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AN EMPIRICAL STUDY ON THE EFFECTS OF COVID-LIKE ENVIRONMENTAL PERTURBATION ON ATTITUDE TOWARDS INNOVATION IN CONSTRUCTION

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ABSTRACT

This paper presents preliminary results from an empirical study on the effects of environmental perturbation (an unexpected, disruptive, social or economic event), such as the pandemic-driven disruptions, on attitude towards innovation. The results based on a survey with 266 construction professionals from multiple countries demonstrate that such perturbations force a change in the attitude towards innovation, both among individuals and organisations. The study also validates the earlier claims that this change can be positive as well as negative. Cases of both increase and decrease in innovation-related activities are reported. Findings also suggest that the perturbation-induced excitation aligns the needs and priorities of the different actors in the ecosystem, fostering innovation activities.

INTRODUCTION

Innovation and attitude towards innovation has long been a topic of interest in the construction sector. Traditionally, there has been an overwhelming concern that the construction industry shows a lukewarm attitude towards change and innovation (Dubois and Gadde 2002). Nonetheless, the COVID 19 pandemic situation has shown that the construction industry, like many other industries, was forced by the immediate challenge to accept innovation and changes in response to the crisis.

The pandemic situation and the broader societal response have demonstrated numerous innovation activities and forced people to adopt different behaviours and attitudes towards change under environmental perturbation. Enviromental perturbation refers to an unexpected, major disruptive event in the social or economic environment (Meyer 1982). This phenomenon is neither new nor surprising. Under a sweeping generality, such observations can also be explained using the phrase 'Necessity is the mother of invention'. However, leaving the observations to such generalisations does not help. Instead, what can such events reveal about innovation, our attitude towards innovation, and perhaps about necessity? This research aims to investigate such questions.

This research seeks to advance the theoretical and conceptual understanding of the effects of environmental perturbation on professionals' attitude towards innovation, building on the empirical data and observations from the COVID 19 crisis. The exceptional perturbation events and situations brought about by COVID 19 provide a unique opportunity to collect data across different geographical regions and a wide range of actors and contextual factors. At the same time, the extent of perturbation brought about by COVID 19 remains an outlier. Consequently, the theoretical model to be explored should also consider the likely exaggerated nature of the empirical data from the current situation. Hence, this research does not seek to limit the study of the collected data as a one-off situation. Instead, the aim is to build on this data and the existing theoretical models of innovation under environmental perturbation. The primary goal is to investigate whether the exaggerated perturbation demonstrates patterns that are also observable or have been observed in other situations, albeit not as distinctly as in these exceptional situations.

Therefore, this research builds on the authors' prior work (Singh 2014, Singh and Holsmtrom 2015), which discusses environmental perturbation and innovation-related attitude of actors from the perspective of Maslow's Hierarchy of Needs (HON) (Maslow 1943). The first objective is to test whether the new empirical findings from the COVID 19 situation are consistent with the previously reported findings and theoretical models (Singh and Holmstrom 2015) or not. After that, the goal is to further build on the theoretical concepts and extend the understanding of the relationships between environmental perturbations, innovation, the innovation-related attitude of actors in the innovation ecosystem, and some of the underlying factors associated with them.

This paper reports the preliminary details of the empirical study that was initiated after the pandemic driven disruptions that emerged in the summer of 2020. The rest of the article is structured as follows. Initially, the background literature is briefly introduced to provide the theoretical and conceptual basis of this research. The research methodology section outlines the research framework, including details of the empirical approach. After that, preliminary results from the empirical data are presented. Finally, the paper concludes with a discussion on the preliminary results and findings.

BACKGROUND LITERATURE

Innovation and innovation diffusion have been studied across various disciplines (e.g. Fagerberg and Verspagen 2009), including construction, where the slow rate of innovation and innovation diffusion has been a concern (Dubois and Gadde 2002). Multiple factors and models that explain innovation and innovation diffusion have been reported (e.g. Fagerberg and Verspagen 2009). Rogers' seminal work on the diffusion of innovation is one of the most influential works in this area (Rogers 1962, 1995, Rogers and Kincaid 1981). Rogers' model reflects the social contagion effects (Burt 1987) in the innovation ecosystem. Besides the social contagion effects, discernible differences in attitude towards innovation have been noted among the different categories of actors in Rogers' model: the innovators, early adopters, early majority, late majority, and the laggards (Rogers 1995). While Rogers' innovation diffusion model has been validated and tested widely over the years, it primarily explains the innovation diffusion behaviour in regular environmental conditions. Still, it does not explain the conditions for innovations to emerge or diffusion patterns in perturbed environments. In contrast, others (e.g., Meyer 1982) have found that environmental perturbation and jolt disrupt and alter innovation patterns.

