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THE DELPHI METHOD AS A RESEARCH TOOL: AN APPLICATION IN TRANSPORTATION AND LOGISTICS SYSTEMS EVALUATIONS

***Abstract:** Delphi is a technique by which a group of experts attempts to generate ideas or find a solution for a specific problem by amassing ideas. In other words, it is a method for the systematic collection and aggregation of informed judgments from a group of experts on specific questions or issues. The Delphi method has proven a popular tool in various application areas for identifying and prioritizing issues for managerial decision-making. Review of Delphi method's application in different transportation and logistics systems evaluations with guidelines for making design choices during the process that ensure a valid study will be presented in this paper.*

***Keywords:** Delphi Method, Application, Transport, Logistics*

1. INTRODUCTION

The Delphi technique was developed during the 1950s by workers at the RAND Corporation while involved on a U.S. Air Force sponsored project. The objective was to develop a technique to obtain the most reliable consensus of a group of experts. Since it is designed, the Delphi technique has become a widely used tool for measuring and aiding forecasting, planning and decision making tool in a variety of disciplines.

While researchers have developed variations of the method since its introduction, Delphi may be, in general, characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. It allows access to the attributes of interacting groups (knowledge from a variety of sources, creative synthesis, etc.), while pre-empting their negative aspects (attributable to social,

personal and political conflicts, etc.). Further more, the method allows input from a larger number of participants than could feasibly be included in a group or committee meeting, and from members who are geographically dispersed.

Delphi is not a procedure intended to challenge statistical or model-based procedures, against which human judgment is generally shown to be inferior. Delphi researchers employ this method primarily in cases in which pure model-based statistical methods are not practical or possible because of the lack of appropriate historical, economic or technical data, and thus where some form of human judgmental input is necessary, and typically use a series of questionnaires interspersed with controlled opinion feedback. The Delphi method captures a wide range of interrelated variables and multidimensional features common to most complex problems, both of which are necessary elements for detailed scientific analysis. Such input needs to be used as

efficiently as possible, and for this purpose the Delphi technique might serve a role.

Delphi is a relatively inexpensive method to organize and administer. It is one of the most popular forecasting techniques for technological and industry-wide forecasting and it is estimated that 90% of technological forecasts and studies are based on Delphi [9].

This paper is organized in the following way: a variety of important factors need to be considered in Delphi researches are identified in Section 2; review of Delphi method's application (as a judgment or forecasting or decision-aiding tool) in different studies that treat transportation and logistics systems problems is presented in Section 3, and concluding remarks are given in Section 4.

2. SOME IMPORTANT NOTES ON DELPHI METHOD

Four key features may be regarded as necessary for defining a procedure as a 'Delphi': anonymity, iteration, controlled feedback, and the analyzed and statistical aggregation of group response.

Anonymity is achieved through the use of questionnaires. By allowing the individual group members to express their opinions and judgments privately, undue social pressures (from dominant or dogmatic individuals, from a majority) should be avoided. Furthermore, with the iteration of the questionnaire over a number of rounds, the individuals are given the opportunity to change their opinions and judgments without fear of losing face in the eyes of the (anonymous) others in the group [17].

At the beginning Delphi researchers clearly outline one or more questions that research study investigates. Factors which will answer the questions have to be identified in the next step. Pre-testing is also an important reliability assurance for the Delphi method. It can be used to verify if the identified factors are indeed

pertinent.

Selecting an appropriate group of experts who are qualified to answer the questions is one of the most critical requirements. A Delphi study does not depend on a statistical sample that attempts to be representative of any population. It is a group decision mechanism requiring qualified experts who have deep understanding of the issues.

The size and constitution of the group of experts depends on the nature of the research question and the dimensions along which the experts will probably vary. It is common practice to divide experts into panels which represent different stakeholder groups (for example: academics, practitioners, government officials, etc.). These groups probably would have somewhat different perspectives. Since it is a goal to obtain a reasonable degree of consensus, it would be best to have panels that separate these groups. This design also permits comparison of the perspectives of the different stakeholder groups. Delphi literature recommends that each panel size is 10 to 18 people. The design of iterative process which will ensure the identification and invitation of the most qualified experts can be found in [17].

The initial questionnaire for a Delphi survey is very simple, since it consists of an open-ended solicitation of ideas. These individual factors are then consolidated into a single set by the monitor team, who produce a structured questionnaire from which the views, opinions and judgments of the Delphi panelists may be elicited in a quantitative manner on subsequent rounds. After each of these rounds, responses are analyzed and statistically summarized, which are then presented to the panelists for further consideration. The forecast or assessment for each item in the questionnaire is typically represented by the statistical average (mean/median) on the final round. A number of different metrics for measuring non-parametric

assessments or forecasts exists, but Kendall's W coefficient of concordance is widely recognized as the best [17]. The value of W ranges from 0 to 1, with 0 indicating no consensus, and 1 indicating perfect consensus between lists. Hence, from the third round onwards, panelists are given the opportunity to alter prior estimates on the basis of the provided feedback (the mean assessment of the item for the panel, the panelist's ranking of the item in the former round, an indication of the current level of consensus, etc). Furthermore, if panelists' assessments fall outside "pre-specified agreement level" they may be asked to give reasons why they believe their selections are correct against the majority opinion. This procedure continues until certain stability in panelists' responses is achieved.

