

Scenarios and the Delphi Method - A Perspective from the Contributions of North American Authors

Jhon W Zartha^a, William E. Halal^b, Juan C Palacio^c, Juan C Oviedo^d,
^aSchool of Engineering, Faculty of Agroindustrial Engineering. Universidad Pontificia Bolivariana, ^bGeorge Washington University, ^cDirector Faculty of Agroindustrial Engineering. Universidad Pontificia Bolivariana, ^dResearch profesor. Universidad Pontificia Bolivariana, Email: Jhon.zartha@upb.edu.co, halal@gwu.edu, juan.palacio@upb.edu.co, juan.oviedo@upb.edu.co

This article seeks to identify the North American contributions to the foresight framed in studies on scenarios and the Delphi method. For this purpose two search equations were made in the Scopus database, with the keywords “foresight”, “Delphi Method” and “Scenarios”. In order to find papers on Delphi applications and scenarios, based on the results obtained, an in-depth analysis was carried out on the documents of authors from the United States and Canada. In the search equation one, focused on scenarios, 66 papers were found, and 50 papers in the search equation focused on the Delphi method. From these 116 papers, 20 were studies conducted by authors from North America. Among the most important results, the contributions against methods and techniques used for Delphi such as Delphi policy, focus groups and WEB Tool for Delphi in real-time are highlighted. In scenarios, they made contributions in serious games, game cards, imaginative narratives, and sensitivity analysis. It was also found that North America, in the sample analysed, has collaborated with 17 percent of the total of papers for scenarios, and in Delphi, 14 percent. In scenarios that take into consideration the top five countries, North America contributes 30 percent – a figure higher than the 20 percent of France, which is considered the country of origin of the scenarios. Whereas with Delphi in the top four countries, North America is the region that contributes the most, with 25 percent, equal with Japan.

Key words: *Foresight, methods, scenarios, Delphi, North America.*



Introduction

The term prospective is used to delineate from forecasts and to emphasise the exploratory nature of the processes involved. Prospective extends to both normative and exploratory approaches to future research (Schatzmann et al., 2013). According to a large number of academics and practitioners, "foresight" was born in France in the late 1950s. It was founded by the philosopher Gaston Berger, who named the discipline with the term foresight, which meaning is "to look ahead", and arose to prove that there is no need to suffer the future, but on the contrary that it can be built (Mojica, 2010). Foresight is preactive and proactive anticipation to illuminate present actions with the light of possible and desirable futures; preparing for anticipated changes does not preclude reacting to bring about desired changes (Godet & Durance, 2007).

Scenario planning is an effective foresight technique for dealing with the speed and scale of disruptive innovation, while a scenario is a vision of a possible future state of the world and its relevant environment, and the scenarios are, methodologically, stories built on future alternatives in which today's decisions could be made (Graham, Mehmood & Coles, 2015). Scenarios are a rich description of a possible future, built to explore how innovation might develop, that help to explore trajectories of potentially disruptive innovations and guide investment decisions in products or process development (Drew, 2006).

Delphi is a method of future studies that compiles expert panel assessments of specific theses or arguments related to the future through rounds of iterative questionnaires that are repeated at least twice (see, for example, Kuusi, 1999; Mannermaa, 1991 cited by Auvinen, Tuominen & Ahlqvist, 2012). In the classical approach, this method allows an efficient communication among the group of experts who remain anonymous to each other, in order to solve a complex problem. This method allows the obtaining of expert opinions that serve as an eligible contribution in making judgments about the future and solving complex problems in a situation of uncertainty (Nazarko et al, 2015).

The importance of this article lies in the analysis of evidencing the contributions of North American authors in Delphi studies and scenarios through the in-depth analysis of articles in Scopus, with emphasis on the discovery of methods and techniques used.

The questions addressed in this article are: What are the methods and techniques used by the North American authors in the papers found in Scopus on Delphi and scenarios? On what topics, sectors, and technologies are North American authors publishing in foresight, taking into consideration the Scopus database?

Theoretical Framework

Schools of Foresight

The Anglo-Saxon School

The widely known Delphi method, originating at the RAND Corporation in the United States by Olaf Helmer and Theodore J. Gordon, emerged as a tool for predicting a nuclear catastrophe case in the late 1950s, as a means of prioritising expert judgments on a topic of interest to the researcher (León and Montero 2004, cited by Cabero 2013, p. 117).

The French School

Originating at the end of the fifties, thanks to the theoretical constructions of the philosophers Gaston Berger and Bertrand de Jouvenel, the French school is based on the identification of possible futures to choose the most suitable and build it from the present. From the eighties, Michel Godet began to make foresight visible through academic prospective exercises.

The Italian School

The Italian School's maximum theoretical exponent has been Eleonora Barbieri Masini, who sustains all her work on social issues, taking into consideration aspects such as self-organisation, social resilience and collective intelligence, a public decision supported with qualitative methods (Medina, 2000; Mojica, 1998 cited by Baena, 2015).

