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## A Systematic Approach to Applying the Delphi Method in Construction Engineering and Management Research

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**ABSTRACT:** The Delphi Method has been established as an effective way to determine the collective opinion of a group of experts. However, one of the main criticisms of the Delphi Method is that it lacks clear guidelines on how to systematically implement a study. Existing guidelines tend to be difficult to extend to other studies, leading to inconsistent usage of the method. These inconsistencies can lead to various levels of rigor in the application of the Delphi Method. While other papers provide a foundation for defining parameters, additional research is needed to show how to effectively choose and apply them within a study. This paper will demonstrate a set of parameters and how they were chosen with the intention of providing guidance for future Delphi studies. Parameters that will be discussed are; a) the use of content analysis to strengthen the first round of a Modified Delphi study, b) how to operationalize a measure of consensus, c) the importance of defining criteria for expert inclusion in a study, and d) the sufficient number of experts required. By improving the process for applying a Delphi study the method will gain in strength and rigor for its use in future research. How these parameters were implemented in a recently completed Delphi study for research sponsored by the Construction Industry Institute will be discussed. This demonstration will provide future researchers with a starting point for systematically designing Delphi Studies and provide a set of guidelines for successfully executing such studies.

### 1 INTRODUCTION

The Delphi Method has been established as a way to determine the collective opinion of a group of experts on a topic. For the construction industry, where no two projects are alike, the Delphi method is beneficial as it uses the opinions of experts to generate collectively what is the best answer to a posed question. A Delphi study can often become too broad and lose focus from the original purpose, which contributes to usage of a Modified Delphi Method. The Modified Delphi Method is as a version of Delphi in which the first round starts with a pre-existing set of issues, rather than an open ended question about a topic (Keeney et al. 2011). The paper will show how the usage of the Modified Delphi Method can be strengthened by using a content analysis.

One of the main criticisms of the Delphi Method is that it lacks clear guidelines on how to analyze the responses to the surveys (Hallowell and Gambatese 2009); most existing guidelines are vague. This paper will put forward a set of guidelines for creating a Modified Delphi study and determining consensus amongst participants. The study to which this paper will be referring was conducted as part of a research project funded by the Construction Industry Institute. The study is part of RT 294: Deploying Best Practices in Unfamiliar Countries, which sought to develop a systematic approach for a company planning on starting working in a country that they have never worked in before. A Delphi study was used as part of the research in order to identify common barriers to success for companies working abroad.

This paper's intent is to demonstrate how a successful Delphi study was implemented from start to finish providing a guide for future researchers who may wish to utilize the Delphi Method. The paper will also explain how to overcome some common issues with the Delphi Method. This paper focuses on the implementation of the Delphi method and the analysis of the results, and does not provide guidance on determining the appropriateness of the method's use.

## **2 BACKGROUND ON THE DELPHI METHOD**

The Delphi method is based on the idea that the opinion of the group is superior to that of the individual. It relies on a series of anonymous, iterative surveys across which a group can hone their opinions and reach a consensus on an issue (Cuhls 2004). The traditional Delphi Method begins with an open ended question about a topic where participants are asked to respond by listing all relevant issues and ideas (Keeney et al. 2011). This initial round then becomes the list of questions on which the subsequent rounds will be based. A Modified Delphi study utilizes a list of already identified issues and ideas instead of an open ended question (Keeney et al. 2011). These are compiled by the researcher rather than being drawn from the participant responses as in a typical first round.

In the next round the identified issues are presented to the panel of experts, asking for their response to the question and their comments about why they responded the way they did. In each of the subsequent rounds, the issues are presented again along with anonymous information about how other experts in the group responded in the previous round. It provides feedback as to why the other participants responded the way that they did. The feedback is intended to influence the participants when making their selection in the new survey round (Cuhls 2004). The rounds are repeated until the group has come to a consensus on their responses. Typically the Delphi method takes between two and four rounds and can be executed either with electronic or paper based surveys (Keeney et al. 2011, Hallowell and Gambatese 2009). Typically after two rounds the research will begin to see diminishing returns from further input (Hallowell and Gambatese 2009).

A challenge to the execution of the Delphi Method is in the participation of experts. This includes how the criteria for experts should be defined, as well as how many experts are needed for the study to be successful. Currently, guidelines for defining an expert are largely absent and the existing guidelines are often difficult to extend to other studies. There are also conflicting views on how many experts are needed to participate in a study, some Delphi studies have had over 100 participants (Skulmoski et al. 2007), and others less than ten (Hallowell and Gambatese 2009). This wide range leads to a lack of consistency. The higher the number of rounds, the more likely the expert participants will stop responding, thereby reducing the response rate (Skulmoski et al. 2007).

## **3 IMPROVEMENTS ON THE METHOD**

### **3.1 Content Analysis**

As described previously, the traditional Delphi method uses an open ended question for the initial round of the survey process. However, the open ended approach can lead to broad and unfocused responses due to its unstructured nature. The unfocused responses can be problematic if the responses do not fit the needs of the research. This has popularized the usage of the Modified Delphi method where the researchers create a set of initial questions for the first round in order to ensure that the responses and topics to be discussed in the surveys will meet the needs of the research. In order to establish a more rigorous approach for creating the initial question list we propose the use of content analysis.

