Technological Forecasting & Social Change 115 (2017) 143–154

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Real Time Spatial Delphi: Fast convergence of experts' opinions on the territory

Simone Di Zio [a,*], Juan Daniel Castillo Rosas [b], Luana Lamelza [c]

[a] University "G. d'Annunzio", Pescara, Italy
[b] Polytechnic University of Catalonia, Barcelona, Spain
[c] Non-profit association "On The Road", Pescara, Italy

ARTICLE INFO

Article history:
Received 9 June 2016
Received in revised form 8 August 2016
Accepted 28 September 2016
Available online 5 October 2016

Keywords:
Spatial Delphi
Real-Time Delphi
Geo-consensus

ABSTRACT

Considering the advantages of the online consultation methodologies and the potential of WebGIS technology, we introduce a novel real-time Delphi technique, which exploits the features of two existing methods: Real Time Delphi and Spatial Delphi. This new technique, called Real Time Spatial Delphi, preserves most of the advantages of both methods, minimizes the disadvantages, and develops new potential. A panel of experts, suitably chosen according to the application, answers a geo-questionnaire by placing points on an online interactive map and presenting written arguments. The system automatically calculates and displays a circle representing the convergence of the opinions, which shrinks and moves in real-time. The final result is the delimitation of an area most suitable for a given action or for the occurrence of a future event and is immediately usable for decision support and/or spatial scenario building without any processing. We applied this technique to the zoning of street prostitution in Italy and identified several areas inside five municipalities where the zoning was considered most appropriate by the experts. This new Delphi method represents an innovative way of eliciting experts' opinions regarding a simple and intuitive platform, which is potentially applicable to a very broad spectrum of forecast/decision making issues.

1. Introduction

The Rand Corporation (Santa Monica, California) developed the *Delphi method* in the 1950s with the aim of achieving a convergence of opinions across members of a panel of experts to forecast the impact of technology on warfare (Dalkey and Helmer, 1963; Linstone and Turoff, 1975). It is an iterative method with a number of iterations called *rounds*, in which each member of the panel anonymously replies to a questionnaire and subsequently receives feedback regarding the responses of the group. At each round, the experts are invited to revise their judgments in light of the feedback, producing, at least in principle, a progressive reduction of the range of answers and the consequent convergence of opinions. It is commonly recognized that the Delphi method makes better use of group interaction (Rowe et al., 1991), particularly compared with the face-to-face conference methods (Riggs, 1983).

Currently, the method is still broadly in use, generally in a decision-making context and/or a forecasting framework. Delphi has been so widely used that it is considered the foundation of a large variety of methods. During the last half century, several authors have developed a series of Delphi-derived methods; thus, to build a methodological framework for the method we propose in this paper, we present a brief historical overview, citing the most important methods.

In 1970, Murray Turoff proposed the *Policy Delphi* (Turoff, 1970), which is consensus-oriented and used for the analysis of public policies. A different version, called *Public Delphi*, is based on the participation of citizens. Soon after the *Mini Delphi* (Gustafson et al., 1973; Van de Ven and Delbecq, 1974) also known as Estimate-Talk-Estimate (ETE) was proposed, a technique that speeds up the procedure, as it is applied for face to face meetings.

In 1974, the theoretical foundations of the *Markov-Delphi* were laid by De Groot (1974). Chatterjee (1975) studied an alternative solution, based on variable weights, and Marbach (1975) proposed the adoption of weights that minimize the overall variance of the evaluations.

In 1975, David A. Ford proposed the *Shang method* (Ford, 1975), in which some characteristics of the Delphi method are kept but the trouble of asking to rephrase the evaluations at each round is eliminated. In the same year, the Nominal Group Technique was proposed, a problem-solving process that includes the identification of a problem, the generation of a solution and the final decision (Delbecq et al., 1975). In 1979, the *Decision Delphi* was born (Rauch, 1979), a variant oriented to coordinate the decision-making processes of different actors. The *Abacus-Delphi* method was developed in the 1980s and uses the logic of the colors of the Abacus, as defined by François de Régnier (Chapuy et al., 1990; Régnier, 1989).

* Corresponding author at: Department of Legal and Social Sciences, Viale Pindaro, 42, 65 127 Pescara, Italy.
E-mail addresses: s.dizio@unich.it (S. Di Zio), jdcastillo@unam.mx (J.D. Castillo Rosas), lamelzaluana@gmail.com (L. Lamelza).

http://dx.doi.org/10.1016/j.techfore.2016.09.029
0040-1625/

In 2006, Theodore J. Gordon and Adam Pease proposed the *Real Time Delphi* (RTD). This method is a computerized Delphi and does not provide for subsequent rounds, therefore leading to a greater efficiency in terms of execution time (Gordon, 2009; Gordon and Pease, 2006).

A recent innovation is the *Spatial Delphi* (Di Zio and Pacinelli, 2011), suitable when the decision problem involves the choice of a place where a future event may happen. This method replaces some of the basic features of the conventional Delphi with analogues that are "spatial". The last of these Delphi-like methods is the *Spatial Shang* (Di Zio and Staniscia, 2014), a modified version of the Shang method applicable, such as the Spatial Delphi, when consultations and consequent decisions concern matters of geographical location. Nevertheless, both these methods have sequential rounds, while the method that we propose in this paper is roundless.

However, why do all these methods exist? What is the best among them? It is obvious that each method has advantages and disadvantages such that we cannot choose a method that is best of all. In fact, each has some peculiarities that make it more suitable for particular situations. Therefore, a good research question, half a century after the invention of Delphi, could be:

Is it possible to develop a new method by combining some of the existing ones to make the most of their advantages?