Most commonly, round one is structured in order to make the procedure simpler for the monitor team and panelists; the number of rounds is variable, though rarely goes beyond one or two iterations (during which time most change in panelists' responses occurs); and often, panelists may be asked for just a single statistic, or for written justifications of extreme opinions or judgments. These simplifications are particularly common in laboratory studies and have important consequences for the generalization of research findings [16].

3. AN APPLICATION IN TRANSPORT AND LOGISTICS SYSTEMS EVALUATION

The Delphi technique has been around for over half a century. One moment of history that is worth emphasizing, is that of 1975, when the first edition of Linstone and Turoff's [9] edited book on Delphi first appeared and brought notice of the approach to a wider audience. Slowly at first, but at a seemingly growing rate, the technique has flourished, appearing in

more and more academic domains and being used for more and more purposes. Thus, a significant literature is associated with the Delphi method.

Opposed to theoretical or methodology related lessons, practical lessons from the conduct of 'real' Delphis are elaborated in a number of case studies. Review papers of Delphi applications in various application areas such as business, education, health care, real estate, engineering, environment, social science, can also be found in literature. Note that the three most popular areas for Delphi applications are education, business, and health care [21, 22].

To the best of our knowledge there are no online published research paper reviewing Delphi applications in transport and logistics areas. That is why we attempted to gather together details of a number of recently published (English-language) studies involving evaluation of the Delphi technique in transportation and logistics field. We searched through Science Direct and Springer/Kluwer databases as well as EBSCO and ProQuest services. This search produced 22 papers relevant to our present concern.

Regarding Table 1, the studies have been classified according to: area of application, task, Delphi group size, number of rounds, nature of Delphi feedback, and consensus and sensitivity analysis issues. Delphi applications in studies from Table 1 have extended from the prediction of long-range trends in transport, traffic and logistics issues to applications in policy formation and decision making. A number of papers look at the role of Delphi, not as a standalone approach, but as a method that may be enhanced by other approaches, or that may contribute as input to others. Delphi method is very often used to develop an evaluation criteria system which comprises criteria identification, selection and prioritization. In 12 of the 22 papers (55%) Delphi provided inputs for MCDM.

Also, Table 1 shows that various differences exist in Delphi conduction through researches. One of the aims of using Delphi is to achieve consensus amongst panelists. In 10 of the 22 papers (45%) consensus issue was not discussed at all. Evidence from most Delphi studies shows that convergence towards the 'group' average is typical.

Reaching consensus is directly related

to the nature of the feedback presented to panelists (see Table 1). The feedback recommended in the 'classical' Delphi comprises medians or distributions plus arguments of panelists whose estimates fall outside the upper and lower quartiles. In the majority of observed studies feedback usually comprises only medians or means.

Table 1 - Summary of the methodological features of Delphi in experimental studies

Ref.	Area of implementation	Task	Delphi group size	Rounds	Nature of Delphi feedback	*
[1]	Supply chain management	Provides a list of journals, keywords and lines of research	7	NS	NS	-
[2]	Logistics tool selection	Determining inputs for multi criteria decision making	NS	NS	NS	-
[3]	Low cost carriers' destination selection	Ascertaining the weighting, preference and threshold of attributes	NS	2	Mode value, median value, etc	√
[4]	Evaluation of state and privately owned airlines	Determining goals and criteria to evaluate performances related to the goals	21	2	Average rating, standard deviation	-
[5]	Transportation planning	Predict future developments	46	1	-	-
[6]	Evaluation of hazardous waste transportation firms	Criteria definition and evaluation	15	3	NS	√
[8]	Vehicle emissions control - policy making criteria	Criteria evaluation	300	3	NS	-
[9]	3PL in a value chain	Criterion weight evaluation	NS	NS	NS	-
[11]	Aviation industry	Anticipating probable and wildcard scenarios on the future	57	3	mean, standard deviation and interquartile range	√
[12]	Alliance partner selection in the airline industry	Pairwise comparison of the elements in each level of ANP and AHP MCDM methods	25	2	consensus index and weighted priorities	√
[13]	Transshipment Port Selection	Criteria verification and categorization	10	2	Mode quantity, average value, etc	-
[14]	Driver Support Systems	Predicting future developments	117	3	median and interquartile range	√

Table 1. Continued

[15]	ATTelematics implementation	Criteria evaluation	66	NS	NS	–
[16]	External sources of vehicle propulsion	Predicting future developments	45	3	NS	√
[19]	Port management	Indicators determination and evaluation	NS	NS	NS	–
[20]	Road freight transport	Indicators determination and evaluation	100	2	Mean and standard deviation	√
[21]	Traffic safety	Criteria definition and their weight evaluation	40	2	NS	√
[24]	Efficiency of goods transportation	Criteria evaluation	15	2	Mean values	√
[25]	Sustainable transportation system	Scenarios construction and their evaluation	63	2	Mean values	√
[26]	Public transportation	Determining inputs for multi criteria decision making	NS	2	Mean values	√
[27]	International distribution center location	Determining inputs for multi criteria decision making	3	2	NS	√
[28]	Bus scheduling	Indicators determination and evaluation	20	2	Medium values	–

4. CONCLUSION

The Delphi method is a versatile research tool that researchers can employ at various points in their research. Use of the Delphi method for forecasting and issue identification/prioritization in transport and logistics systems are

observed in this paper. The number of papers analyzed and reviewed here leads us to a conclusion that Delphi method has significant impact on researches in those areas and that Delphi conducted according to ‘ideal’ specifications can perform more quality results.

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