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PROPOSITION OF A METHOD TO MEASURE RANKINGS USING THE DELPHI TECHNIQUE

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ABSTRACT

Delphi technique has been largely used in researches, as much via its traditional form, focused on estimations, as via its ranking-type. However, despite being a technique established for over 60 years, there are not in the academic literature, until now, properly structured and complete schemes or scripts that can be used to apply the Delphi technique in its ranking-type. In order to fill this gap, a new script is presented in this paper – the Method for Achieving Rankings Using the Delphi Technique (MARD, in its abbreviated form). In addition, it is depicted a study in which MARD was applied. Due to be derived from scripts already tested, MARD takes into account several aspects that the authors of those scripts believe to be relevant, and also presents, in a more detailed way, the steps to be performed along all stages required to carry out a Delphi panel in its ranking-type. MARD showed to be complete and robust, by providing adequate methodological support for the Delphi panel presented as an example, and by revealing potential to

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be generalized and therefore applied to other sorts of Delphi panels in its ranking-type.

Key-words: Delphi technique. Ranking-type. Ranking measure. Delphi scheme. Procedure.

RESUMO

A técnica Delphi tem sido largamente empregada em estudos e pesquisas, tanto em sua forma tradicional, voltada à geração de estimativas, quanto para a elaboração de *rankings*. Entretanto, apesar de ser uma técnica criada há mais de 60 anos, ainda não se encontram na literatura acadêmica proposições adequadamente estruturadas e completas de sistemáticas e métodos para aplicação da Delphi em sua *ranking form*. Para suprir esta lacuna, propõe-se um Método para Obter e Analisar *Rankings* com Emprego da Técnica Delphi (abreviadamente, MARD). Em adição, é descrito um estudo no qual o MARD foi utilizado. Por ser derivado de roteiros testados, o MARD contempla uma série de aspectos considerados relevantes por autores de outras metodologias e apresenta ainda, de forma bastante detalhada, os passos a serem cumpridos em todas as etapas requeridas para a realização de um painel Delphi nesta modalidade. O MARD mostrou-se completo e robusto, provendo o adequado suporte metodológico para a realização do painel Delphi apresentado como exemplo e demonstrando ter potencial para generalização e consequente emprego em outros tipos de painéis Delphi em seu *ranking form*.

Palavras-chave: Técnica Delphi. *Ranking*. Mensuração de *ranking*. Roteiro Delphi. Procedimento.

1 INTRODUCTION

The Delphi technique has been extensively employed in studies and research in various fields of science. Both in its traditional form – focused on generating estimates- as for the preparation of rankings, several papers have been published that employ Delphi as the main research method (Dalkey & Helmer, 1962; Okoli & Pawlowski, 2004; Skulmoski, Hartman & Krahn, 2007).

Nevertheless, despite the fact that this technique was coined over 60 years ago, to date, academic literature does not adequately offer structured and comprehensive methodological propositions for the application of Delphi in its ranking format. Findings include customized routines which were prepared and utilized in a spot manner, at specific surveys. Nevertheless, it is our understanding that none provide a sufficient level of structuring and completeness with proven potential for generalization purposes, enabling ample application to varied types of research.

Those who wish to utilize the Delphi method in its ranking form and seek reference to this effect often stumble across a set of fragments which hampers the carrying out of activities in an orderly and consistent manner. To bridge this gap, a new scheme is herein proposed named Method to obtain and Analyze Rankings employing the Delphi technique (in short, MARD) which proves to be endowed with the required structuring, completeness and generalization potential.

This article is structured into four sections: in the first, theoretical reference pertaining to the Delphi technique is presented, emphasizing application routines extracted from literature; next, MARD characteristics and the gaps it poses to address are discussed; subsequently, a sample application of MARD is presented and finally, conclusions and final thoughts are highlighted.

1 THE DELPHI TECHNIQUE

1.1 DEFINITION, HISTORY AND APPLICATION MODALITIES

The Delphi technique was developed in the US by Rand Corporation during the 1950´s to support military strategic-oriented surveys. Initially known as Expert Judgment (Rand Corporation, 2005), it was later renamed to Delphi

and first mentioned at the company in an internal document dated 14/11/1951 called "The use of experts for the estimation of bombing requirements" (Dalkey & Helmer, 1962).

In an instrument used to promote Delphi´s externally, Dalkey and Helmer (1962) define the same as a technique by means of which one seeks to obtain the most reliable collective opinion from a group of specialists, subject to individual questionnaires and/or interviews combined with controlled feedback, during a long series of cycles or rounds. In so proceeding, the authors state that the process, should it not necessarily shape consensus, at least leads to the convergence of replies by the end of a relatively small number of cycles.

Per his understanding Dalkey (1967) defines Delphi´s basic characteristics: (a) anonymity, (b) controlled feedback and (c) statistics associated with collective replies. Anonymity implies in participant unawareness of the individual opinion of the other respondents so as to avoid interference or influence of any sort. Controlled feedback refers to dissemination, at the end of each cycle of participant opinions to each other, in the form of standard summaries prepared by researchers. Statistics associated with collective replies are explained by numeric figures which are able to represent the set of specialist opinions at the end of each cycle in an appropriate manner.

In as much as the controlled feedback aspect is concerned, Dalkey (1969) further added issues involving interaction, reinforcing the relevance of cycles in the Delphi application process and demonstrating its inseparable connection with feedback.

Subsequently, other authors, particularly Rowe, Wright and Bolger (1991), chose to understand that Delphi presents four basic characteristics, placing interaction in separate and reinforcing that the repetition of the questioning process via cycles offers specialists the opportunity to reconsider their opinions in light of the group´s collective knowledge.