Content analysis is a systematic approach to analyzing data sources for information. It is a research method that analyzes a group of sources to develop a list of recurring themes or items relevant to the context in which they are presented (Krippendorff 2004). This analysis of existing subject matter leads to

a more focused method for identifying relevant information in a subject area; allowing the researcher to ensure the survey will be compatible with their research goals.

By using content analysis, the topics to be discussed in a Modified Delphi study can be supported by a selection of credible sources in their validity and the list can be recreated from the sources, rather than a researcher developing the questions on his or her own. Sources that may be used include academic papers, industry journals, internal company reports, focus groups and interviews, amongst others. Content analysis is an established method for analyzing the information and themes within a source of information (Krippendorff 2004). The use of content analysis is straightforward. By analyzing a source with a specific goal, content pieces can be extracted. The pieces can be further organized according to trends and themes within the collection of content pieces. The identified themes can be refined into the list of questions for use in the first round of a Delphi study.

There are several key characteristics that should be inherent in a content analysis. The first of which is that the content analysis should be pragmatic, or include the context of the content piece in the analysis (Krippendorff 2004) which is important for Construction Engineering and Management (CEM) research as to ensure that the projects to which the content is referring are within the scope of the research topic. Convenience sampling where sources that are readily accessible and known to contain relevant content pieces can be used as the starting point for the content analysis (Krippendorff 2004). To ensure an adequate sample size the "Split Half Technique," is appropriate; this is where the sample size is considered large enough that you can split the content pieces in half and achieve similar results from both halves (Krippendorff 2004). This technique can be more beneficial than using all of the sources as it saves the researcher time while generating the same outcome.

Another benefit of this method is the overall reduction in time needed to complete the study. By eliminating the traditional first round of the Delphi method, the study length can often be shortened by at least one additional round. Since the Modified Delphi using content analysis is more focused, it can also provide the opportunity for a shorter study as there will be less time eliminating items that are not relevant to the topic. By identifying a list of items that is already relevant, the focus can be more about how relevant the items are instead of how relevant they are to the topic.

### **3.2 Parameters for Operationalizing a Measure of Consensus**

A key criticism about the implementation of the Delphi Method is the lack of specific criteria and guidance for use in the analysis of the responses. Within the Delphi Method, analysis focuses on determining if consensus has been reached by the group. Achieving consensus on an issue is to consider the discussion on that issue complete; therefore it is no longer necessary to include the issue in the subsequent rounds of the study. If a group reaches a majority opinion or consensus, on an issue, it can be terminated (Dajani et al. 1979) but we lack guidance for measuring those criteria.

The mode is an appropriate way of determining what the overall response of the group is. It is a more appropriate parameter, compared to the arithmetic mean, as we are seeking consistency in the responses. In the Delphi study we conducted as part of a Construction Industry Institute (CII) project, participants chose from a set of responses on a six point Likert scale which ranged from Strongly Disagree to Strongly Agree. A six point scale was chosen in order to force the experts to choose a side in their responses, since neutral was not an option. These responses were converted to numeric representations to simplify the analysis. However, these numbers are arbitrary and lack a defined value. Due to the arbitrary nature of the numbers, the mode acts as a better representation of what the group response is than an arithmetic average. The mode describes the most common answer rather than attempting to attribute values to responses.

For the CII study we performed, a combination of the mode and the standard deviation was used to create the stopping criteria for issues within the Delphi study. Standard deviation indicates the spread of the responses about the mean which makes it ideal for determining consensus. The smaller the standard deviation the more closely grouped the responses are. A standard deviation of less than or equal to one is suggested for determining if the survey respondents have reached a consensus when paired with a six-

point Likert scale. The first criteria considered was the standard deviation of the responses, if it was found to be less than one, then the group could be considered to be at a consensus. However, to accept or reject the issue, the mode needs to be considered as well. The accept/reject criteria for the mode is that it needed to be less than two (to reject) or greater than five (to accept), representing a consensus of disagree and agree respectively. These were the boundaries for the mode as when the standard deviation of less than one is also considered, the majority of the group would have to be plotted on the agree or disagree side of the Likert scale. For this research a value of one was selected to complement the mode of five; however, for a different Likert scale another value may be more appropriate as long as it ensures that the responses fall clearly to one side of the response spectrum. Once accepted or rejected based on consensus, the subsequent rounds of the Delphi study become shorter in length (i.e., fewer issues to evaluate) which helps prevent participant fatigue.

