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# Methods and Techniques in Studies Related to the Delphi Method, Innovation Strategy, and Innovation Management Models

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**Abstract:**

This article gathers results from a review and analysis of methods and techniques used in the Delphi method, innovation strategy, and innovation management models in organizations. The methodology used included the construction of search equations in databases such as Scopus and freepatentsonline, Google Scholar, ProQuest and universities such as the Massachusetts Institute of Technology, Manchester and George Washington. A total of 151 related documents were obtained out of which 72 were selected. A frequency analysis of each method and technique was carried out. Some of the most representative results were: in the Delphi method, the most used is the modified Delphi method (MDM), while the most used technique are questionnaires; in innovation strategy, the most used methods are literature analysis and authors' theoretical analysis, while the most used technique is the Likert scale; finally, in organizational innovation management models, the most used method is matrices and literature analysis, while the most used technique are the mean and P value.

**Keywords:** Methods, techniques, Delphi method, innovation strategy, innovation management model

## INTRODUCTION

Scientific articles, theses, technical documents and patents related to the Delphi method, innovation strategy and innovation management models have limited information on methods and techniques used. This paper aims to identify the most used methods and techniques in the three thematic axes and quantify their frequency of use, as well as aligning these results with the current doctoral thesis entitled "The modified Delphi method as a catalyst for innovation strategy within the framework of a model of innovation management in organizations of the productive sector", for the Doctorate in Administration of the University of Medellín, Colombia.

## THEORETICAL FRAMEWORK

The Delphi method is a method of anonymous consultation to experts about a particular topic through successive rounds and with some statistical analysis. It has been characterized by having multiple applications in different sectors around the world, especially on technology and innovation studies [1] [2]. However, since its inception in the 40s, there have been changes in its methodology, and nowadays it mostly corresponds to an MDM, characterized by anonymity, different alternatives to the consensus, less rounds, etc [3].

An innovation strategy refers to how an organization generates new or improved products, services and processes. Studies carried out by [4] [5] have an in-depth discussion on the stages and the importance to formulate and implement a strategy of innovation, and the foundations or approximations for an adequate strategy.

In terms of innovation management models, these are models of organizational structures that contain innovation process models [6] [7], and other functions or management activities such as project management, foresight, technology monitoring, and knowledge management, among others.

When speaking of innovation management models or I+D+i management models, it frequently refers to representing processes and organizational structures.

## METHODS AND TECHNIQUES

The definition of "method" will be taken into account in this paper's analysis. The term is of epistemological order, based on the logic of scientific thought that emerges from the theory [8].

On the other hand, a "technique" is understood as what arises from knowledge derived from specific actions, defined as know-how experience [9]. Techniques refer to the means or procedure that allow reaching objectives.

Research techniques comprise a set of systematically organized procedures that guide the researcher in the task of deepening knowledge and approaching new lines of research. They can be used in any branch of knowledge that seeks logic and understanding of scientific knowledge of events [10].

## METHODOLOGY

**Phase I:**

Search equations for articles and patents were formulated in the three main components or axes of the study. These were applied in scientific databases for articles and patents, such as: Scopus, freepatentsonline, and other databases such as Google Scholar, ProQuest, and university databases such as MIT, Manchester, George Washington, among others.

An instrument or comparative table was applied to documents gathered (Table 1). It allowed to extract information related to the type of contribution, innovation, context, techniques or tools, level of detail, and if software or mathematical models were used. Columns two and three (A1 or Author 1, A2 or Author 2...) contain the information for each document.