In its original format, the Delphi technique was ideated to be applied to situations that called for the generation of estimates concerning a given theme or subject; Dalkey (1969) confirms that Delphi´s initial applications were conducted to this effect. Later on, Delbecq, Van de Ven and Gustafson (1975) referred to use of Delphi to obtain appraisals on the relevance of requirements related to

given themes in the modality that thereinafter became known as ranking-type or ranking format.

Whether to generate estimates or to obtain rankings, Delphi can be applied to the exploration of future situations, behavior of variables, technological prospection and proposition of recommendations amongst other types of surveys.

1.2 DELPHI APPLICATIONS

Gupta and Clarke (1996) conducted extensive bibliographical research on the use of the Delphi technique during the period comprising 1975 and 1994 and identified 463 articles in which Delphi was employed, in 254 of which as the main technique and in the remaining 209 as a secondary tool. In as much as applications are concerned, these were distributed throughout the most diverse areas of knowledge, namely: education, business, management, marketing manufacturing, finance, economy, human resources, health, information and administration, real estate, international business, social sciences, engineering, entertainment and tourism, environmental studies and transportation.

Schmidt (1997) in turn mentions the existence of Delphi applications in the estimates modality, in the fields of public administration, medicine and technology dissemination and, in the ranking format, in the fields of education, operations management and information technology (IT). Rowe and Wright (1999) mention studies in the fields of healthcare, marketing, education, IT, transportation and engineering in which Delphi was employed. Okoli and Pawlowski (2004) presented an extensive list of studies in the field of IT in which the Delphi technique was applied, both to produce estimates and to prepare rankings. Likewise, Skulmoski, Hartman and Krahn (2007) presented a list of studies where Delphi was also used.

Rowe and Wright (1999) in their mappings to evaluate the subject matter in an in-depth manner selected 27 studies published between 1962 and 1996 in which Delphi was employed and verified that in approximately two thirds of these, only two or three cycles were conducted (in eight or nine studies respectively); in the remainder, four to seven cycles were conducted. In these 27 studies, the number of specialists involved varied between three and 98, with most concentrating in and around the four to 11 range.

Skulmoski, Hartman and Krahn (2007) in their findings documented the application of Delphi to 16 different studies published between 1973 and 2005 and detected that in 11, three cycles were conducted, in 3, only two cycles and in the 2 remaining papers, only one single cycle. Considering the set of studies, the number of specialists involved varied from 3 to 171, greater concentration being encountered in the 9 to 21 range.

These authors also conducted extensive research as to the use of Delphi in thesis and dissertations and at the time identified 280 studies of this kind in the ProQuest (www.proquest.co.uk/en-UK/default.shtml) database, having examined 41 of these in greater detail. Once again amongst the latter set of papers, three cycle applications appeared most often, totaling 29 versus 7 with two cycles, 4 with four cycles and 1 with 5 cycles. The number of specialists involved varied from 8 to 345, the largest concentration having been found with the 11 to 37 range. Dissertation and thesis themes also varied and comprised IT, education, healthcare, medicine, psychotherapy, business administration and sports.

On the 20th of August, 2010 an advanced search using "Delphi" as argument in abstracts or amongst key words conducted at the University of São Paulo´s digital thesis and dissertations data bank (www.teses.usp.br), resulted in the identification of nine masters dissertations and 14 doctorate thesis written by Brazilian students that employed the Delphi technique. The field of nursing relies on seven studies, that of civil engineering and medicine with three each, human resources and nuclear technology both feature two each and the rest is distributed amongst the fields of IT, business administration, accounting, production engineering, education and sports. The number of specialists involved ranged from 10 to 134 amongst thesis and from 11 to 99 amongst dissertations (Chaves, 2011).

Another search conducted on 05/12/2012 at the EBSCO database (search.ebscohost.com), using the regular tool and "Delphi" as the main argument and "Dissertations" as source type, resulted in the identification of 163 documents in which the Delphi technique was employed, scattered throughout the following fields of knowledge (main field, in the case of documents that refer to several areas):

- Medicine, Nursing and Healthcare: 63;

- Education and Culture: 48;
- Arts, Sports and Leisure: 21;
- Business Administration and Management: 15;
- Psychology: 15;
- Tourism: 1.

1.3 DELPHI APPLICATION SCRIPTS

Schmidt (1997) emphasized that should Delphi be used for the purpose of obtaining estimates, the ideators of the technique themselves and other researchers subsequently defined sets of application schemes whilst the ranking format at the time did not have an equivalent structured systematic.

To apply Delphi for the purpose of obtaining estimates, Dalkey and Helmer (1962) propose a scheme whereby in each of the cycles or rounds, the following activities are conducted: (1) present the questions to participating specialists; (2) collect replies, plot these into charts, depersonalize findings, produce a summary and (3) return the summary to participants together with another new set of queries.

Linstone and Turoff (1975) in turn introduce a routine for the application of Delphi to obtain estimates comprising four steps per cycle, namely:

(1) explore the subject matter of discussion, during which each participant contributes with whatever individual information he or she might be aware of, concerning the theme;

(2) obtain a collective group vision of the theme, defining points of agreeance and disagreeance;

(3) in the event of there being relevant points of disagreement, reevaluate them views to exploring differences and revising standpoints;

(4) finalize the assessment, concluding the analysis of the compiled information and generating feedback;

Skulmoski, Hartman and Krahn (2007) in turn claim to rather work with three cycle panels and to this effect developed a specific routine comprising 12 stages, as featured in Figure 1.