Seeking a conceptual model that could explain the actors' attitude towards innovation and innovation diffusion in both regular and perturbed environmental conditions, Singh and colleagues (Singh 2014, Singh and Holmstrom 2015) investigated and found congruence between Rogers model of innovation diffusion (Roger and Kincaid 1981) and Maslow's HON (Maslow 1943). Hence, this research builds on Singh and colleagues' basic premises and findings, as outlined below.

Actors in the innovation diffusion ecosystem and their hierarchy of needs

The five categories of actors in Rogers' innovation diffusion model have been found to demonstrate discernible behavioural attributes. In general, innovators are risk-takers, early adopters aspire to be opinion leaders, and the early majority are pragmatists. In contrast, the late majority and laggards are conservative and sceptical, demonstrating basic security needs (Roger 1995). Singh and Holmstrom (2015) argue that this actor-behaviour mapping is congruent with the different levels of needs identified in Maslow's HON (1943). The innovators and early adopters are associated with higher-order needs of self-actualisation and esteem. The rest of the actors reflect lower-order needs for the sense of belonging, risk aversion, and security.

Further, Singh and Holmstrom (2015) only differentiate between primary needs and secondary needs to distinguish between primal needs of safety and security and higher-order needs associated with self-actualisation, esteem, and creativity. Considering only two broad levels of HON instead of the five specific levels proposed by Maslow allows Singh and Holmstrom's model to

- address the noted shortcomings and criticism of Maslow's specific need levels (Hall and Nougaim 1968, Hagerty 1999).
- group the actors' needs in binary categories such that secondary-needs (higher-order) pertain to a positive attitude towards innovation. In contrast, primary-needs (lower-order) pertain to the neutral and negative attitude towards innovation.
- apply the HON model not only to individuals but also to organisations as actors.

Further, building on an analogy from the phenomenon of excitation of atoms under environmental perturbation, Singh and Holmstrom (2015) propose that the effects of environmental perturbation on changes in attitude towards innovation can be explained in terms of stable and excited state behaviours of the actors (see Figure 1). Singh and Holmstrom (2015) argue that under perturbed environmental conditions with adequate intensity (threshold level), actors may switch from their stable (default) state to excited state. In effect, they demonstrate a change in their attitude towards innovation. In Singh and Holmstrom's model, actors can be put in different categories based on their stable state needs and the threshold levels needed to alter their attitude towards innovation through excitation.

One of the notable claims of Singh and Holmstrom's model, called 'excitable innovation-behaviour model' from hereon, is that excitation need not always lead to a positive change towards innovation. Instead, it argues that for actors whose stable state behaviour corresponds to positive innovation-behaviour, the environmental perturbation may push them to demonstrate a neutral or negative attitude towards innovation.

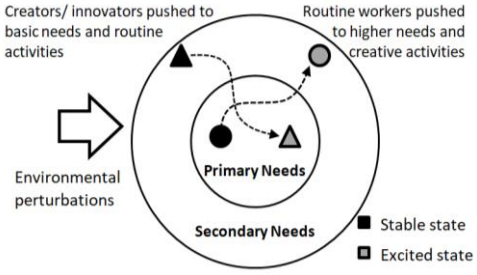

Figure 1: Excitable innovation-behaviour model (Singh Holmstrom 2015)

So far, the excitable innovation-behaviour model is primarily built on abductive reasoning, limited anecdotal evidence and observations, and secondary data from the Building Information Modeling (BIM) and construction Information Technology (IT) context. Further empirical evidence is needed to validate and refine their proposition.