**Table 1.** Comparison criteria

| **Comparison criteria / Proposal** | **A1** | **A2…** |
|---|---|---|
| **Contribution type:** (**Mo:** Model, **Met:** Methodology, **Me:** Method, **CA:** Concept analysis) | | |
| **Type of contribution:** (**P:** Product, **T:** Technological, **Pro:** Process, **O:** Organizational, **M:** Market, **AK:** all kinds, **US:** unspecified) | | |
| **Context for which the proposal applies:** (**B:** Business, **C:** College, **RC:** Research center, **US:** unspecified) | | |
| **Techniques or tools involved:** | | |
| **Level of detail of the proposal:** (**Ca:** categories, **V:** Variables, **D:** Description, **I:** Indicators) | | |
| **With software or mathematical models to support the proposal:** (**Y:** yes, **N:** No, **Na:** Does not apply) | | |

**Source:** Own elaboration.

**Phase II:**

Documents obtained were reviewed and only some of them contained approaches about their methods and techniques. The following format was used:

**Table 2.** Filter format for document analysis.

| **Author** | **Title** | **Important aspects** | **Main contributions (methods and techniques)** | **Commentaries (personal)** |
|---|---|---|---|---|
| | | | | |

**Source:** Own elaboration.

**Phase III:**

Techniques and methods were analyzed and their frequencies were established in three thematic axes (Delphi method, innovation strategy, and innovation management model) in order to identify the most appropriate, representative and common methods and techniques.

## RESULTS

Search equations for articles and patents used in the three main components or study axes are shown in Table 3:

**Table 3.** Search equations for articles and patents in the three thematic axes.

| **Thematic axis** | **Search equations used in Scopus** |
|---|---|
| Delphi method | TITLE-ABS-KEY”Delphi” |
| | TITLE-ABS-KEY”Delphi method” |
| | TITLE-ABS-KEY(business strategy)AND (delphi) |
| | TITLE-ABS-KEY(corporate strategy) |
| Innovation strategy | TITLE-ABS-KEY(corporate strategy) AND innovation |
| | TITLE-ABS-KEY(strategy) |
| | TITLE-ABS-KEY("business strategy") AND (innovation) |
| | TITLE-ABS-KEY("business strategy") AND (innovation) AND (delphi) |
| Innovation management model | TITLE-ABS-KEY("innovation management") |

**Source:** Own elaboration.

A total of 101 scientific articles, 4 doctoral theses, 22 books, 13 technical documents, 8 patents and 3 standards (2 international, Spain and United Kingdom and 1 national) were obtained.

New values were obtained after applying comparison criteria and the filter format to 151 documents: 40 documents for the Delphi method, 16 documents for the innovation strategy, and 16 documents for the innovation management models. Only these documents made explicit mention of the methods and techniques used. Tables gathering most relevant information were made, starting with the Delphi method (Table 4), in this table only the 29 most recent articles out of a total of 40 obtained are referenced.