The Delphi Method

The Delphi Method was developed at the RAND Corporation in the late 1950s and 1960s as an effective means of collecting and synthesising expert judgments. Since the first RAND study was published in 1964, the technique has been used extensively in a wide range of subjects (Celiktas & Kocar, 2010a; Banuls & Salmeron, 2008; Yuan, Chih-Hung Hsieh & Wang, 2006; Gordon & Pease, 2006; Builes & Manrique, 2000). It became popular when applied to a large-scale national technology forecast in the 1960s in the USA. (Helmer, 1983 quoted by Cuhls, 2001). It allows for expert opinions that serve as an eligible contribution in making judgments about the future and solving complex problems in a situation of uncertainty (Nazarko et al, 2015).

The Scenario Technique or Method

Scenarios are a technique or method of foresight, originated in the RAND Corporation in the 1960s. RAND employed Herman Kahn, renowned for popularising scenario planning, and since trivial predictions cannot capture such levels of complexity, the scenario technique has

gained popularity and is considered one of the central techniques of contemporary futures research (Schatzmann et al., 2013). Scenarios are a description of a possible future, built to study how innovation might develop. In addition, they help to explore the trajectories of potentially disruptive innovations and guide investment decisions in products or process development (Drew, 2006).

Methodology

Phase I.

Two search equations performed in the Scopus database with the keywords "foresight", "Delphi Method" and "scenarios", yielded a total of 116 papers. The equations used were:

TITLE-ABS-KEY (foresight W/2 scenarios) AND NOT Delphi

TITLE-ABS-KEY ("Delphi Method" AND foresight AND NOT scenarios)

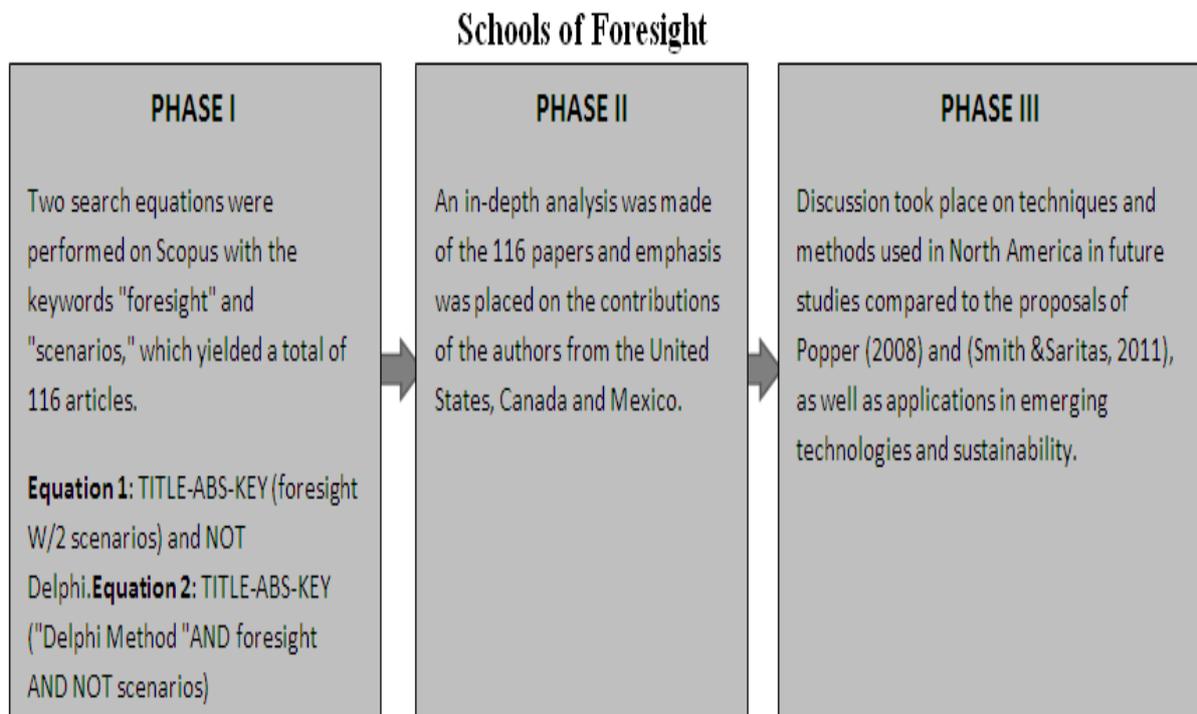
Phase II.

Papers that were directly related to authors from the United States, Canada and Mexico were selected and in-depth analysis was conducted.

Phase III.

An analysis was carried out on the techniques and methods used in North American future studies, compared with the proposals of Popper (2008) and (Smith & Saritas, 2011) and applications in sustainability.

