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Risk Attitudes and Global Infrastructure Technology Choices

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Abstract

Past research shows that Hofstede's cultural dimension of uncertainty avoidance explains variance in nations' technology choice for sanitation and electricity infrastructure construction. The uncertainty avoidance dimension describes the way that nations deal with ambiguity and uncertainty. This paper is part of a larger project that links that previous national scale research to the project level that is most relevant to the construction practice. As such, this paper reviews methods from the literature that measure individual risk attitudes, including issues of measurement and risk determinants. For example, this paper discusses paid real-stakes lotteries, general risk questions, and context specific risk questions. Respondent gender, age, and income are identified as determinants of risky behavior. The utility of these various measurement strategies is discussed with specific regard to future research intended to explain variance in the construction of distributed household renewable electricity infrastructure. Finally, a questionnaire design for future research is proposed.

INTRODUCTION

Construction has become a fundamentally global business; as firms expand internationally they need to discover what and how differences impact construction practice (Javernick-Will and Scott 2010). Research treating the impacts of social factors on infrastructure construction is part of an emergent research stream treating the social sustainability of infrastructure. One part of this stream considers the impacts of culture on infrastructure construction (Kaminsky 2015; Valdes□Vasquez and Klotz 2013). Unfortunately, however, while culture is a frequently referenced construct in the construction engineering literature there is not yet a consensus on how to measure and apply it in construction research or practice (Allison and Kaminsky 2015).

Contributing to this literature, my recent research has shown that Hofstede's cultural dimensions—defined below—explain variability in the construction of particular technology types in both sanitation (Kaminsky 2015) and electrical infrastructure (Kaminsky under review). In particular, the cultural dimension of *uncertainty avoidance* shows strong and statistically significant relationships with infrastructure technology choice. However, these past analyses were performed at the national level. While that level of analysis is certainly useful for infrastructure policy, it is less so for construction practice. As such, the current paper reviews ways

to measure risk attitudes for individuals, who are responsible for household infrastructure construction decisions. This means the findings of this paper are limited to distributed, household infrastructure; we do not address organizational risk profiles. Still, this limitation should not be seen to unduly limit the scope of the infrastructure that is considered; for example, distributed septic sanitation systems serve 25% of the US population (EPA 2010).

HOFSTEDE'S CULTURAL DIMENSIONS

Hofstede's cultural dimensions (Hofstede 2001) were developed from a set of 88,000 surveys answered by employees of IBM between 1967 and 1973. These surveys were used to create four quantified cultural dimensions, measured from 0-120. While quantification of a topic as complex as culture is highly contested, Hofstede claims they provide useful comparative information. The four dimensions are:

- *Individualism vs. Collectivism:* "a preference for a loosely-knit social framework in which individuals are expected to take care of only themselves and their immediate families" vs. a "preference for a tightly-knit framework in society in which individuals can expect their relatives or members of a particular in-group to look after them in exchange for unquestioning loyalty" (Hofstede 2014).
- *Masculinity vs. Femininity*: "a preference in society for achievement, heroism, assertiveness, and material rewards for success. Society at large is more competitive" vs. a "preference for cooperation, modesty, caring for the weak and quality of life. Society at large is more consensus-oriented" (Hofstede 2014).
- *Power Distance*: "the degree to which the less powerful members of a society accept and expect that power is distributed unequally. The fundamental issue here is how a society handles inequalities among people" (Hofstede 2014).
- *Uncertainty Avoidance*: "expresses the degree to which the members of a society feel uncomfortable with uncertainty and ambiguity" (Hofstede 2014).

While past work discovered various relationships between these cultural dimensions and infrastructure technology choice, here we focus on the uncertainty avoidance dimension.

UNCERTAINTY AVOIDANCE & INFRASTRUCTURE

Past work has shown that the cultural dimension of uncertainty avoidance explains technology choice for electrical and sanitation infrastructure. For example, renewable electricity technologies are more prevalent in nations with high uncertainty avoidance scores (Kaminsky under review). In another example, high uncertainty avoidance scores translate to building sewers rather than distributed onsite sanitation systems (Kaminsky 2015) at the national level. However, it can be problematic to apply analyses at the national level to smaller units of analysis. For example, populations within nations are culturally heterogeneous (Taras et al. 2010); for example, there are real cultural differences between Texas, New York, Iowa, and

Puerto Rico despite the fact that all are part of the United States of America. In addition, there is concern about ecological fallacy.