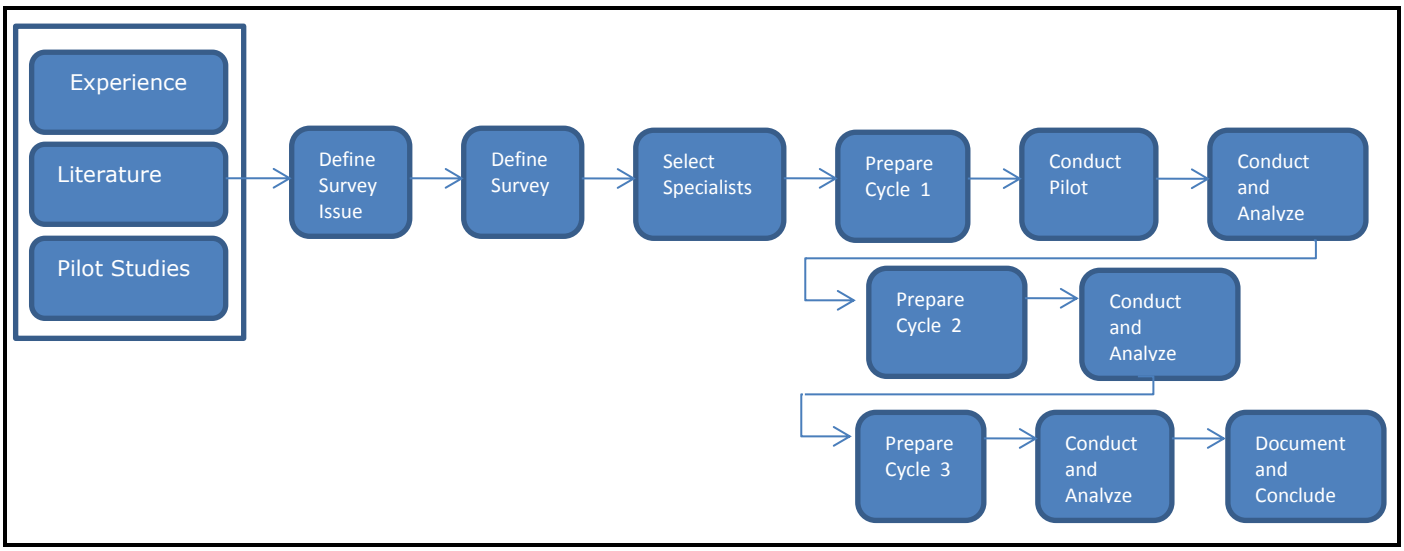

Figure 1: Three cycle Delphi application routine

Source: Adapted from Skulmoski, Hartman and Krahn (2007, p. 3).

Schmidt (1997) proposes a five stage script that is especially designed for Delphi ranking format panels, presented in Figure 2 hereunder:

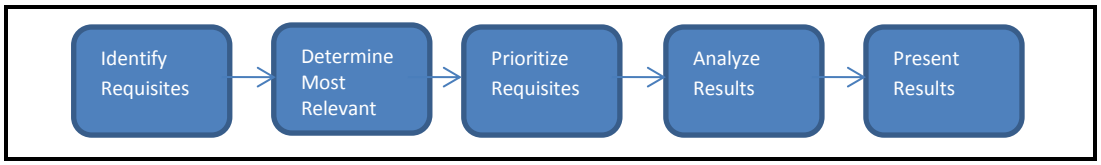

Figure 2: Five stage Delphi application routine

Source: Adapted from Schmidt (1997, pp. 768-772).

To obtain the collective ranking (during Stage 3), Schmidt (1997) recommends the application of the statistical method proposed by Kendall and Smith (1939), which emphasizes the use of the agreement coefficient W to determine when the series of cycles may be interrupted. The underlying reason for this is that variations in the W figure are directly related to the level of agreeance between panelists: if there is a significant increase in the W figure from one cycle to another, the panel can be terminated and if there is no significant increase in the W figure between three consecutive cycles, the panel can also be terminated; in both cases, whatever ordered, consolidated list is reached at the time of termination, this is what is used for final ranking purposes.

So as to complement the necessary set of tools required for the application of the Delphi technique, Okoli and Pawlowski (2004) propose a

routine to identify and choose the specialists that shall be invited to take part in a Delphi panel. Figure 3 offers a summarized perspective of this proposal.

