HOW KNOWLEDGE FROM INNOVATION COMPETITIONS CAN ADVANCE SUSTAINABLE INNOVATION TARGETS IN ARCHITECTURAL DESIGN COMPETITIONS

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Abstract

Modern interpretations of sustainable building design are founded upon innovative application of new products and technology, often for the first time. Such examples are at the forefront of the 'prototype' nature of buildings that result from both design and technological innovations. Architectural design competitions are the primary competition in the construction industry, primarily concerned with design innovation, and are a popular procurement method for large public projects. Although such conceptual competitions often lack the physical dimension such as prototyping, they have been shown to be very effective in generating project specific radical designs. More broadly industry-based contests can be used to trigger research and knowledge creation, as well as investment in industry, with the competition rules and judging criteria critical to directing the entrants towards radical designs and technological solutions. The limitation of architectural design competitions to design criteria is limiting to the advancement of functional, performance criteria in the industry. This lack of emphasis is restricting the application of innovative sustainable solutions in the building industry through such competitions.

This research demonstrates how knowledge from innovation contests in other industries can benefit the application of sustainable innovation and technology in architectural design competitions. This can be achieved primarily from a modification to the design of the competition environment, including scope and judging criteria and expected degree of resolution. The results of this study show that a design competition with a comprehensive scope and demonstrable outputs are more likely to result in more focussed sustainable innovation solutions.

Keywords

sustainable design, buildings, innovation, competition, Architectural Design Competitions

Introduction

Competitions as a source of innovation

A central theme of the literature on industry competitions is that innovation is enhanced by 'staged' competitions (where teams compete for a prize). Such staged competitions are usually an ex ante prize to determine the best technological or constructed idea or outcome in response to a specific target. Staged competitions are referred to in different fields as global challenges (X-prize.org, 2017) recognition prizes (Stine, 2009) innovation contests (Kay, 2011). Competitions of this nature are shown to provide numerous benefits over typical market responses to progressing innovation such as reaching a broad range of entrants, pay only for performance, leverage of outside resources, creating parallel innovation, and attract public interest (Wagner, 2011). Early innovation stage competitions are broadly categorised as ideas, concept or design competitions, where individuals or firms are invited to design a response to the competition brief. Early stage competitions often lack the physical dimension however

have been shown to be very effective in ideas generation and promotion (Carvalho, 2009). As well as early stage concept, ideas or design competitions, industry competitions can be designed to address a more advanced stage of the innovation development, and individuals or teams are judged on a working prototype or market ready outcome. In contrast, Ex post competitions such as industry awards that are common in the construction industry, recognise innovation development that occurred independently from the awards judging. The industry awards mechanism therefore tend to reward the outcome of innovation which are typically best practice and high achievement projects (Khan, 2015). Such ex post competitions have less direct impact on the innovation process.

Despite the use of innovation competition in other industries, the construction industry is relatively backwards, and is repeatedly found to have lower overall rates of adoption of innovation than other industries (Dibner & Lemer, 1992; Johnson & Tatum, 1993; Slaughter, 1993). So despite being described as "a lively source of new ideas" a general conclusion is that "the rate of innovation lags behind most other sectors, and appears to be falling further and further behind" (Graham, 1998). Architectural design competitions exist within the construction industry as a beacon of hope as a pre-existing competition framework that is well accepted by the industry and offers the potential for similar gains in sustainable innovation as seen in other industries.

Literature Review

Despite their widespread use in other industries, technological focussed innovation competitions are in their relative infancy in the construction industry, despite the long-standing existence of architectural design competitions. This represents an inconsistency between the current competition outcomes and the needs of the industry, as construction projects can no longer target purely aesthetic architectural goals without specific performance targets.

Architectural Design Competitions (ADC's)

Despite their long history and increasing interest, research on architectural design competitions (ADC's) is relatively poor (Adamczyk, Chupin, Bilodeau, & Cormier, 2004; Volker, 2010; Zettersten G, 2009). Research on ADC's tends to focus on the history of their use (Andersson, 2013), the make-up of the jury, fair and equitable judging and specifics of the competition rules and the responsibility of the jury for the interests of the client, teams, society, the winning entry and the organisation that the jury represents (Kazemian & Rönn, 2009).