MEASURING RISK ATTITUDES

To address these concerns, we need a tool that can take simple, local, and reliable measurements of the uncertainty avoidance dimension at the individual level. Fortunately, there is a large existing literature dealing with the measurement of individual risk attitudes. This section sketches the outlines of this body of knowledge, highlighting major approaches to the measurement of risk attitudes and describing ongoing theoretical debates regarding each approach.

Lotteries

Common approaches to lotteries intended to elicit risk attitudes (or, expected utilities that may be translated to risk attitudes) are identified in Harrison and Rutstrom (2008). The *Multiple Price List* (MPL) method for measuring risk attitudes offers the research participant a list of binary lotteries choices (Holt and Laury 2002; Miller et al. 1969). The research participant chooses one of the offered lotteries, and then that lottery is carried out to determine the incentive the respondent receives for participation. A criticism of this approach is that that it may encourage the research participant to choose middle options; however, this framing effect has not been found to be systematic (Harrison and Rutström 2008 p. 47). The *Random Lottery Pairs* (RLP) method for measuring risk attitude offers the research participant a series of paired lotteries to choose from. In other words, the research participant first chooses between two lotteries, and only then is offered a second pair of lotteries to choose between. After making choices between all the lottery pairs, one of chosen lotteries is randomly selected to be carried out for the research participant incentive. The primary difference between RLP and the previously discussed MPL is the way in which lotteries are offered. In MPL the research participant sees all the lotteries at once and chooses one; in RLP the research participant makes multiple choices between pairs of lotteries. In a similar method, the *Ordered Lottery Selection* method for measuring risk attitudes asks the research participant to select a single lottery from an ordered list (Binswanger 1980, 1981) where each lottery sequentially increases payoff value and variance. The *Becker, Degroot and Marschak* (1964) method (BDM) departs somewhat from the above lottery methods by asking the RP to give a price for which (s)he would give up the opportunity to play a given lottery (Kachelmeier and Shehata 1992). However, evidence suggests that respondents often do not understand BDM (Plott and Zeiler 2005), making BDM results potentially unreliable in practice.

Each of these lottery approaches provides monetary payouts to the research participant. This is done because some researchers believe that the provision of incentives will improve research results. However, evidence suggests that the impact of monetary incentives on research participants is mixed, depending (among other factors) on the type of tasks involved in the research. Of particular relevance to this study is evidence that suggests that low incentives lead research participants to report they are more risk-preferring than they do when higher incentives are offered (Camerer and Hogarth 1999). As considerable evidence suggests that people tend to be somewhat risk adverse (Harrison and Rutström 2008), this suggests that high

stakes paid incentives may more accurately reflect behavior. However, financial incentives are costly, are logistically more difficult to complete, and lottery designs are known to be more difficult for respondents to understand. This last is an important issue, especially for respondents with less formal mathematics education. For example, Cook et al. (2011) report that about half of the respondents they studied did not understand risk lotteries despite active participation in research activities, and strongly suggest that a method that can detect whether or not respondents understand the research be built into the design.

Risk Questionnaires & Risk Context

An alternative to lotteries is the use of questionnaires intended to elicit risk attitudes. A key advantage of questionnaires is that they may avoid they need for incentive payments to respondents and thus enable larger sample sizes. Another advantage is that they are simpler to understand; as discussed above this is a significant advantage. A disadvantage is that they are harder to quantify.

Risk questionnaires may ask a *general risk question* such as "How do you see yourself: are you a person who is fully prepared to take risks or do you try to avoid taking risks?" (Dohmen et al. 2011 p. 525). In that particular study, Dohmen et al conclude that the general risk question is most highly correlated with actual overall risky behavior than were lotteries or context-specific risk questions. More generally, a number of studies suggest that a validated general risk question can be used to explain variation in earnings (Bonin et al. 2007), geographic mobility (Jaeger et al. 2010), or entrepreneurial behavior (Caliendo et al. 2009).

