lot of people who entered the contest thinking they'd win by cheating. Then they have safety requirements. If you have more than 50V then you have to comply with certain electrical safety and that's reasonable, battery has to be bolted to the frame, battery box has to have certain insulation, certain spacing, pages of electrical safety but then – BTW we decided we don't need airbags for the contest. Have to carry same weight but don't need to have the bag in the cavity. The emphasis is on battery protection than on driver protection. It's skewed. They all require driver to go through certain driving course which costs $2-3000. So you need race car driving certification just so you can drive on dynamometer. Ever since the new rules came out, I can see the meter running rapidly and it's gonna cost me 10-15k more just to make the rules that I don't agree with for a high mileage contest. Before that I was 100% gung ho to be in preliminary contest at 75mpg and then evaluate how I stack against other contestants and decide if I wanna put extra 5-10k. So I asked the people I had taken help from. They have skewed the contest towards electric vehicles, in my mind with new rules. You cant build more efficient electric motors, they are already 90-95% efficient. So it doesn't make sense. Electric motors have been around much longer than gasoline engine has. Battery technology has gotten lot better but right now its just a matter of putting lots of $s. Most electricity comes from coal powered plants and they are not clean. Is this a contest for clean energy or high mileage?
W: Do you have any outside investors
L: I have 2 small outside investors that put in around 15-20k. I put around 100k solid myself. No corporate sponsors
W: So what happens from here?
L: I have every intention to continue on my project. My goal was always to create a high mileage vehicle and to prove 75-80mpg on regular basis; it would last as long as real car. Never to sell it to

big guys. Then I thought if I could get it to some who wanted to purchase this. I think I could do that on my own. I am not deterred to finish my project. I am very deterred from doing xprize.
W: Is there anything that you are going to drop and start focusing on something else after dropping out of contest?
L: I don't have to become certified race car driver. Some other safety things, I do have airbags. Theres nothing from old rules that I am dropping and nothing from new ones that I even started complying with so I guess nothings changed. I agree with all of the safety requirements except for race car driving certification except they previously talked about removable gas tank or something
W: So do you think, even though you are not contesting, that auto prize is a good idea.
L: I think most of the contestants are in it for the advertising. Look at the big guys participating in it. They have no intention to get into 100mpg, they are in it for advertising. For them it's a great venue to go out and promote their vehicle and say they are high mileage. They are not 100mpg high milage.
W: Do you think there will be more evolutionary change that will come out of this contest?
L: Absolutely not. Few websites talk about nifty things like hydraulic system, he is not revolutionary. You cannot take the car in your garage and press air into it and get 100mpg. Its worse efficiency than charging up battery. I mean there are some ideas that capture peoples imagination, they are not as realistic as one would think – in real world, not on calculator. Because I'd like to build things, design and engineer them
W: Do you the race will change the public perception about anything?
L: My biggest fear is that it is going to cause push towards electric vehicle and I don't believe that's the future of transportation. I do believe it's a niche market for family that has 2-3 cars for them to drive back and forth from work. My biggest thing is that xprize said that they want to get to the mainstream America. I am saying that's not electric vehicle.
W: Do you think winner will be an electric vehicle?
L: Absolutely. In both classes. In alternative class it will be Aptera. It's a $15-16m company and right guy incharge of it. Sleek design, its attractive gets the attention of public, they will sell few of them not in NY because it's a 3 wheeler but in southern states. In mainstream class, it will be Neil Youngs car, again an electric car. I truly believe he's out there to get some attention. Its wonderful what hes doing but he never did the math. Ya I think it will be electric the ones with deep pockets.
What I like abt Xprize is they are trying hard to get equivalent of mpg for electric vehicles rather than just mpg.
W: If another team called you up and said they needed extra help and would like to use your engine design, would you still be in the competition or are you done?
L: I don't know. I think I am done. I am disappointed with xprize. There are many things. Like they said they don't want to have anything to do with govt grants but then they come and say they want to use govt standards of safety and they used govt officials to put the rules and it just got too big. Too many opinionators, too many lobbyists. My favorite saying is that America is gonna go broke on too much safety coz no one knows how much we need. I think xprize has gone way beyond what its original goal. It was supposed to be contest about innovation in high mileage rather than innovation in safety rules
B: Going in to the contest, how did you fancy your chances of winning?
L: I said, I didn't go in to win but you never know, My theory was if I could build a hybrid vehicle that could get 80mpg and it was a $25k car, I was way ahead of the game than any electric car which could go 200 miles but would cost way more. That doesn't make sense to me. I could stick with gasoline that's the infrastructure for today. My car is assembled differently but it doesn't cost any more than the normal car. My expectation was that I would get noticed as a conventional automobile that has double the mileage of vehicles today.

APPENDIX G: Questionnaire for the aborted Survey

Team Name:

Questions about the Team's Parent Organization

1: Was the organization formed explicitly to enter PIAXP or did it pre-exist?

2: What year was the organization incorporated?

3: In which country is the organization's headquarters?

4: Is the organization public or private?