### **3.3 Expert Criteria**

The selection of experts is a critical component of the Delphi Method. It is difficult to ensure that your experts meet the needs of the study without the criteria being too specific so as to cause sampling bias (Hallowell and Gambatese 2009). This is an issue when using academic credentials as a way of determining expertise in the construction industry. Criteria for expert selection should be based on experience in areas relevant to the research topic. For the construction industry where experience is often valued more than education (Rosenbaum et al. 2001), ensuring past experience on multiple relevant projects is a strong indicator of expertise. In the CII study we conducted, the following criteria were used; the experts were defined as individuals that: 1) had at least ten years of experience managing projects or programs; 2) had at least five years of that experience involved managing international projects or programs; 3) had experience working internationally for at least one year; 4) had experience working in at least three countries; and 5) had experience with at least three of the five phases of a project lifecycle. As the topic for the study was Deploying Best Practices in Unfamiliar Countries, and the Delphi study conducted focused on issues and barriers to successful international projects, the criteria were chosen to ensure enough experience in the industry while also validating that their expertise contains significant experience working abroad. Different research studies would require different criteria for identifying experts, however this study indicates that choosing the criteria based on experience is a good way to ensure adequate background on the subject matter.

### **3.4 Number of Participants**

Another common criticism with the Delphi method is the lack of guidelines on a recommended number of participants to ensure a study with accurate results. While Hallowell and Gambatese recommend (2009) 12 to 15 participants as a manageable number, a higher number of participants—a minimum of 30 per round—is suggested. The reasoning behind this is that the central limit theorem dictates that with a minimum number of data points—often recommended to be 30 (Levine et. al. 2011)—the data can be assumed to follow a normal distribution pattern that is representative of the population. If the data is intended to be analyzed using standard statistical methods, a population of 30 can strengthen the analysis by providing enough data points in the sample to assume reliability in the results.

The use of electronic based survey software for the Delphi Method has simplified the management and analysis of the responses. This makes it easier to utilize larger numbers of participants. After the initial effort to enter the participants' information such as their email addresses into the survey software, the effort to manage participants is about the same with 10 participants as it is for 60. And a higher level of participation generally leads to better results by providing a more accurately represented sample.

As with most survey based research methods, response rates and attrition can greatly diminish the sample size. As this study was part of a CII research project, it was supported by a research team of industry experts. In order to recruit and verify the credentials of the expert panel, our research team reached out to the professional networks of the industry members of the research team to identify potential participants. The team identified 60 potential participants from 19 different organizations. We asked our team to collectively identify 60 persons that met the expert criteria in order to ensure sufficient participation throughout all rounds of the study; of those 60 individuals, 53 agreed to participate

Another challenge encountered in survey based research, particularly online surveys, is that attrition rates tend to be high. Online surveys often average response rates around 33% (Nutly 2008). To improve response rates there are a variety of methods available, such as repeated reminder emails and demonstrating that a response will be used, which can improve response rates (Nutly 2008). In order to counteract potential attrition, several reminders were sent during each round of the study by the individuals who had identified the person as an expert. Information on the purpose of the project was provided to the participants during the recruiting process as well. By relying on their professional relationships to encourage participation, a response rate of at least 33 participants, or 62%, was maintained for each round. This allowed for more reliable statistical analysis of the sample, as the minimum of 30 participants was met.

#### **4 CONCLUSIONS**

The result of the Delphi study implementation described in this paper was the identification of 62 issues that are commonly encountered when deploying best practices in unfamiliar countries. During the initial information gathering phase of the Modified Delphi study approach employed, 57 issues were initially identified through the use of content analysis. The experts identified six additional issues during the first round of the study and rejected one of the ones identified by the content analysis resulting in a final total of 62 issues.

The findings of this paper are subject to limitations that must be noted. The Modified Delphi study in this case was not used simultaneously with another method or simultaneously with the standard Delphi Methodology. Due to this limitation the results of the study cannot be compared directly to other approaches. However, the benefits of the Modified Delphi study can be observed in the results of the study, in which only six issues were added and one rejected from the list of 57 generated by the content analysis. This demonstrates that up front content analysis in the Modified Delphi study approach can provide an effective starting point for the use during the survey rounds of the Delphi study.

In CEM research, the Delphi Method has been increasing in popularity as a way to utilize the knowledge base of industry experts to achieve various research aims. In order to refine and improve the use of the Delphi Method, we need further discussion on how to improve the consistency and enhance the rigor of the application of the method. In this paper we make several suggestions to improve the application of the Delphi Method in CEM research. First, we propose the use of content analysis to systematically analyze existing information as it can improve the initial list of issues as a starting point for the Delphi Method and may lead to fewer rounds which reduces participant attrition and fatigue. Second, we propose that Delphi Method users operationalize a quantitative measure of consensus. Third, we propose that clear and topically relevant criteria are established for the recruitment of experts. And, finally, we propose that Delphi Method researchers seek to achieve a minimum of 30 respondents in the pool of experts. Taken together, these refinements to executing Delphi studies will enhance the consistency of the responses and will allow more uniform application of the method in CEM research. It is the hope of the authors that improving the consistency in outcomes and approaches to the Delphi Method will increase its usage by CEM researchers and the value of the contributions to the CEM field.

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