A key debate underlying the measurement of risk attitudes—regarding both questionnaires and real-stakes lotteries—regards whether or not people have a universal risk tolerance, or if this is instead context dependent (Weber et al. 2002). For example, Dohmen et al. (2011) find that *context specific risk questions* provide better information regarding that particular context. These questions might ask (for example) about taking risks in the context of driving vehicles, personal finances, sports, work tasks, or health.

Respondent Context

The scale of the uncertainty is also thought to impact risk behavior; all things being equal, most decision makers will prefer to resolve uncertainties with larger impacts (Bell 1995). The perception of a large impact, however, is certainty dependent on the individual decision maker. For example, it is thought that the perception of risks is related to respondent assets (Pratt 1964)—in other words, the size of the risk must be understood as it relates to respondent wealth. Demographic context is another factor known to influence risk attitudes. For example, females are often found to be more risk averse than males (e.g. Rosen et al. 2003). A related concern regards *hypothetical bias*. Hypothetical bias is bias introduced because research respondents are considering hypothetical rather than actual decisions (Harrison et al. 2007). Another complicating factor is background risk: if a participant feels s(he) is at a sufficiently high level of risk, s(he) may neglect a small, independent risk (Quiggin 2003).

Two Caveats

The first caveat is that research indicates that different measures for risk attitudes may produce different results (Dohmen et al. 2011; Kahneman and Tversky 2000; Loomes and Pogrebna 2014). Kahneman and Tversky (2000) suggest this is due to framing effects and the nonlinearity of decision weights. *Framing effects* are effects of the presentation of a risky choice. For example, choices framed in terms of lives saved are more appealing than those framed in terms of lives lost, even if the outcome of the two frames is the same.

The second caveat is that there is considerable and longstanding evidence that people often behave in ways that contradict the assumptions in decision theory. We do not treat these debates here, but simply note that even if a perfect measure of risk attitude existed it would not provide a perfect prediction of how people behave when faced with uncertainty. We refer the reader elsewhere (Edwards 1992; Hogarth 1987; Kahneman and Tversky 1979; Slovic 1987; Von Winterfeldt and Edwards 1986) for some foundational discussions of behavioral decision making paradoxes.

DISCUSSION

The research application we are immediately interested in regards distributed infrastructure construction decisions made at the household level. Especially in cases where households are gaining access to infrastructure for the first time, it is reasonable to expect that they will not have good information regarding the potential impacts of these innovations. These are decisions made under conditions of uncertainty, and with imprecise preferences (Loomes and Pogrebna 2014). In this situation, the literature suggests the choice of a risk attitude elicitation procedure as close as possible to the decision under study. In addition, the use of multiple measures can provide a check of how reliable the elicited risk attitudes are.

Households gaining access to sanitation infrastructure for the first time tend to be poorer than households with sanitation systems (WHO/UNICEF JMP 2013) and thereby tend to have fewer years of formal education (UN 2011). Taken together with the findings reported in Cook et al. (2011), this suggests that lottery methods are inappropriate in this setting. We cannot make this type of a priori generalization with distributed electrical infrastructure, as household solar systems that supplement grid connections are becoming increasingly common (Barbose et al. 2014). However, as the goal of my research is to produce an output that is not just theoretically interesting but also useful to industry, simplicity in design is an important factor. Indeed, for future research treating utility scale infrastructure, paid stakes lotteries could be legally infeasible for industry to implement, given laws regarding gifts and United States federal employees (US Office of Government Ethics 1987) who might reasonably be expected to make this level of infrastructure decisions. As such, a questionnaire is preferred.

CONCLUSION & PROPOSED QUESTIONNAIRE

The ultimate goal of the larger research project is to discover a way to use risk attitudes to predict household renewable electricity infrastructure construction behavior. The first step of this project is to measure risk attitudes. To do so, we propose to use a combination of a general risk question and context specific risk

questions. we will ask these questions to adult heads of household. The general risk question will be modeled on Dohmen et al. (2011 p. 524): "How willing are you to take risks, in general?" To attempt context specific questions, we will also ask about risk attitudes in particular contexts as described below.

For electrical infrastructure, the selected contexts are drawn from previous research that explored reasons for household adoption of renewable electricity infrastructure (Kaminsky under review; Labay and Kinnear 1981). The questionnaire will be administered to selected households that do and do not have household solar systems installed at their home. In each case, the sequence of questions is intended to have the respondent think about each context specific risk question (asked at the end of each sequence) in terms of their own preferences, the likelihood of the risk, and the potential consequence of the risk. In other words, the lettered questions below are intended to guide the respondent to think about various aspects of a contextual risk that the literature suggests is important to decisions about the construction of household renewable electricity infrastructure, before responding to the context specific risk questions. These latter are bulleted in the lists below. All questions are written to avoid indicating social desirability of any answers.