Singh and colleagues (Singh 2014, Singh Holmstrom 2015) also distinguish three different types of actors in terms of their innovation-related roles and needs in the innovation ecosystem, namely, the need to innovate, the need for the innovation, and the need for the diffusion of

innovation (See Figure 2). Based on this categorisation, Singh and Holmstrom (2015) argue that

- the change in attitude towards innovation is not limited to the transition from primary needs to secondary needs or vice versa. Actors may also switch between the need to innovate, the need for the innovation, and the need for the diffusion of innovation.
- in general, successful innovation and wider innovation diffusion require fulfilment of all the three categories of needs.
- the innovation and innovation adoption-related behaviour is influenced not only by social contagion effect, but also by the actors' degrees of freedom in the network. How actors respond to their innovation-related needs is also influenced by the dependencies in their network.

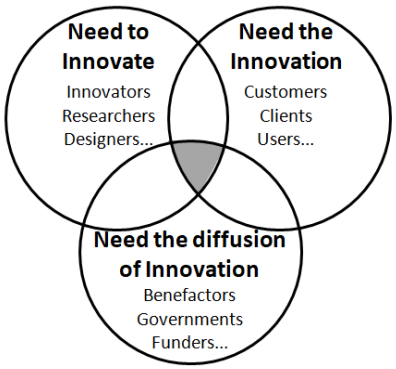

Figure 2: Types of innovation-related needs in the ecosystem (Singh Holmstrom 2015)

RESEARCH METHODOLOGY

Research aim and objectives

This research aims to build on the excitable innovation-behaviour model proposed by Singh and Holsmtrom (2014) to understand the patterns and reasons for changes in actors' attitude towards innovation under environmental perturbations. The primary goal is to test whether their propositions and theoretical model explaining innovation-related needs and attitude of actors are valid and consistent with the innovation-related changes observable during the COVID 19 situation. More specifically, the main objectives of this research are to

- test whether the same kinds of excitation can be observed for both individuals as well as organisations.
- test whether the excitation-induced changes in attitude towards innovation can be both positive (leading to an increase in innovation) as well as negative (leading to a decrease in innovation).
- investigate if the contextual factors such as job profile, years of experience, etc. influence the actors' response to environmental perturbation.
- explore whether there is further evidence to suggest that the actors' degrees of freedom and network dependencies affect their attitude towards innovation.

Research framework

Figure 3 shows the research framework. The empirical data is collected through questionnaire-based surveys and follow-up interviews with some of the survey respondents.

The design of the questionnaire is based on the theoretical model proposed by Singh and Holmstrom (2015). While the existing theoretical model was based on adbuction, anecdotal evidence, and secondary data, the novelty of this work lies in the creation of a research framework based on questionnaire design and interviews. Most of the survey questions are based on multiple-choice answers, allowing specific answers from respondents regarding individual and organisation attitude towards innovation. This approach enables quantitative insights based on the number of responses. In addition to the multiple choices, respondents can also provide additional comments and open-ended statements in many of the questions. Thus, the questionnaire responses allow both quantitative and qualitative insights.

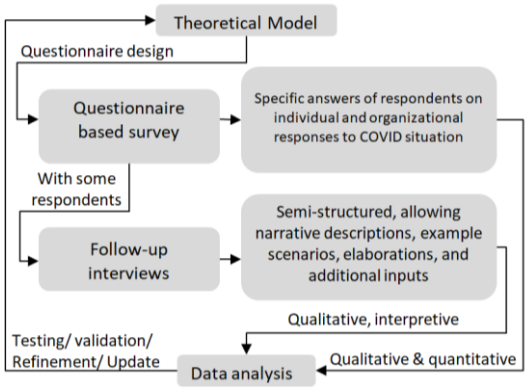

Figure 3: The research framework

The questionnaire-based survey is followed by a 30-60 minute semi-structured interview with some of the survey respondents, shortlisted from the pool of respondents who volunteered for a follow-up interview. The semi-structured interviews allow the respondents to explain their earlier responses, provide narrative descriptions about their experiences and job profile, observations in the context of the COVID 19 situation, and provide tangible examples and inputs to complement their survey responses. The data collected from the semi-structured interviews are recorded on tape (only if the interviewees consent to it), and allow qualitative and interpretive analysis. The data analysis from the surveys and the interviews put together will enable testing, validation, and refinement of the theoretical models. The analysis, testing, validation and refinement steps will be iterative. The analysis will be conducted from different perspectives and at varying levels of details, as further new insights and patterns emerge from the data.