**Table 4.** Methods and techniques found on Delphi method studies between 1993 and 2014.

| **Método Delphi** | | | | | |
|---|---|---|---|---|---|
| **Journal** | **Author** | **Year** | **Country** | **Método** | **Técnica** |
| Procedia - Social and Behavioral Sciences | [11] | 2013 | Italy | Unmentioned | Media, P-value, Questionnaires, Kendalls |
| Journal of Neurology | [12] | 2013 | Germany | Unmentioned | P value, Questionnaires, Correlation, Spearman test, Fisher test |
| Wseas transactions on business and economics | [13] | 2013 | Taiwan | Diffuse analytical hierarchy or diffuse hierarchical AHP analysis | Eigenvalue, Questionnaires, Nominal scale, Consistency indicator |
| International weekly journal of science | [14]. | 2014 | UK | Unmentioned | Likert, Questionnaires, Kappa Value |
| Food Control | [15] | 2013 | USA | MDM – Modified Delphi Method | Media, Mode, Medium, Likert, Questionnaires, Beta Expert |
| Fibres & Textiles in Eastern Europe | [16] | 2013 | Poland | Policy delphi, Delphi Conference, Generation of scenarios | Questionnaires |
| Educación XX1 | [3] | 2014 | Spain | MDM – Modified Delphi Method | Mean, Likert |
| International Journal of Accounting Information Systems | [17] | 2013 | USA | Literature analysis | Kendalls, Use of stakeholders |
| Expert Systems with Applications | [18] | 2013 | Korea | Matrices, diffuse analytical hierarchy or diffuse hierarchical AHP analysis | Likert, Interviews, Questionnaires |
| BMC Medical Informatics and Decision Making | [19] | 2013 | France | Matrices, Delphi method, diffuse cognitive maps | Mode, Median, Standard deviation, P-value, Questionnaires, Interquartile range, Stability test, Mann-Whitney nonparametric test |
| Expert Systems with Applications | [20] | 2013 | Greece – UK | Unmentioned | Medium, Likert, Wilcoxon Test |
| Revista Latina de Comunicación Social | [21] | 2013 | Spain | Delphi method, | Medium, Medium, Use of stakeholders |
| Journal of Environmental Management | [22] | 2013 | South Korea | Matrices, literature analysis | Interviews, Questionnaires, consistency indicators |
| Biogeosciences and Forestry | [23] | 2013 | Portugal – Algeria - Italy | Unmentioned | Likert |
| Journal of the American College of Surgeons | [24] | 2013 | USA | Literature analysis, original Delphi | Likert, Questionnaires, Use of stakeholders |
| Complementary Therapies in Medicine | [25] | 2013 | Japan | Unmentioned | Mean, Standard deviation, Likert, Minimum and maximum value |
| European Journal of Scientific Research | [26] | 2012 | India | Fuzzy Delphi Method | Triangular diffuse numbers |
| Reumatismo | [27] | 2012 | Italy | Literature analysis, MDM – Modified Delphi Method | Mean, Likert |
| TechnologicalForecasting& Social Change | [28] | 2012 | Taiwan | Matrices | Value P, Likert, Questionnaires |
| Technological Forecasting and Social Change | [29] | 2012 | Germany | Real-time Delphi, Generation of scenarios | Questionnaires, Use of stakeholders |

| | | | | | |
|---|---|---|---|---|---|
| Revista de Ciencias Sociales | [30] | 2012 | Venezuela | MDM – Modified Delphi Method | Mean, Median, Standard deviation, Questionnaires, Interquartile range |
| Revista Cubana de Educación Médica Superior | [31] | 2012 | Mexico | MDM – Modified Delphi Method | Likert, Questionnaires |
| Bulgarian Journal of Agricultural Science | [32] | 2012 | Slovenia | MDM – Modified Delphi Method | Interviews, Questionnaires |
| Archivos Latinoamericanos de Nutrición | [33]. | 2012 | Chile | MDM – Modified Delphi Method | Median, Likert, Questionnaires |
| Revista Anales de Psicología | [34] | 2012 | Spain | Matrices, MDM – Modified Delphi Method | Questionnaires |
| MeatScience | [35] | 2012 | Spain | Unmentioned | Standard deviation, Questionnaires, Use of stakeholders |
| Revista Española de Documentación Científica | [36] | 2012 | Spain | MDM – Modified Delphi Method | Median, Questionnaires, Minimum and maximum value, Correlation |
| International Information Institute | [37] | 2012 | China | Unmentioned | Questionnaires |
| Journal of Ecotourism | [38] | 2011 | USA | MDM – Modified Delphi Method | Mode, Standard deviation, P value, Questionnaires |

**Source:** Own elaboration.

**Table 5.** Methods and techniques found on innovation strategy studies

In this table only the 10 most recent articles out of a total of 16 obtained are referenced.