To simplify the questionnaire, we will abandon the ten point scale used for context specific risk questions in Dohmen et. al. (2011) in favor of a five point scale for the context specific risk questions. To follow Loomes and Pogrebna's (2014) advice to include a test of respondent understanding, we will ask the respondent to explain answers to me using open-ended follow-up questions that probe for examples and explanations of the respondent's answer (Spradley 1979). Answers will be audio recorded to retain the open-ended answers for analysis. Cognitive interviewing techniques will be used to test the questionnaire in a pilot prior to wide implementation (Willis 2004). We will also collect demographic factors known to impact risk attitudes, including respondent gender, household income, age, and years of formal education.

General

- How willing are you to take risks, in general? [not willing to take risks, sometimes willing to take risks, neutral, usually willing to take risks, always willing to take risks]

a. Why? Can you give me an example?

- How willing are you to take risks with your electricity supply? [not willing to take risks, sometimes willing to take risks, neutral, usually willing to take risks, always willing to take risks]

a. Why? Can you give me an example?

Local Control

a. Some people think it's important to generate their own electricity right at their home, while others prefer to leave electricity supply up to a centralized company or government utility. Which do you prefer? [home generation, supply by organization]
b. Why? Can you give me an example?
c. Is your preference weak, moderate, or strong?

d. Regardless of your preference, do you think it's very risky, moderately risky, or not risky to let an organization or government supply your electricity?
e. Regardless of your preference, do you think it's very risky, moderately risky, or not risky to supply your own electricity?

- Generally speaking, how willing are you to take risks regarding letting someone else control your electricity supply? [not willing to take risks, sometimes willing to take risks, neutral, usually willing to take risks, always willing to take risks]

f. Why? Can you give me an example?

Environmental Protection

a. Some people try to protect the environment by putting solar panels on their house, but other people think that there are more important things to worry about. If you decided to build a household solar system, would environmental impacts be very important, somewhat important, or unimportant to your decision?
b. Why? Can you give me an example?

- Generally speaking, how willing are you to take risks regarding the environment? [not willing to take risks, sometimes willing to take risks, neutral, usually willing to take risks, always willing to take risks]

c. Why? Can you give me an example?

Energy Reliability

a. Some places have electricity all the time, other places have blackouts, and some have no electricity at all. How often do you have electricity? [we don't ever have electricity, sometimes, usually, virtually always]
b. Do you think your electricity reliability will get better, worse, or stay the same in the next five years?
c. How certain are you that this change will happen? [not certain, somewhat certain, very certain]
d. If you are right, how much of a problem is it? [big problem/very bad, neutral, small/no problem]

- Generally speaking, how willing are you to take risks regarding the reliability of your electricity supply? [not willing to take risks, sometimes willing to take risks, neutral, usually willing to take risks, always willing to take risks]

e. Why? Can you give me an example?

Investment

a. If you install household solar electricity, you might eventually save more money than you spent on it, but you might not. Do you think most people save money, break even, or lose money with household solar? [save money, break even, lose money]
b. How certain are you that this would happen? [not certain, somewhat certain, very certain]
c. If you are right, how much of a problem is it? [big problem/very bad, neutral, small/no problem]

- Generally speaking, how willing are you to invest money now for possible benefit in the future? [not willing to take risks, sometimes willing to take risks, neutral, usually willing to take risks, always willing to take risks]

d. Why? Can you give me an example?

Future Energy Cost

a. Over the next few years, some people think the cost of electricity will go up, and some people think it will go down. Do you think it will go up, down, or stay about the same?
b. How certain are you that this will happen? [not certain, somewhat certain, very certain]
c. If you are right, how much of a problem is it? [big problem/very bad, neutral, small/no problem]

- Generally speaking, how willing are you to take risks regarding the future cost of electricity? [not willing to take risks, sometimes willing to take risks, neutral, usually willing to take risks, always willing to take risks]

d. Why? Can you give me an example?

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