5: Is the organization for profit or not-for-profit?

6: How many people were employed by the organization in 2008?

7: What were the organization's annual revenues in 2008?

8: How many patents did the organization hold in 2008?

9: Which of the following best describes the industry that the organization operates in (pick one):

- Traditional Automobile Manufacture
- Alternative Energy Automobile Manufacture
- Automotive Component or Subsystem Manufacture
- Advanced Materials/Technology Provider
- Other (please specify)

10: What was the chief motivation for the organization to enter PIAXP (choose one)?

- To Win the Financial Prize
- To Generate Positive Public Relations (PR)
- To Create and Develop Valuable Intellectual Property

11: Will the organization continue to exist once the competition has ended?

Questions about Team Size, Structure and Demographics

X: How many individuals are members of your core PIAXP team?

- Full Time Members (dedicated to project during normal work hours)
- Part Time Members (work part time on project during normal work hours)
- Spare Time Members (work part time on project outside normal work hours)

X: What percentage of the core team is collocated?

X: How many different geographic locations are represented in the core team?

X: What is the educational level of your core team (give percentages)?

X: What is the disciplinary background of your core team (give percentages)?

- Engineering (Electrical, Mechanical, Chemical, etc.)
- Classic Sciences (Physics, Chemistry, Materials, etc.)
- Computer Science (Software, Hardware, Systems, etc.)
- Other

X: How many years of *general work experience* do core team members have on average?

X: How many years of *automotive work experience* do core team members have on average?

X: How many total patents does the core team hold?

X: What is the gender composition of your core team (give percentages)?

X: What is ethnic composition of your core team (give percentages)?

X: How many different nationalities are represented on the core team?

X: Which of the following answers best captures how the core team came to be formed (choose one)?

- Friends who share a common interest and volunteered for PIAXP
- Work Colleagues who share a common interest and volunteered for PIAXP
- Work Colleagues who share a common interest and were asked to work on this project

X: Which of the following answers best captures how your project team is being financed (choose one)?

- Self Funded (including working without pay)
- Funding from friends, family and angels
- Formal backing from a sponsor organization
- Funding from the Parent organization

Questions about Team Leadership and Process:

X: Does your team have a formal team leader?

X: How many layers of hierarchy are there in your team structure (i.e., how many levels of authority)?

X: To what degree would you say your team is hierarchical versus democratic with respect to decision-making? Answer on a 1-7 scale, where 1=very hierarchical; 7=very democratic

Questions about Team Capabilities:

X: Please assess the degree to which you have immediate access to the following capabilities:

- NOTE: Assess on a 1-7 scale, where 1=no access; 7=full access
- Circuit Board Design and Fabrication Tools
- Computer Aided Design and Simulation Tools
- Other....

Questions about Team Expectations

X: Assess current progress towards meeting your technical objectives for the system, using a percentage scale? Percentage scale, where 100% = met technical objectives

X: How many months do you estimate it will be until you have a fully functional prototype? (0=have one now)

X: What is your estimate of the probability you will meet your technical goals for this competition?

X: What is your estimate of the probability you will win this competition?

Questions about the Team's Technical Approach

X: How would you characterize the approach you are taking within critical vehicle subsystems?

- Energy (Gas versus Electric)

- Propulsion (Mechanical versus Electrical)

- Body (Metal versus Composite)

- Other....

X: Please estimate the Complexity of your Solution on a 1-7 scale, in each of these areas:

- NOTE: Assess on a 1-7 scale, where 1=very simple; 7=very complex

- Software

- Electrical Hardware

- Propulsion system

- Body

- Manufacturing and Assembly

- Systems Integration

- Other...

Questions about the Team's Plans Upon Completing the Competition

X: What will happen to the prize money should the team win (choose one)?

- The parent organization will keep it
- The team will keep it and split amongst themselves
- Not yet been decided

X: What will happen to the work products and intellectual property that the team produces (choose one)?

- They will be owned by the parent organization
- They will be owned by the team
- Not yet been decided

X: What will happen to the team itself (choose one)?

- We will return to our "day jobs" in the parent organization or elsewhere
- We will continue to work on this initiative within this team
- We will disband and pursue other opportunities
- Not yet been decided

For the sake of this survey, we talk about the organization that is funding the team

– We refer to the entity you work for as the organization/firm

- We refer to the group engaged in the work as the team – in some cases the team and the firm will be the same but in others, the team will exist within an organization

For those who are not full-time what other activities to they engage in?

- Other work within the organization

- Other work outside the organization for another organization

- Other work outside the organization for educational purposes

For newly formed teams:

- In what capacity did team members know one another prior to PIAXP (check all that apply)

- Work colleagues
- College
- Social

Has anyone left/joined the team since the start of the competition? If so, how many people

Which of the following best captures how the core team is being paid?

Have you agreed among the team what will happen if you win the prize – do you have a contract among the team

How long would it take you to fabricate a printed circuit board and where

Software XXX

Body

Prototype

Development Strategy: in-house (team), in-house (org), out-source

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