Questionnaire design

The list of questions is shown in Table 1. The first 12 questions are profile questions that establish the respondent's background and contextualise them.

Questions 9 to 12 also indicate how the immediate ecosystem around the respondent responded to the COVID 19 situation. Questions 13 and 14 provide respondents feedback about their organisation's response to the COVID 19 situation. Questions 15 and 16 provide insights into respondents perception of how their colleagues (other individuals) responded to the COVID 19 situation. Questions 17 and 18 are respondents feedback about they responded to the COVID 19 situation.

The questionnaire design allows insights into various contextual factors that might influence how actors respond to environmental perturbations with regards to their attitude towards innovation. The questions also allow comparisons on how individuals and organisations responded to the situation. Separate questions were included about how the respondents reacted versus how they thought their colleagues reacted in the situation. This will enable checking for potential actor-observer bias in responses (Jones and Nisbett 1971). In the actor-observer bias, people are known to assess their own actions differently from how they assess others' actions.

Question 19 collects a list of respondents who were willing to volunteer for a follow-up interview.

Table 1: List of questions included in the survey

	Question
1	What is your job title?
2	For how many years have you been in the given role?
3	How many years have you been working in the Built Environment?
4	In which country do you work?
5	Which option(s) better describe your organisation?
6	How many employees work in your organisation?
7	How many people in your company have a similar role as you?
8	How many people do you manage directly?
9	Which of these statements define your organisation's attitude towards innovation when it is business as usual?
10	Which of these statements define the majority of individuals' (professionals in your team or close network) responses towards innovation when it is business as usual?
11	As part of your usual role, are you responsible for carrying out innovation in your organisation?
12	Did your country of work adopt any lockdown measures during COVID 19?
13	During COVID 19, the time your organisation spent on innovation ...
14	Why did the organisation change its attitude towards innovation?
15	During COVID 19, the time your colleagues (in team or close network) spent on innovation ...
16	Why did the majority of individuals (professionals in your team or close network) change their attitude towards innovation?
17	During COVID 19, the time you spent on innovation ...
18	Why did you change your attitude towards innovation?
19	If you are willing to take part in a follow-up interview, please leave your email address here

Follow-up interviews

Follow-up semi-structured interviews are being conducted to collect further data and inputs from some of the survey respondents who volunteered for the same. This part of data collection is still ongoing, and so far six such semi-structured interviews have been conducted. More interviews are scheduled for the coming months. A brief outline of the interview protocol is described below:

- Total duration: 30 minutes to 60 minutes.
- Interview Mode: online via a video conferencing tool such as Microsoft Teams or Skype.
- Interviews with each participant is conducted separately, with one or two researchers conducting the interview.
- Each interview starts with an introduction. Volunteers are thanked for their availability, and a quick summary of the research scope is presented to refresh their memories.
- Interviewees are then asked to comment on the answers they provided to the survey questions, and whether their responses to any questions have changed since then.
- They are also asked to provide tangible examples of questions pertaining to their own attitude, their colleagues, and their organisation.
- If they reported changes in their attitude and innovation-related behaviour, they are asked to explain the *trigger event* and provide an example. For example, the company announced job cuts, lockdown in their country, etc.
- They were asked to describe the options and alternatives that were there when they or their colleagues or their organisation had to make the innovation-related decisions.
- Asked if they could identify/ describe the tipping point or the threshold that forced a change in the attitude (own/ colleagues/organisations).
- Asked how long they thought the changes in behaviour (if any) would last?
- Asked if anything has changed since the survey? If so, what and why?

- Asked if they can recall other perturbation events that changed attitudes towards innovation, besides the current COVID19 situation? If so, they are asked to describe the context.
- Asked if they think such perturbations can be created artificially or by design to foster innovation or the rate of innovation adoption?
- Is it possible to artificially create such an excitation within organisations without putting pressure on employees? Is there something that can create a sense of urgency and the desired response? Have they experienced such a situation? Do they have examples?
- Asked if they agree to be contacted in 6 months for another follow-up interview.