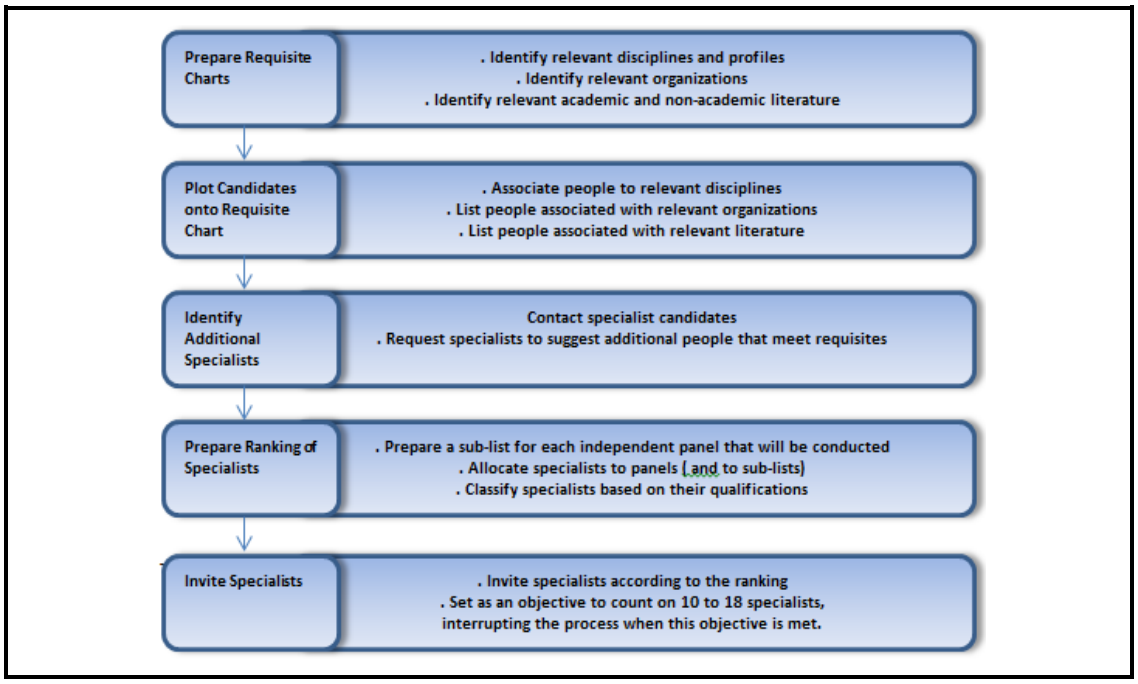

Figure 3: Delphi panel specialists selection scheme

Source: Adapted from Okoli and Pawlowski (2004, p. 21).

1.4 CRITICAL ANALYSIS OF ROUTINES FOR OBTAINING RANKINGS

Amongst the routines presented in the previous topic, there are two that are applicable to Delphi panels in their ranking format: that of Skulmoski, Hartman and Krahn (2007) and Schmidt´s (1997).

The routine proposed by Skulmoski, Hartman and Krahn (2007) - which also is applicable to panels focusing on the obtaining of estimates - is deemed insufficient from a stage detailing standpoint, despite comprising a large number of details. Negative aspects in special include:

- the selection of specialists - one of the most relevant stages of the process - offers no highlights in as much as procedures to be followed but rather only mentions requisites that panelists must meet;
- the use of statistics to determine if the panel may or not be deemed terminated is but explored in a superficial manner, without any suggestion being offered to this effect; all one finds is a brief note on the fact that the coefficient of agreement W was employed in some of the studies the authors analyzed.

The only script that is exclusively designed for Delphi panels in its ranking format is that of Schmidt (1997). Our understanding is that it is precious and offers lots of details as to the use of statistical analysis to determine rankings, to verify agreeance of opinions amongst participants and to determine if the panel may or not be deemed terminated. Nevertheless, this routine is hindered by the fact that it is not complete given it does not cover the formation of the group of specialists nor does it provide an outline or routine for the panel itself.

2 MARD´S STRUCTURE

MARD derives from the consolidation and extension of routines proposed by Schmidt (1997), by Skulmoski, Hartman and Krahn (2007) and by Okoli and Pawlowski (2004). MARD propositions are presented in Chart 1 in a comparative manner, using scripts promoted by the mentioned authors as reference, namely:

Routine Proposed by Skulmoski, Hartman and Krahn (2007)	Routine Proposed by Okoli and Pawlowski (2004)	Routine Proposed by Schmidt (1997)	MARD
– Design the Survey			1. Outline the Panel
– Select Specialists	– Prepare the Requirements Chart – Populate the Requirements Chart with Candidates – Identify Additional Specialists – Prepare the Ranking of Specialists – Invite Specialists		2. Form the Group of Panelists
– Prepare Cycle N[1] – Conduct Pilot Round		– Explore Requisites – Determine the Most Relevant Requisites – Prioritize Requisites	3. Prepare Cycle N of the Panel
– Conduct and Analyze Cycle N[1]			4. Conduct Cycle N of the Panel
– Document and Terminate the Survey		– Analyze Results – Present Results	5. Prepare Conclusions

[1] Reference to a generic cycle N is an adaption to these authors original proposition, who define different stages for each cycle (see Figure 1).

Chart 1: Comparison between Delphi application outlines

The five MARD detailed stages comprise:

- *Stage 1 – Outline the Panel*

– Includes the panel´s overall structure, pre-defining the number of cycles and of themes to be explored during each cycle and also provides a draft of each questionnaire that shall be applied;

– this stage has no comparable equivalence amongst other schemes used as reference but is deemed vital and must be conducted in this detailed manner given the fact that it shapes the structure to be used during the entire panel.

- *Stage 2 – Form the Group of Panelists*

– In addition to comprising all relevant aspects covered by the schemes used as reference, this stage explores in an in-depth manner the issue concerning the sizing of the group of specialists;

– the formation of the group comprises the identification of potential participants, the selection of those to be invited, the invitation itself and the negotiation rounds involving participation comprising agendas, availability, impairments and other logistic aspects;

– the identification and selection of potential participants must take into account a set of qualification factors or requisites, amongst which experience in the theme under survey, professional and/or academic expertise (accordingly) and interest in taking part and contributing (Delbecq, Van de Ven & Gustafson, 1975; Okoli & Pawlowski, 2004);

– should the survey call for the participation of panelists with different specializations and/or backgrounds, one might rather subdivide them into subgroups per profile as suggested by Okoli and Pawlowski (2004), or alternatively form a single group comprised of different profiles;

– furthermore, it is at this stage that the number of panel participants is defined and to this effect there is no generally accepted universal rule; bibliographical references mentioned in the second section of this study shape

the information presented in Table 1 whereby one notices that there is a major variation in as much as the number of panelists is concerned;

– as of numbers pictured in Table 1 and once each of the mentioned sources is analyzed one notices that, considering a concentration interval ranging from 4 to 65 (which is the widest interval shown in the table´s far right column), most panels resorted to a number of participants between these limits.