ADC's are a well-established pathway to generate a large number of quality design proposals at relatively low cost (Lipstadt, 1989; Nasar, 1999). The ADC as a procurement strategy is therefore well established within the industry and in theory provides an excellent case of industry relevant competition, with benefits also to architects evident from the active marketing of winning competitions entries on their websites (Rönn, 2013). For Robert Gutman, the premier sociologist on Architectural practice "the basic intention of the design competition method… is to bring architectural markets closer to the condition that economic theory calls 'perfect competition' (Larson, 1994). According to Lipstadt (2006) there are two main competition structures - open and invited; and two main competition populations - national and international. The objectives of the competition can be ideas only, or less commonly 'tout court', which is the submission of resolved designs. Such a narrow focus on design considerations in ADC's ignores the important technological aspects related to modern buildings, such as demonstrable sustainability performance requirements. Such omission is rendering the current Architectural design competition irrelevant to the industry. However, with learnings from the innovation competition experience from other industries, it is possible to introduce new criteria to the judging of architectural design competitions that addresses key concerns relevant to industry requirements.

Innovation Contests

Innovation contests generally are defined as "IT-based and time-limited competitions arranged by an organization or individual calling on the general public or a specific target group to make use of their expertise, skills or creativity in order to submit a solution for a particular task previously defined by the organizer who strives for an innovative solution" (Adamczyk, Bullinger, & Möslein, 2012). Competitions of this type can be one-offs or repeated competitions such as those used regularly by the US Government or the X-Prize Foundation, both of which tend to focus on development of technological prototypes in response to a challenge or need unmet by industry. In the context of buildings, this could include the innovative technological solutions to achieve net-zero energy or net-zero carbon buildings. Despite the 'pure' competition format, such prize incentivised challenges are often in pursuit of a private outcome for a new innovation that is not currently available, such as the provision of private space flight, and others are in response to a more direct need such as development of autonomous vehicles (Stine, 2009). Such competitions usually target an issue specific to the competition organiser in isolation of other industry goals and although held by repeat organiser, they are not a repeated competition.

Such contests often have large prize money attached, and these large-scale competitions have attracted the attention of policy makers to the point that U.S. government agencies now use prizes more commonly(Stine, 2009). McKinsey & Co. estimates that that sector may be worth as much as $2 billion if rewards offered by all types of prizes are included. Prizes may be more relevant in certain industries, with the aviation and aerospace industry being good examples.

	Knowledge Ecology International (2008)	**Masters & Delbecq (2008)**	**McKinsey & Company (2009)**	**Stine (2009)**
Dataset content	204 awards and prizes	89 technology prizes	219 prizes worth $100,000 or more	14 U.S. federally-funded innovation inducement prizes
Coverage (years)	1567-2007	1567-2008	1769-2007	2004-2011
Rewards (cumulative total in parentheses)	From $2.56 to proposal of $80 billion (>$80 billion)	From less than $50,000 to $53 million ($400 million)	From $100,000 to $30 million ($357 million)	From $250,000 to $10 million ($51 million)
Top technology areas (share of prize competitions in parentheses)	Medicine (18%) Aerospace (8%) Agriculture/food (8%)	Aviation (20%) Medicine (11%) Transport (10%)	Climate/Environment (11%) Medicine (9%) Aerospace (5%)	Aerospace (43%) Energy (29%) Defence (14%)

Table 1: Innovation competition datasets recently compiled by the literature

Luciano Kay (2012) comprehensively analysed the prize incentive category with specific focus on how prize entrants respond to prize incentives, how they organize R&D activities, and how technology advancement takes place in the context of prize competitions. The research findings show that there is a wide range of motivation for an entrant to participate and notes the importance of entrants from outside the field, with non-monetary incentives shown to have the greatest incentive power. A key finding of this extensive research on prize incentivised challenges is that they can induce innovation over and above what would have occurred anyway, although this depends on the context and entrant specific factors. Breakthrough innovation can be enabled but not directly induced. It is notable that this extensive research and data set does not include a single building or construction focussed project, despite the need for innovation in this sector. Although the ADC is a well-established competition format, it is currently underutilised when considering the need for technological innovation, such as is required for sustainable outcomes. Haller, Bullinger, and Möslein (2011) suggest that innovation contests can be used to trigger research and knowledge creation as well as investment in industry, demonstrating the industry level benefits of a sustainable performance focussed innovation competition.