DATA COLLECTION

Data collection using the questionnaire survey

The survey was done online using Google Forms. The questionnaire links were shared through the research team's professional network via emails, Linkedin contacts, and through a friend of friend networks. The target respondents were mostly from the industry, with only a handful of exceptions.

Though the initial target was 150 responses, the online form was kept open for nearly 3 months, given the study's positive response and feedback. During this period, 266 were obtained from different parts of the world. Nearly half (131) of the survey respondents expressed willingness to be available for a one-hour follow-up interview. This positive response was unusually high. The researchers did not anticipate that so many respondents from the industry would be available for a one-hour interview on the research topic. Therefore, only some of these respondents are being approached for follow-up interviews.

Data collection using interviews

The data collection using interviews is currently an ongoing activity, though some interviews are already done. The semi-structured interviews prove particularly useful in getting descriptive details, examples and anecdotal evidence from the interviewees.

The semi-structured approach gives the flexibility to allow for a free flow of discussion. It also ensures that the interviewees cover the desired set of topics and questions in their responses. It also enables the interviewers (researchers) to adapt and formulate additional questions depending on the new aspects of the subject that emerge from the comments and descriptions.

A structured analysis of the recorded data will be conducted using conversation analysis and verbal protocol analysis. However, some preliminary insights have already started to emerge through unstructured qualitative observations and note-taking during the interviews.

PRELIMINARY RESULTS AND DISCUSSION

The survey questions allow for varying analysis levels, especially with 266 responses that will enable filtering data across different sub-groups with a reasonable number of responses in the different sub-groups. Consequently, only the initial and broad set of patterns in the answers are presented in this paper. The authors also recognize that the COVID-19 situation had an observable general impact across the construction industry, but the discussions in this paper will be restricted to the specific insights from the survey and the interviews.

Figure 4 provides some charts that provide contextual background to establish the profiles of the respondents. As shown in Figure 4.A, these respondents represent a wide range of organisations in terms of size: 20.7% of the respondents from companies with less than 10 staff members, 22.9% of the respondents come from organisations with more than 5000 staff members. Such diversity in profiles of the respondents may also allow looking for the potential influence of organisational size on individual's change in attitude towards innovation under environmental perturbation. In contrast to the diversity in profiles across some parameters, nearly 84% of the respondents (4.B) indicated that they are involved in innovation-related activities at their regular jobs.

Figures 4C and 4D show responses with regards to the respondents' organisation as well as their own approach towards innovation in usual circumstances.

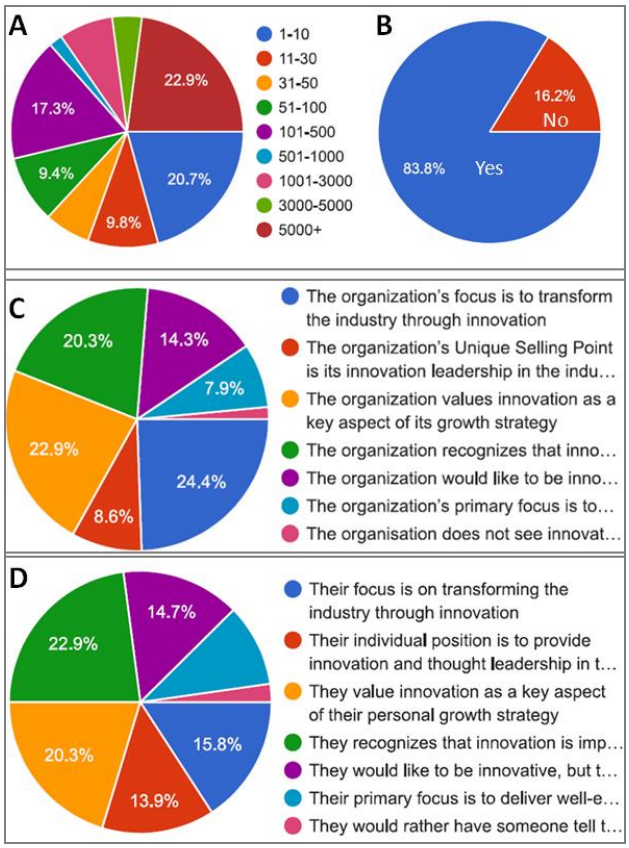

Figure 4: Respondents' profile related answers

For example, 14.3% respondents believed that their organisation would like to innovate under normal circumstances, but they are too busy with their routine jobs to pursue innovative activities. Similarly, 14.7% respondents indicated that they themselves would like to innovate, but they cannot do so actively because they are too busy in their routine activities and jobs. The responses indicate that the innovation-related needs of these actors are lower in their priority as compared to their immediate needs to fulfill the routine requirements.