Independently of Delphi, we have observed a remarkable development of the online consultation methods over the last decade because they allow for collecting large amounts of data in a short time and for reaching people anywhere on the globe. Moreover, the use of Geographic Information Systems (GIS), especially those that use web technologies (WebGIS), is becoming increasingly widespread. Currently, we see an exponential growth of geographic data because knowing where something happens, or where something could happen, is of fundamental importance for making decisions. As stated by Longley et al. (2005), "everything that happens, happens somewhere".

Considering the advantages of the online consultation technologies and within the scope of the methods dealing with WebGIS technology, we consider if it is possible to develop a novel Delphi method that exploits the features of other existing methods. To this end, we focus on the Spatial Delphi and Real Time Delphi; the possibility of integrating them into one new method has interesting implications, both from a methodological and practical point of view. From the examination of the theoretical backgrounds and the applications found in the literature, it is possible to combine the advantages of both methods, minimizing the disadvantages.

In the following, we will develop a method that arises from bringing together the logic of the Real Time Delphi, which is *roundless* (Gordon, 2009), and the potential of the Spatial Delphi in the management of geographical problems. Consequently, we call it the *Real Time Spatial Delphi* (RTSD) method, with which it is possible to consult experts on issues related to the territory in an efficient, real-time way, with very short times and low costs. The main product of a RTSD study is the delimitation of one (or more) area(s) on the territory that, according to the convergence of the opinions of a panel of experts, is most suitable for a given action or for the occurrence of a future event. Therefore, the results are immediately usable for decision support and/or spatial scenario building without any further processing.

The RTSD is based on a WebGIS interface, with a series of tools and functionalities that make it adaptable to a very large number of applications. The web platform is part of a larger project, called Geospatial System of Collective Intelligence (Castillo Rosas et al., 2015a,b), and designed to support the decision-making process in geographic complex scenarios.

The main goals of this paper are to present the RTSD method, discuss its potentials and show an application.

Among some of the applications made in this initial testing phase of the system, we will present a study on the issue of zoning of street prostitution in a district of five municipalities in the Abruzzo region (Italy).

The remainder of the paper is organized as follows: after a comparison between the Real Time Delphi and the Spatial Delphi (Section 2), in Section 3, we illustrate the Real Time Spatial Delphi, while Section 4 outlines the application to the zoning of street prostitution. In Section 5, we present the results, and in Section 6, we conclude with a brief discussion.

2. The Real Time Delphi and the Spatial Delphi compared

In this section, we describe the main characteristics of the Real Time Delphi and the Spatial Delphi to highlight their strengths and weaknesses. From this comparative analysis will arise the methodological assumptions of the method that we propose, i.e., the Real Time Spatial Delphi.

Since the early years of use of the Delphi method, despite its potential, it has emerged that the procedure is time-consuming and costly. Consequently, there were many attempts to use the Internet to speed up the Delphi process and reduce costs. Murray Turoff conducted an early experiment by linking experts in a network (Turoff, 1972); later, he designed a Social Decision Support System to allow a large group of people to vote and interact dynamically (Turoff et al., 2002).

Important studies were conducted in Finland, resulting - in 2008 - in a system called *eDelfoi*. Significantly, in 2006, Theodore J. Gordon and Adam Pease developed the Real Time Delphi (Gordon and Pease, 2006), first as an open source program and then improved and largely used by the Millennium Project (a non-profit global participatory futures research think tank).

In a RTD, each expert of a panel anonymously answers questions in an online questionnaire. For each question, he/she can also give written arguments and then, whenever he/she considers it appropriate, comes back to the study, seeing his/her original inputs. If in the meantime other experts have responded, some group statistics (i.e., number of responses, average, median or interquartile range) are displayed next to each question and new judgments and comments can be provided, in the light of the statistical synthesis of the group responses and the arguments. The experts can repeat the process, reassessing and adjusting their responses, as often as they want (Gordon, 2009; Gordon and Pease, 2006).

The primary innovation of the RTD is the absence of repeated rounds (*roundless*) because the statistical synthesis is calculated automatically and displayed in real time. This reduces the overall time frame normally required to conduct this type of study, producing high efficiency in terms of time and cost needed to perform the analysis. With this system, experts are not forced to respond a fixed number of times and at preset time intervals, as in the conventional Delphi. Moreover, they are not compelled to complete the entire questionnaire in one sitting (Gordon, 2009; Gordon and Pease, 2006). The number and locations of participants are various, and through the interface of the questionnaire, you can include hyperlinks to reference material to allow the respondents to retrieve supporting information online while completing the questionnaire.

It has been empirically demonstrated that the final results of a RTD are not significantly different from the results of a conventional Delphi (Gnatzy et al., 2011); therefore, the particular features of the RTD do not affect the results. Finally, a considerable advantage is that the boxes in which the experts can type comments for their own answers and consult the reasons of others are interactive.

We now turn to the main features of the Spatial Delphi (SD). The founding idea of this method is that in Delphi applications, the geographic element has been too often underestimated; nevertheless, many decision/forecast problems are related, in some way, to the territory. With the SD, the convergence of the opinions of a panel of experts regarding a little portion of the territory can be achieved according to the Delphi logic (Di Zio and Pacinelli, 2011). The authors of the Spatial Delphi method indicated three particular contexts in which it can be used: 1) in the present, when the problem involves choosing an optimal