Methods

This research uses the well-established Innovation Decision Model (IDM) from the Diffusion of Innovation (DOI) theory (Rogers, 1995) with critical case study analysis to analyse two cases.

The DOI Theory

Rogers (1995) DOI theory addresses many aspects of innovation with the specific emphasis on the generation (idea), diffusion (movement) and adoption (uptake) of innovations. The generation phase begins with the recognition of a problem or need, leading to research and development (R&D) and eventual commercialisation if the innovation is successful. Innovation generation does not automatically mean it will be adopted by the market regardless of if it is radical or incremental. The generation of innovation is most commonly in response to an identified need, although this is not always the case. Idea generation can be collectively referred to as ideas generation, project definition, problem-solving, design and development, production and marketing and communication, which describes the various stages of development (Gopalakrishnan & Damanpour, 1994). Diffusion is defined as the process by which "an innovation is communicated through certain channels over time among the members of a social system (Rogers, 2003) and represents the primary mechanism of spreading an innovation for adoption or implementation by the end user. Following successful diffusion of an innovation an organisation or individual must still decide to adopt it for use. Rogers differentiates the adoption process from the diffusion process in that the diffusion process occurs within society, as a group process; whereas, the adoption process pertains to an individual. The 'Innovation-Decision Model' (IDM) can be used to explain how innovations proceed to adoption within an organisation in an industry environment. Table 2 (below) indicates the stages of decision making that occurs about an innovation. In most competitions, innovations decisions are limited to the first three stages due to the lack of implementation criteria of an innovation in a competition.

The five stages of the Innovation Decision Model are as follows:

Stages of the Innovation Decision Model	
Stage	**Definition**
Knowledge	The Decision Maker is first exposed to an innovation but lacks information about the innovation. During this stage the individual has not yet been inspired to find out more information about the innovation.
Persuasion	The Decision Maker is interested in the innovation and actively seeks related information / details.
Decision	The Decision Maker takes the concept of the change and weighs the advantages / disadvantages of using the innovation and decides whether to adopt or reject the innovation. Due to the individualistic nature of this stage, Rogers notes that it is the most difficult stage on which to acquire empirical evidence.
Implementation	The Decision Maker employs the innovation to a varying degree depending on the situation. During this stage the individual also determines the usefulness of the innovation and may search for further information about it.
Confirmation	The Decision Maker finalizes his / her decision to continue using the innovation. This stage is both intrapersonal (may cause cognitive dissonance) and interpersonal, confirmation the group has made the right decision.

Table 1: Stages of the DOI Innovation Decision Model

Case study analysis for theory development

Case studies are appropriate to be used to test or generate theory and are particularly appropriate for areas where the research is still in its infancy, formative stages where there are no solid theoretical foundations. It is preferred when "how" or "why" questions are being posed (Yin, 1994). According to Eisenhardt (1989),the case study research method represents an inductive approach and that allows the in-depth study of individual cases (or innovations), which will provide a detailed understanding that would not be possible using more cross-sectional methods. It can include data from direct observation and systematic interviewing as well as from public and private archives. Any fact relevant to the stream of events describing the phenomenon is a potential datum in a case study, since context is important (Leonard-Barton, 1990). The case study approach has been used extensively in the analysis of the decision making process (Pettigrew, 2014). A critical case is used in order to generalise about other innovations, in this case to view how innovations have progressed through the IDM. The case study data is collected via content analysis (Bell & Bryman, 2007).

Following data collection, innovation factors were compared with the DOI Decision Implementation Model categories. This analysis highlights where the competition has strengths and weaknesses related to innovation progression and will identify key factors that drive innovation. The historical case-based perspective involves matching patterns in the data with theoretical explanations (Yin, 1994).

Case Studies

Architectural Design Competitions (ADC's)

In Australia, the Architects Institute of Australia (AIA) and the newly released guidelines by the Office of the Victorian Government Architect (OVGA) provide guidance and model conditions for competitions (AIA, 2015; OVGA, 2018). In addition, the Australian Institute of Landscape Architects (AILA) also produced their own guidelines for promotion and conduct of competitions (AILA, 2009). Although the AILA guidelines do not specifically relate to buildings, it is a valuable cross-reference to the third-party management of construction related competitions in Australia. ADC's are often beneficial to smaller firms as an opportunity to gain exposure on a project that's scale and budget would normally exclude them. However, the nature of the submission process results in countless hours of work that may never result in a successful submission. Such time spent on competitions therefore present a risk to a firm of any size but are particularly risky as a strategy to smaller firms, but is also representative of the importance given to ADC's.