Table1: Delphi panel sizing

Source	Type	Minimum	Maximum	Concentration Interval	
Rowe and Wright (1999)	Articles	3	98	4	11
Skulmoski, Hartman and Krahn (2007)	Articles	3	171	9	21
Skulmoski, Hartman and Krahn (2007)	Thesis	8	345	11	37
Okoli and Pawlowski (2004)	Recommendation	10	18	–	–
Rowe and Wright (2001)	Recommendation	5	20	–	–
USP´s Digital Thesis and Dissertations Library	Thesis	10	134	10	65
Biblioteca Digital de Teses e Dissertações da USP	Dissertations	11	99	11	21

- *Stage 3 – Prepare Cycle N of the Panel*

– Refers to the preparation of the questionnaire pertaining to each panel cycle; this stage consolidates the steps proposed by both Schmidt (1997) and Skulmoski, Hartman and Krahn (2007) in their respective routines, improving and complementing the same with relevant details;

– in compliance with Skulmoski, Hartman and Krahn´s (2007) suggestion, the questionnaire designed for use during the first cycle may contain open or structured questions; open questions are those that require panelists to expose their opinions without offering them explicit references, whilst structured questions offer panelists a starting point, as of which they are asked to elaborate responses;

– an open question would typically be phrased as: "List the major benefits one might obtain from purchasing cloud computing services", whilst a

structured question on the same theme might be: "Literature mentions that reduced initial investments, dynamics scalability and reduced mobilization of human and infrastructure resources are some of the prime benefits one might obtain from acquiring cloud computing services: do you disagree with any item of this list and/or would rather add some other benefit to the same?";

– open questions tend to extend the scope of discussion since they enable panelists to shape replies without bonds to guiding references whilst the more references structured questions offer, the further limited the scope of discussions become, conditioning panelists to follow a line of thought proposed by the researcher;

– questionnaires designed for use in the remaining panel cycles, i.e., after the first one, should portray closed questions since these focus on treating attributes or requisites that have already been introduced the previous cycle.

- *Stage 4 – Conduct Cycle N of the Panel*

– This refers to the forwarding to panelists of individual cycle questionnaires and to the follow-up and collection of replies. It also comprises the subsequent plotting of replies and response analysis. Much like the previous stage, this one also consolidates the stages proposed by Schmidt (1997) and by Skulmoski, Hartman and Krahn (2007) in their respective routines, improving and complementing the same;

– replies at panels of the ranking type primarily focus on the proposition and ordering of lists; individual indications must be consolidated to obtain collective opinions that in turn must be confirmed so as to verify the level of agreement concerning prioritizations;

– once replies involving the proposition are obtained, consolidation poses to obtain distinct elements which have been collectively proposed and thus represent the opinion of the group of panelists on a given theme; to this effect, eventual indications of repeated elements are discarded (those which have similar definitions) and all distinct indications accordingly identified are used to compile the list of propositions;

– in as much as replies to the questions that require prioritization are concerned, so as to obtain the most collectively nominated elements which represent the opinion of the group of panelists on a given theme, a collective

prioritization scheme must be applied; our recommendation is that this scheme be that proposed by Kendall and Smith (1939), including Kendall´s (1945) suggestion involving a variant that poses to solve issues involving draws;

– in general terms, this collective prioritization scheme proposes that initially, each element that shows up in an individually ranked list receive a weight which corresponds to its position in the list, i.e., the element placed in position 1 receives weight 1, the element placed in position 2 receives weight 2 and so forth; these weights must be attributed to each panelist´s list and the sum of the weights of a given element comes to represent its position in the collective list in such a manner that the element with the lowest added figure occupies position 1, the element with the second lowest sum figure occupies position 2 and thus successively;

– in cycles where lists are not effectively ordered by panelists but only the *Z* most relevant elements are pointed out, to each of them the scheme would attribute weight 1 and to the non-indicated remainder, a *Z*+1 weight would be applied; this would characterize draws both between those selected and those not selected; in this case, according to Kendall´s (1945) guidance, the weights of the elements in tie must be substituted by the simple average of the positions they occupy in the list whereby elements with the lowest sum figures are deemed the most relevant;

– once the collective ranking is obtained, the level of agreement between panelists must be verified by means of calculating statistics *W* per Kendall´s (1945) recommendation; the formula to obtain *W* is:

$$W = \frac{S}{\frac{1}{12}\left(n^3 - n\right)m^2 - m\sum_{j=1}^{m} T_j}$$

whereby: n = quantity of elements present in each individually ranked list that is prepared concerning a panel´s theme;

m = quantity of individually ranked lists prepared concerning a panel´s theme;

T_j = adjustment factor related to the total number of draws that appeared in ranked list j, obtained via:

$$T_j = \left(\sum_{i=1}^{G_j} \left(t_{ij}^3 - t_{ij} \right) \right) / 12$$

whereby: t_{ij} = quantity of elements in the $n^{th.}$ group of draws in ranked list j;

G_j = quantity of distinct groups of elements in tie in ranked list j;