Such patterns also suggest that the contextual factors often influence innovation-related behaviour. Further, besides looking at the overall patterns across the 266 respondents, it is also possible to look at individual responses in detail, and qualitatively assess their response in connection to the contextual factors.

Figure 5 summarises the overall patterns in the change in innovation-related behaviour induced by the environmental perturbation- COVID 19. 47.7% respondents indicate that their innovation-related activities increased because of COVID 19 related disruptions. When asked about their colleagues and their organisation's response, 39.5% and 46.6% respondents believed, respectively, that their colleagues and organisations innovation-related activities increased. The corresponding decrease (+stopped) in innovation-related activities of respondents themselves, their colleagues and their organisations are 10.2(+4.9)%, 13.5(+4.9)%, and 13.5(+5.6)% respectively.

These responses validate the earlier findings that environmental perturbations alter innovation-related behaviours, but not always necessarily leading to an increase in innovation. Instead, there are a significant number of cases where environmental perturbation also reduces innovation-related activities.

Figure 6 shows the responses to the reason of change on the innovation-related behaviours of the subjects changed. For instance, with regards to their behaviour, 47.4(26.7+20.7)% respondents said that they did so because they thought it was the right thing to do and to help the society, while 31.2% said that their innovation-related behaviour did not change. They rated the corresponding numbers for their colleagues at 43.3(33.1+10.2)% and 30.8% respectively. The corresponding numbers for their organisations at 50(41.7+8.3)% and 27.4% respectively. These patterns indicate high levels of a voluntary change in innovation-related behaviour arising out of environmental perturbation. The results also show a significant number of cases where the management told the actors to change their innovation-related behaviour.

Broadly, the survey results provide further empirical validation of the excitable innovation-behaviour model (Singh and Holmstrom 2015), demonstrating that this excitation is observable at both individual and organisations level. At the same time, these broad patterns also validate that the excitation can be positive (increase in innovation-behaviour) and negative (decrease in innovation behaviour).