The ADC is most often an 'open source' design competition designed to explore design possibilities from a number of different designers, to a single functional brief. The winning design is subjectively selected by an independent jury of design professionals and client representatives. The independence of the jury is vital to the fair conduct of a competition (International Union of Architects, 2017). ADC's offer a unique mechanism for architectural design procurement which would normally consist of a client tendering a project or selecting an architect directly to work with, prior to the commencement of design.

In accordance with the Innovation Decision Model, ADC's are limited to the knowledge and persuasion stages, although a decision is made to determine the winning entry, this is not always continued through to construction. The ADC process therefore represents a modified procurement process more than a true competition environment, with the finalist awarded based on a number of merits that extend beyond the best design, such as past work or existing relationships, as well as the capacity of the firm to complete the project, representing an inherent bias in the judging process. The ADC rarely includes criteria related to actual performance, representing a significant weakness in the competition in regards to sustainable targes for buildings. The nature and scale of buildings does prevent prototyping to be included as part of the competition process, however simpler targets like energy modelling outcomes, assessment of carbon impact, thermal comfort, could be easily introduced. In the absence of such targets the competition criteria remains narrowly focussed on design outcomes. Outside of performance targets, a strength of the ADC process is the transparency to the selection process Architecture competitions which

is important for public buildings and in some countries architectural competition is mandatory for these projects.

X-Prize

In contrast to the ADC, the X-Prize competition is a U.S. based global initiative that represents a more typical ‘innovation contest’ with repetitive but disconnected competitions that drive focussed innovation. The X-Prize is organised by the X-Prize foundation, a not-for-profit organisation which is the brainchild of Peter Diamantis, an entrepreneur (X-prize.org, 2019). The X-Prize foundation determines, directs and facilitates competitions in response to internally chosen global challenges and needs. X-Prize competitions occur in many different industries and in some cases, the organisation of the competition criteria extends up to a year before the competition is opened to ensure the criteria is relevant to the industry. Administratively the competitions are relatively simple to manage, this being a key strength of the format. X-Prize participants are usually specialised teams (like ADC’s), however there are examples of all student teams in the competitions. Unlike most innovation contests, the X-Prize competitions are judged on 'finish line' requirements of the competition criteria, rather than a selection committee discussing the relative merits of different endeavours, described as ‘best on simultaneous submission’ (Davis, 2002) as is used in awards and design competitions that dominate the construction industry. The finish line criteria provide a different type of motivation for competing teams to target a final result, with a specific emphasis on timeframes.

The finish line criteria, which can be best described as the achievement of a functional or performance target aligns with the Innovation Decision Model ‘decision’ stage on the basis that the entry has demonstrated innovation with a satisfactory level of performance as dictated by the competition brief. This additional step over the ADC competition results in a higher chance of implementation based on the proven performance. With regards to innovation radicalness, the finish line criteria are particularly relevant where the method of achieving the goal is not important, thus creating a wide solution space for entrants to operate within. The equivalent approach for sustainable targets in an ADC is to require net-zero energy performance to be demonstrated but not to indicate how this should be achieved. The unique X-Prize format necessarily focusses the competition on innovation outcomes rather than subjective design choices. The X-Prize format provides many beneficial lessons from the series; the format is highly focussed on innovation development, is cheap and easy to implement, although requires a significant amount of funding or sponsorship. A key factor in the open ‘global challenge’ format used by X-Prize is attracting sponsorship for the prize money, which is comparatively difficult in building projects that have a budget constraint. This innovation focus is easily adaptable to the ADC platform through the use of specific competition criteria, which is then reflected in the judging.

Results

The following analysis of the two competition platforms against the DOI Innovation Decision Model demonstrates how the X-Prize format favours performance-based outcomes which leads to a more likely decision and implementation.