S = sum of the squares of the differences between the sum of ranks of element k and ranks total average, obtained via:

$$S = \sum_{k=1}^{n} \left(\left(\sum_{j=1}^{m} rank_{jk} \right) - \left(m(n+1)/12 \right) \right)^2$$

whereby: $rank_{jk}$ = weight attributed to position k occupied by an element in ranked list j;

– a interpretation of the *W* coefficient can be conducted using the ranges suggested by Schmidt (1997) which are duly presented in Table 2 below:

Table 2: Interpretation of the *W* coefficient

Ranges for Coefficient *W*	Meaning	Ranges for Coefficient *W*	Meaning
Up to 0,1	Very low	More than 0,5 and up to 0,7	High
More than 0,1 and up to 0,3	Low	More than 0,7 and up to 0,9	Very High
More than 0,3 and up to 0,5	Moderate		

Source: Schmidt (1997, p. 767).

– coefficient *W* indicates when a Delphi panel may be terminated since its behavior, from one cycle to another, is directly related to the level of agreeance between panelists: if there is no significant change in the value of *W* along at least three cycles, the process may be interrupted since it means panelists have reached their limit of agreeance and tend to no longer change their opinions; likewise, if there is a significant increase in the value of *W* from one cycle to another, reaching a moderate to greater level, the process can also be interrupted because this means the an adequate level of agreeance has been reached and it is no longer necessary to involve specialists in a new and

expensive cycle; in both situations, the consolidated ranked list of the most recent cycle is used as final ranking;

– the significance of *W* must be verified by applying an χ^2 test, following Friedman´s (1940) guidance; this χ^2 holds (*n*-1) degrees of freedom and must be calculated by means of formula:

$$\chi^2 = m(n-1)W$$

whereby variables *n*, *m* and *W* have the same above mentioned meanings.

- *Stage 5 – Prepare Conclusions*

– comprises the preparation of final conclusions based on results obtained with the execution of the panel´s cycles;

– must also comprise the exploration of result generalization possibilities and future research complementation.

3 MARD APPLICATION

MARD was applied to a research project developed in 2010 and 2011, whose core included a Delphi panel with specialists and Brazilian academicians. Inserted in Chaves (2011) the survey sought to identify and establish rankings concerning barriers, potential benefits and risks associated with the adoption of cloud computing.

The Delphi panel was entirely conducted over the internet using SurveyShare (www.surveyshare.com) software, both employed to prepare questionnaires and to receive and register replies. For the sake of convenience, the forwarding of questionnaires was conducted using a conventional electronic mail system despite the fact that SurveyShare also offers this feature.

For the sake of offering a sample application of MARD, the presentation of the study conducted at the panel only covers the first four stages of the scheme and is limited exclusively to the issue concerning benefits, given that the other themes (barriers and risks) were treated in the same manner and it is our understanding that one theme is enough for the purpose of herein offering an example.

3.1 STAGE 1 – PANEL STRUCTURING

The application of MARD drove the definition concerning the fact that the Delphi panel would in principle, comprise at least a minimum of five cycles and that others might be added should results obtained by the end of these still not indicate a satisfactory degree of agreeance amongst panelists.

Cycle 1 focused on the capturing of barriers and potential benefits associated with the adoption of cloud computing. Cycle 2 consisted of an in-depth investigation, initiating the composition of barriers and benefits rankings and collecting indications as to risks deemed inherent to cloud computing. Cycle 3 complemented the definition of barrier and benefits rankings and initiated the composition of the ranking of risks. Cycle 4 complemented the definition of the ranking of risks and promoted the revision of barriers and benefits rankings so as to improve the level of agreeance between participants. Cycle 5 foresaw a revision of the ranking of risks and, if need be, yet another revision of barriers and benefits rankings.

However, given that this ended up not being necessary, it was not conducted since all agreeance degrees by then prove to be satisfactory, i.e. by the end of Cycle 4.

This stage further included, for each cycle, the preparation of a draft of the questionnaires yet to be finalized and applied.

3.2 STAGE 2 – FORMATION OF THE GROUP OF PANELISTS

The authors chose to conduct the panel with the participation of a single group of specialists, bringing together academicians and IT professionals. Persons from the researchers own networks were invited, comprising three academicians and 19 professionals who at the time, were employed as executives at IT companies that operate in Brazil.

Invitees fully met the established requirements which included: (a) advanced knowledge in cloud computing; (b) acknowledged competence in their respective market place; (c) effective interest in taking part in a study of the kind; (d) effective availability of time to participate in assignments within the foreseen intensity, i.e., five cycles with an estimated dedication of one hour to

reply to each questionnaire; (e) for IT professionals, the holding of upper level executive positions at their respective employers.

The invitation was accepted by three academicians and 13 professionals, forming a satisfactory group of both in terms of size and relative proportion.

3.3 STAGES 3 AND 4 – PREPARE AND CONDUCT PANEL CYCLES

Conducted cycles comprised the following activities:

- *Cycle 1 – Capturing of Potential Benefits*

– This cycle included the preparation and forwarding of the first questionnaire and subsequent plotting and analysis of replies; by means of open questions, the questionnaire sought to collect panelists opinions as to the potential benefits involving the hiring of cloud computing services and was replied by three academicians and 11 of the 13 IT professionals;

– compilation and interpretation of indications made by panelists led to the obtaining of a consolidated list containing 12 distinct benefits, presented in Chart 2.