| **Innovation Strategy** | | | | | |
|---|---|---|---|---|---|
| **Journal** | **Author** | **Year** | **Country** | **Method** | **Technique** |
| Journal of Technology Management & Innovation | [39] | 2011 | Colombia | Diagnosis or innovation profile, Map of I+D+i projects | Likert, questionnaires, Map of I+D+i projects |
| IFIP Advances in Information and Communication Technology | [40] | 2010 | Canada | Literature analysis, Delphi method, Investigation - action | Questionnaires |
| Journal of Business Research | [41] | 2004 | Denmark - Germany | Covariance matrices, factor analysis | Interviews, questionnaires, Cronbach Alfa, Multi-item scale, correlation, Convergence validity, Maximum likelihood, Validation of scale |
| International Journal of Innovation Management | [42] | 2014 | South Africa | Multiple regression analysis | Mean, Standard deviation, P-value, Likert, Eigenvalue, Questionnaires, Cronbach Alpha, correlation, Maximum likelihood |
| Journal Futures | [43] | 2010 | Germany | Literature analysis, Case studies | Interviews |
| Elsevier - Long RangePlanning | [44] | 2010 | USA | Author's theoretical analysis | Unmentioned |
| Journal of International Business Studies | [45] | 2014 | USA | Author's theoretical analysis | Unmentioned |
| **Books, patents, technical documents, conferences** | **Author** | **Year** | **Country** | **Method** | **Technique** |
| Strategic Management of Technological | [46] | 2013 | USA | Case study | Unmentioned |

| | | | | | |
|---|---|---|---|---|---|
| Innovation | | | | | |
| http://www.strategyand.pwc.com/ | [47] | 2015 | UK | Diagnosis or innovation profile | Likert |
| Les stratégie d' innovation | [48] | 2013 | Algeria | Author's theoretical analysis | Unmentioned |

**Source:** Own elaboration

Finally, results regarding innovation management models are shown in Table 6, there are only 6 documents of the 16 in order not to affect the extent of the paper

**Table 6.** Methods and techniques found on innovation management model studies.

| **Innovation management model** | | | | | |
|---|---|---|---|---|---|
| **Journal** | **Author** | **Year** | **Country** | **Method** | **Technique** |
| International Business & Economics Research Journal | [49] | 2014 | South Africa | Factor analysis, Matrices of correlations, Multiple regression | Likert, Coefficient, Eigenvalue, Chi-square |
| Foresight | [50] | 2015 | Russia | Literature analysis | Interviews |
| Journal of Industrial Engineering and Management | [51] | 2014 | Turkey | Matrices | Unmentioned |
| R&D Management | [52] | 2008 | Spain | Literature analysis | Likert, Interviews, questionnaires |
| Academy of Management Review | [53] | 2008 | UK | Empirical analysis | Mean, Standard deviation, P-value, Test F, Coefficient r 2 adjusted |
| **Thesis** | **Author** | **Year** | **Country** | **Method** | **Technique** |
| Doctoral Thesis - Polytechnic University of Valencia | [54] | 2011 | Spain | Unmentioned | Mean, Covariance, P-value, Test F, Chi-square |

**Source:** Own elaboration.

**Delphi Method**

The method most used in the 40 analyzed documents was the modified Delphi method (25.00%), followed by matrices (16.67%). The most used techniques were questionnaires (20.34%) and Likert scales (11.86%).

6 out of the 15 recorded methods, as well as 15 out of the 31 recorded techniques appear only once in the articles.

There was no mention of the Delphi method in the 40 documents analyzed on indexes of relevance and congruence, as well as on coefficients or methodologies to measure the degree of expertise of the participants in a Delphi. A single study shows the use of a consistency index [13], which indicates decision-maker inconsistencies, as well as those that result from preferences generated at random. This test was carried out to clarify the overall coherence of the comparison matrix, made up of experts' judgments regarding the evaluation of factors related to supply chain in Taiwanese companies.

**Innovation Strategy**

The most frequently found methods and techniques in the 16 analyzed documents related to innovation strategy are: literature analysis and author's theoretical analysis (22.73% for both). The most used techniques are questionnaires (13.51%) and Likert scales (8.11%). 8 of the 12 methods and 11 out of the 21 techniques appear only once in the articles.

**Innovation Management Mode**

According to the 16 analyzed documents, the most used methods in innovation management models are matrices (33.33%) and literature analysis (26.67%), while the most used techniques are mean and P value (12.50% each). 4 of 7 methods and 6 of 15 techniques make a single appearance on analyzed articles.