Case study comparison with the Innovation Decision Model			
Stage	IDM Definition	ADC Outcome	X- Prize Outcome
Knowledge	The Decision Maker is first exposed to an innovation but lacks information about the innovation. During this stage the individual has not yet been inspired to find out more information about the innovation.	Achieved - Like all competition, ADC's are highly effective at delivering new knowledge of design innovation to the Decision Maker. No performance innovation is provided	Achieved - Like all competition, X-Prize very publicly provides knowledge about design and performance of the innovation to the Decision Maker
Persuasion	The Decision Maker is interested in the innovation and actively seeks related information / details.	Achieved – The design innovation is easily identified and able to be considered against the assessment criteria No performance innovation is provided	Achieved – The innovation is easily identified and able to be considered against the assessment criteria. The finish line criteria pre-establishes the innovation as fit for purpose for design and performance.
Decision	The Decision Maker takes the concept of the change and weighs the advantages / disadvantages of using the innovation and decides whether to adopt or reject the innovation.	Partially achieve – The Decision Maker is likely to consider the benefits of the design innovation alongside other subjective criteria, such as past experience	Achieved – The competition criteria requires the entrant to demonstrate the suitability of the innovation for the proposed use., which enhances the ability of the Decision Maker to make a decision
Implementation	The individual employs the innovation to a varying degree depending on the situation. During this stage the individual also determines the usefulness of the innovation and may search for further information about it.	Beyond Competition – There is specific commitment to the innovation beyond the concept stage	Potentially Achieved – The proving of the innovation in the competition criteria provides observability and trialability for the Decision Maker to proceed to implementation immediately.
Confirmation	The individual finalizes his / her decision to continue using the innovation. This stage is both intrapersonal (may cause cognitive dissonance) and interpersonal, confirmation the group has made the right decision.	Beyond Competition – There is specific commitment to the innovation beyond the concept stage	Beyond Competition – There is specific commitment to the innovation beyond the concept stage

Table 2: Case study comparison with IDM

Discussion

The comparison of the ADC and X-Prize formats raise a number of relevant points that can be used to refocus the ADC on sustainable innovation.

- Other industries place a high value of competitions for innovation benefits, however the construction industry is behind despite the strong existing ADC platform.

- The current ADC format is not effective in judging performance-based criteria because it is primarily subjective, and narrowly focussed on design not performance.

- Judging performance-based criteria is difficult in a concept stage competition, due to a lack of prototype level trialability or observability, however the introduction of demonstrated performance targets would significantly enhance the innovation efforts towards sustainable targets.

- Introducing performance-based criteria to the judging is possible based on predicted performance (e.g. modelling), limitation to certain outcomes (net-zero calculation) or a demonstration of performance based on the selection of components.

- The ADC's are primarily a procurement decision model, where firms are judged based on their submission along with numerous other factors related to their ability to deliver the project. This dilutes the quality of the submission from a performance perspective compared to the innovation contest model.

- The scale of buildings makes it very difficult to proceed to prototyping of innovation and therefore construction industry projects are limited to the combination existing technology rather than the generation of new technology. It is also likely that early stage competition criteria will be required such as computer modelling in place of tested performance of prototypes.

- The X-Prize model requires proof of the performance of the innovation prior to winning the competition, which provides a measurable criterion.

- The X-Prize format provides an extensive competition environment that involves the industry beyond the competitor and organiser. This has the effect of diffusing innovation through the industry beyond the innovation developed in competition.

- The X-Prize is reliant on large prize money that is consistent with the grand challenge nature of the competitions.

- Competitions are shown to be valuable in the diffusion of technological innovation irrespective of if the innovation is adopted into the final production version.

- Despite the potential benefits, both competitions are limited to drive adoption of innovation into building projects, resulting in a lack of implementation and confirmation as described by the DOI innovation decision model.

Conclusion

Industry based competition is demonstrated to be successful in driving and diffusing innovation beyond what would have occurred normally. Industry specific competitions vary in their design and criteria, which is critical to the direction taken by the entrants. In the case of the X-prize, a finish-line criterion provides a large solution space for teams to explore performance based innovation. In contrast, the ADC format is limited to design innovation and this is inconsistent with the needs of the industry. Modification to the ADC format to include performance-based criteria, as well as adopting other strengths of the X-Prize format such as sponsorship and industry involvement would further enhance architectural design competitions ability to target sustainable outcomes.

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