Nbr.	Statement	Features in literature?[1]
V1	Enables IT focus to concentrate on business and core processes	No
V2	Favors greater simplicity and less effort to manage IT allocated assets	Yes
V3	Reduces or eliminates the need for having to deal with the planning of capacities and other processes associated with proprietary assets	Yes
V4	Promotes opportunities involving technological improvement and acquisition of new knowledge	Yes
V5	Demands smaller initial investments for one to have the same level of resources and technology	Yes
V6	Enables faster implementation of new services and applications	Yes
V7	Offers greater service availability levels	Yes
V8	Offers scalability, providing flexibility to expand and deal with peak and seasonality conditions	Yes
V9	Ensures service portability, making supplier change feasible	Yes
V10	Allows for global reduction of both IT investments and maintenance expenditures	Yes
V11	Enables the substitution of investments in assets (CAPEX) for expenses (OPEX), generating fiscal benefits	Yes
V12	Increases the global level of security in IT as long as suppliers comply with SLAs	No
V13	Eases access to innovations, enabling the use of new types of applications and services that under other conditions one would not be able to use	Unique

Nbr.	Statement	Features in literature?[1]
V14	Enables reduced mobilization of human resources and infrastructure for IT purposes	Unique

[1] Given this is an example, references where benefits were identified have not been mentioned.

Chart 2: Potential benefits associated with the adoption of cloud computing

- *Cycle 2 – Selection of the Most Relevant Potential Benefits*

– This cycle comprised the preparation and forwarding of the second questionnaire and the subsequent plotting and analysis of replies; before the list of benefits to be inserted in the questionnaire was prepared, a cross-check was conducted between the 12 most relevant points mentioned by panelists and those obtained from researched bibliographical references. On one hand this enabled researches to conclude that benefits mentioned by panelists in part coincided with those extracted from bibliographical references, and, furthermore, on the other, the identification of two relevant benefits that were not mentioned by panelists but which were added to the list (Chart 2 in itself demonstrates how benefits extracted from literature were associated or received additions as mentioned by panelists);

– this questionnaire was sent to the remaining 14 panelists to whom researchers requested they indicate the 10 most relevant benefits amongst those listed, without prioritizing them and it was replied by three academicians and 9 IT professionals;

– despite being requested to indicate 10 benefits, not all panelists did so, some having indicated fewer; in any event, with replies in hands, a list of the collectively most indicated 10 benefits was prepared; the preparation of this list followed MARD´s Stage 4 guidelines and results are presented in Table 3, whose weights (that appear in the central cells) already reflect adjustments in light of draws;

– it must be noted that this collective list did not as yet represent a ranking given that in this cycle, panelists merely chose the most relevant benefits without ordering the same; therefore this cycle basically enabled the elimination of four benefits deemed less relevant by the group (which have their respective weights marked with a grey background in the collective list presented in Table 3).

Table 3: Most relevant potential benefits

Panelists	Benefits														Effects of Draws		
	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	t1	t2	τ
A	11,5	4,5	4,5	11,5	4,5	4,5	11,5	4,5	4,5	11,5	4,5	11,5	11,5	4,5	8	6	60
B	5,5	5,5	5,5	5,5	5,5	12,5	5,5	5,5	12,5	5,5	5,5	12,5	12,5	5,5	10	4	88
C	12,5	5,5	5,5	12,5	5,5	5,5	5,5	5,5	5,5	5,5	5,5	12,5	12,5	5,5	10	4	88
D	4	11	11	11	4	4	11	4	11	11	4	11	4	4	7	7	56
E	5,5	5,5	5,5	12,5	5,5	5,5	12,5	5,5	12,5	5,5	5,5	12,5	5,5	5,5	10	4	88
F	5,5	5,5	5,5	12,5	5,5	5,5	5,5	5,5	12,5	12,5	5,5	12,5	5,5	5,5	10	4	88
G	5,5	5,5	5,5	12,5	5,5	5,5	5,5	5,5	12,5	12,5	5,5	5,5	12,5	5,5	10	4	88
H	5,5	5,5	5,5	12,5	5,5	5,5	5,5	5,5	12,5	12,5	5,5	12,5	5,5	5,5	10	4	88
I	5,5	12,5	5,5	5,5	5,5	5,5	12,5	5,5	12,5	5,5	5,5	12,5	5,5	5,5	10	4	88
J	5,5	5,5	12,5	5,5	5,5	5,5	5,5	5,5	12,5	12,5	5,5	12,5	5,5	5,5	10	4	88
K	5,5	5,5	5,5	12,5	5,5	5,5	5,5	5,5	12,5	12,5	5,5	5,5	5,5	12,5	10	4	88
L	5	5	5	12	5	5	12	5	12	12	12	5	5	5	9	5	70
R = ∑ranks	77	77	77	126	63	70	98	63	133	119	70	126	91	70		∑τ =	973
X = R − x̄	-13,0	-13,0	-13,0	36,0	-27,0	-20,0	8,0	-27,0	43,0	29,0	-20,0	36,0	1,0	-20,0			
Y = X^2	169,00	169,00	169,00	1296,00	729,00	400,00	64,00	729,00	1849,00	841,00	400,00	1296,00	1,00	400,00			
					n =	14		x̄ =	90,0	W =	0,404						
					m =	12		S =	8512,0	χ2 =	62,980						

- *Cycle 3 – Preparation of the Potential Benefits Ranking*

– This cycle comprised the preparation and forwarding of the third questionnaire and the subsequent plotting and analysis of replies; the questionnaire was sent to the remaining 12 panelists – having been replied by three academicians and by 8 IT professionals – who were requested to prepare a ranking of benefits as of the 10 most mentioned, as highlighted in Table 3;

– the plotting of replies to this questionnaire enabled the obtaining of a consolidated ranking of benefits; Table 4 introduces individual and collective rankings, the latter reflecting the group´s consolidated opinion (this table´s line marked with a grey background indicates the positions of benefits in the consolidated ranking);

– Table 4 also presents the value of agreeance coefficient *W*, which in this panel was 0,144 and means that the consolidated ranking expressed a low level of agreeance between panelists; the χ^2 test demonstrated that the significance of *W* was $p = 0,1$.