**DISCUSSION**

Studies with the Delphi method are intensive in the MDM and the use of matrices. This is important because since its inception in the RAND Corporation, the Delphi method has undergone a great number of variations, among which fewer rounds are highlighted: In the documents consulted, the tendency to use two rounds, or even one with real time Delphi. Other methods, such as fuzzy Delphi, are of negligible frequency. In relation to schools for future studies, that is, the Anglo-Saxon with the Delphi method as its main exponent, and the French with cross-impacts and scenarios as its main methodologies, it is only observed that 3 of the studies analyzed made use of the French approach of prospective. The

use of Likert scale as a technique is emphasized, although with varying qualifications (from 0 to 5, 0 to 7 or 0 to 9 points).

Fuzzy Delphi Method appears in 6 studies, and 5 of them correspond to applications in countries such as Taiwan and Japan. Only in India does a new application appear [55]. This topic may represent a potential for new applications of future studies through fuzzy Delphi.

Only two Delphi studies mention the generation of scenarios as a method: [16] apply the Delphi method in the framework of a prospective project in the Polish textile industry. Their methodology combines the Delphi method with hypothesis in four categories of critical technologies for the competitive position of Poland in the textile industry. In another study with similar characteristics, [29] shows the results of a real-time Delphi on the factors that will influence the development of infrastructure by 2030. Results are presented in a probable scenario, divided into different aspects, and cite five studies (1976-2003) that have used or combined Delphi and scenarios. Within the 40 studies analyzed, only 2 talk about scenarios. This may represent an opportunity for future applications since the approaches to scenarios are almost exclusive to the French school of prospective, focused on the group discovery of possible, probable and desirable scenarios.

Most commonly used methods in innovation strategies, literature analysis and author's theoretical analysis, suggest that researchers use their own analysis and approaches, and propose their own way to approach their studies and applications on innovation strategy, which does not necessarily coincide with what happens in other areas. Other methods such as diagnostics, innovation profiles and case studies have also been used. Questionnaires and Likert scales continue to be the preferred techniques.

Matrices and literature analysis are the most used methods in studies on innovation management models. In this axis, the use of matrices is not only strictly related to matrix algebra, but also corresponds to double-entry tables where their combinations generate diagnoses or suggest alternatives for users. Arithmetic mean and P value are the most used techniques, and the standard deviation achieves a high percentage, close to the two most representative.

In terms of the geographical concentration of studies on the three thematic axes, the United States has the highest percentage, while in Latin America only two studies on the Delphi method, a study on innovation strategy, and no studies on innovation management models were found. This does not mean that there are no applications or research in the three thematic axes, rather it shows that, in the studies here analyzed, only those were explicit on their use of methods and techniques.

In the studies analyzed on innovation strategy and innovation management model, only [40] mentions or refers to the Delphi method. This may be related to the lack of knowledge about the benefits of the method to consult experts and may manifest the reality of the lack of alignment or articulation of Delphi as a method of prospective studies with innovation strategies and management models.

## CONCLUSIONS

More than half of the methods and techniques have only been used once in the documents analyzed in the innovation strategy and innovation management model components. This shows, at least in this group of documents, that there are no dominant methods and techniques in studies on these topics and, even if an author proposes a specific method or technique, it is difficult for other authors to follow their research design.

Patterns were identified on the use of techniques and tools, which can be useful for future studies and thesis on prospective, innovation strategy and innovation management models.

There is a possibility of using the results of this article in norms or standards on innovation management such as the Spanish standard UNE 166002, the British standard or the Colombian technical standard NTC 5801, since not only conceptual clarity about the three components is presented, themes or axes of the doctoral thesis, but the main techniques and methods which could at least be listed in these standards.

Techniques such as questionnaires and Likert scale are frequently used in Delphi studies and in innovation strategy, while methods such matrices are common in Delphi applications and organizational innovation management models, although they do not always correlate.

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