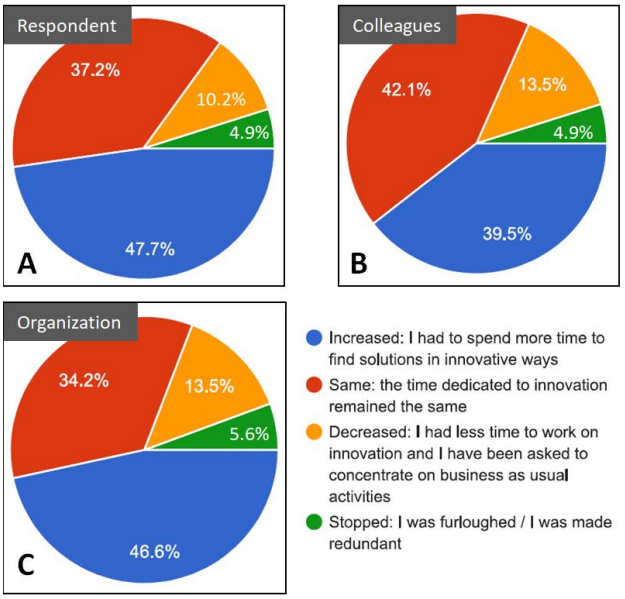

Figure 5: Trends in changes towards innovation

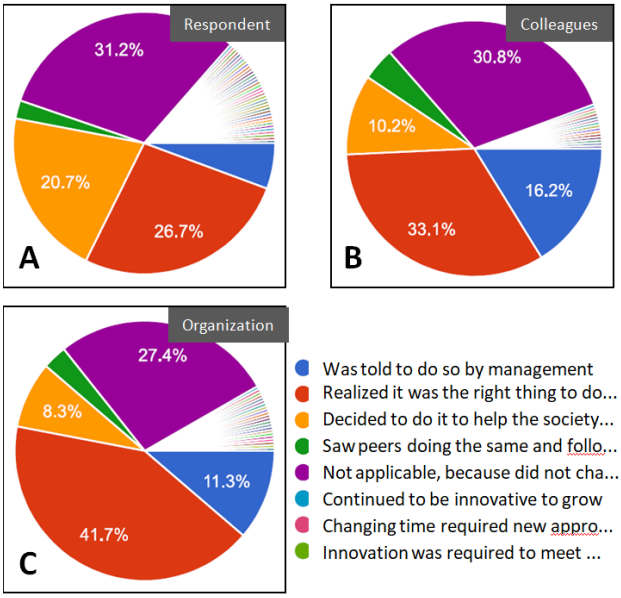

Figure 6: Patterns in reasons for changes in innovation-related activities

Even at the macro-level, the results indicate that contextual factors influence how actors respond to the environmental perturbations in terms of their innovation behaviour. For instance, as seen in Figure 7A, while respondents in many countries reported both decreased and increased innovation-related activities due to the COVID 19 situation, there was no reported decrease in innovation-related activities in other countries. In the latter countries, either the innovation-related activities increased or remained the same as earlier. The collected data can be further analysed using similar filters for different factors. For example, showing how the patterns vary by the respondents' professional background (see Figure 7B) or by the type of organisation the respondent works for (see Figure 7C). The collected data also allows

Figure 7: Breakdown of responses according to (7A) countries, (7B) professional background and (7C) organization type

studying the influence of the organisational size or the respondents' years of experience.

In addition to the preliminary results from the survey data, the interviews conducted so far also validate the excitable innovation-behaviour model (Singh and Holmstrom 2015). For instance, interviewees remarked on how, in some cases, their organisation stopped innovation-related activities. In contrast, in other cases, they took the COVID 19 situation as an opportunity to either initiate innovation-related actions or leverage the contextual demand to successfully relaunch and innovate on a previously unsuccessful idea. Some interviewees also noted demand-driven innovation from the client's side, and the innovation-focused incentives created by the government and other agencies.

The interview discussions validated the excitable innovation behaviour model and also reiterated the importance of the three types of innovation-related needs, i.e., need for the innovation, the need to innovate, and the need for the diffusion of the innovation. Prima facie, the qualitative discussions suggest that the environmental perturbations force a rapid alignment of the need for innovation, the need to innovate, and the need for the diffusion of innovation, enabling faster innovation and innovation adoption cycle. That is, some of the interview discussions seem to suggest that in normal circumstances it often takes a long time for the alignment of the needs and priorities of the innovators, potential users, and those who see opportunity to benefit from the diffusion of innovation, e,g, funders and government agencies. In contrast, the crisis emerging from an environmental perturbation forces rapid alignment of the needs and priorities of the different actors, as the the crisis creates the immediate point(s) of attention.

The limitations of this study must also be noted. First, a majority of the respondents work in the area of BIM or digitialization, and hence, the survey sample is not a true representative of the construction industry as a whole. Similarly, the inequal geographical distribution in the number of responses must also be noted. Second, only preliminary results from the survey are presented, especially based on the overall patterns. Further insights can be gained with a closer inspection of the individual responses. Third, the findings from the interviews are based on preliminary notes. A systematic review of the interview data is yet to be conducted.

CONCLUSIONS

The empirical validation of the exitable innovation-behaviour model can have significant impact on the management of innovation activities in the construction industry and organizations. First, it demonstrates that both individual as well as organizational attitude towards innovation can be altered through excitation and by changing the environmental conditions. Second, it demostrates the the environmental conditions as well as the network dependencies can not only foster innovation, but they may also inhibit or stop innovation activities. Third, it appears that the crisis resulting from the environmental perturbations force a rapid alignment of the needs and priorities of the different types of actors in the innovation ecosystem, namely, the innovators, the potential users of the innovation, and those who are likely to benefit from the diffusion of the innovation, such as the funders and government agencies. The increased innovation activities due to rapid alignment of the different types of needs and priorities of actors under perturbed conditions can have significant impact in how the systemic bottlenecks in innovation diffusion and adoption under normal circumstances are understood.

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