Table 4: *Rankings* of the most relevant potential benefits

Panelists	Benefits									
	V1	V2	V3	V5	V6	V7	V8	V11	V13	V14
A	2	3	9	4	5	7	8	10	6	1
B	3	2	4	5	1	6	7	8	10	9
C	10	8	6	3	4	5	2	1	7	9
D	4	3	2	9	8	10	7	1	6	5
E	2	7	3	4	5	10	9	8	6	1
F	1	2	3	4	6	10	5	9	8	7
G	1	7	5	4	2	3	6	10	8	9
H	10	1	2	7	5	4	6	8	3	9
I	6	9	10	2	3	8	4	5	1	7
J	5	7	6	4	3	9	10	2	1	8
K	5	2	3	4	1	6	7	8	9	10
R = ∑ ranks	49	51	53	50	43	78	71	70	65	75
X = R − $\bar{x}$	-11,5	-9,5	-7,5	-10,5	-17,5	17,5	10,5	9,5	4,5	14,5
Y = X^2	132,25	90,25	56,25	110,25	306,25	306,25	110,25	90,25	20,25	210,25
Position	**2**	**4**	**5**	**3**	**1**	**10**	**8**	**7**	**6**	**9**

n =	10	$\bar{x}$ =	60,5	W =	0,144
m =	11	S =	1432,5	χ^2 =	14,207

- *Cycle 4 – Revision of the Ranking of Potential Benefits*

– This cycle comprised the preparation and forwarding of the fourth questionnaire and the subsequent plotting and analysis of replies; it sought to revise the ranking of benefits established in the previous cycle and was sent to the remaining 11 panelists, all of whom replied to the same;

– each panelist was requested to revise their ranking as to benefits once the collective opinion of the group was known and, since this was an optional revision, only some of them chose to change the ranking they had first prepared;

– Table 5 presents what came of the new individual and collective rankings after modifications; the *W* coefficient then turned to 0,389, meaning that the resulting consolidated ranking expressed a moderate level of agreeance amongst panelists; the χ^2 test demonstrated a significance level of $p < 0,01$ for *W*;

– given the relevant change to a greater figure verified in the agreeance coefficient (approximately 170%), researchers understood that the panel could be terminated and the consolidated ranking obtained in this cycle could be deemed as being the final version.

Table 5: *Rankings* of the most relevant benefits (after revision)

Panelists	Benefits									
	V1	V2	V3	V5	V6	V7	V8	V11	V13	V14
A	2	3	9	4	5	7	8	10	6	1
B	3	2	4	5	1	6	7	8	10	9
C	9	1	4	5	7	6	8	10	3	2
D	4	3	2	9	8	10	7	1	6	5
E	2	5	6	3	1	10	9	8	7	4
F	1	3	5	4	2	10	8	9	6	7
G	1	7	5	4	2	3	6	10	8	9
H	10	1	2	7	5	4	6	8	3	9
I	1	2	4	5	3	8	9	10	6	7
J	2	4	5	3	1	10	8	7	6	9
K	5	2	3	4	1	6	7	8	9	10
R = ∑ ranks	40	33	49	53	36	80	83	89	70	72
X = R − $\bar{x}$	-20,5	-27,5	-11,5	-7,5	-24,5	19,5	22,5	28,5	9,5	11,5
Y = X^2	420,25	756,25	132,25	56,25	600,25	380,25	506,25	812,25	90,25	132,25
Position	**3**	**1**	**4**	**5**	**2**	**8**	**9**	**10**	**6**	**7**

n =	10	$\bar{x}$ =	60,5	W =	0,389
m =	11	S =	3886,5	χ^2 =	38,544

4 CONCLUSIONS AND FINAL CONSIDERATIONS

The reason that led to the development of MARD was the attempt to bridge a gap encountered in academic literature concerning routines supporting the application of the Delphi technique in its ranking format. Till then, available routines were deemed specific, developed for spot use in specific surveys and consequently, incomplete and poorly structured and, even when presented in a single format, it still did not offer enough consistency and completeness to guide the work required by panels of the kind. Furthermore, none promoted envisioning of potential for generalization with views to enabling ample application to varied types of research.

So as to address this setback, MARD is proposed and presents in a very detailed manner, steps that must be taken along all stages required for one to conduct a Delphi panel in its ranking format.

MARD prove to be both complete and robust, providing adequate methodological support for the Delphi panel presented as an example. Since the panel in which it was applied does not feature any characteristic that would

confer to the same a given level of exceptionality, it is reasonable to consider that MARD, despite not having been prepared with prime focus on the perspective of becoming generalized, effectively presents potential to be employed in other types of Delphi panels in its ranking format. For instance, one might mention panels that seek to obtain rankings involving: (1) characteristics or topics associated with a given theme, as per the example presented; (2) estimates of variable values and (3) projection of future situations involving scenarios of uncertainty.

Thus it is understood that MARD can become an instrument of reference for researchers who may come to have to conduct surveys of this kind and who once using the same, might generate contributions for its very improvement.

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