Figure 1. Phases of the methodology



Source: Prepared by the authors

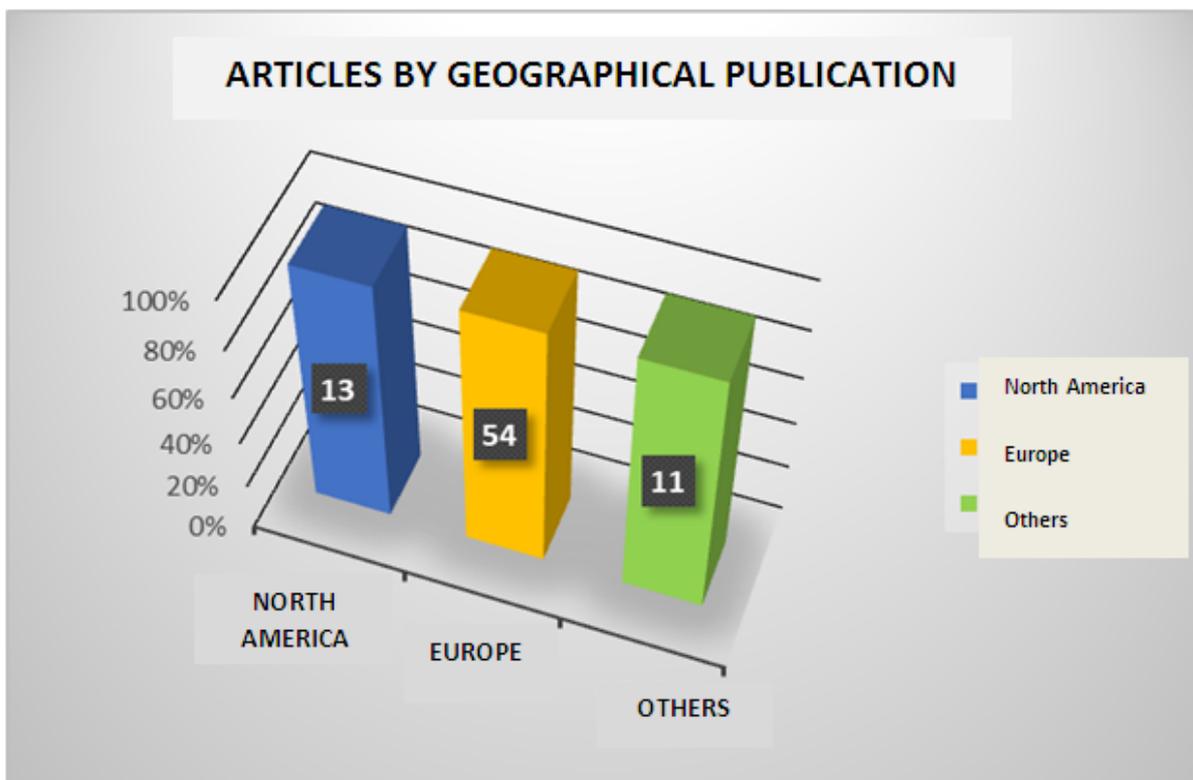
Results

Within the 116 articles, 20 articles from North American authors were identified. Of these, 18 articles from the United States and 2 articles from Canada were found, and no contribution from Mexico was found with the search equations. The most important results are summarised below.

Scenarios

Figure 2 shows the published articles on the scenario methodology by geographical location.

Figure 2. Scenario articles published by geographic location



Source: Prepared by the authors

Figure 2 shows the percentage of articles published by country; Europe concentrates the greatest number of them in Russia, France, Germany, Poland, United Kingdom, Italy, Spain, Slovenia, Austria, Netherlands, Greece, Finland, Portugal and Switzerland. Some applications of this region focus on the development of scenarios and long-term strategies for the water sector in Russia to the year 2030 (Proskuryakova et al., 2018). Others (Siedschlag & Jerković, 2017) present problem space descriptions and planning scenarios for assessing and managing security risks in a 2035 time frame to support the EU's future roles as a provider of security for

its citizens. Pospieszny (2017) defined a direction for future research related to data mining and machine learning for software estimation by proposing several use cases for prescriptive analyses aimed at improving software estimation, optimising resources, improving product quality and ultimately increasing the likelihood of successful project completion. Hussain, et al. (2017) present the combination of technological roadmapping with the scenario method in a case study on the adoption of radio frequency identification technology (RFID) in the national health service of England. Sikander (2016) critically analyses the role of scenarios in strategic foresight. Read (2016) describes a prospective study on the governance of new technologies, using nanotechnology as an example of a case. The paper from Graham et al. (2015) is related to urban supply chain management and its role in the future planning of cities, and finally Vishnevskiy, et al. (2015) discuss the development of an integrated approach to work planning and scenario planning for setting priorities of public authorities in science, technology and innovation in Russia.

Several authors from North America made contributions in the papers on scenarios. Mills (1981), for example, used mathematical models to predict the development of housing construction, starting from the approaches of perfect foresight and imperfect foresight for residential development and the evolution of the housing stock. The paper proposes a model for measuring future development with mathematical formulas. Watson (1999) mentions two studies of scenarios carried out between 1995 and 1996. The first was questioned as to whether imagining the future would be very useful in the daily application of quality, although the result of this first study resulted in the development of new technologies and quality methods, and a new strategy to build global alliances and increase the effectiveness of society's operations. The second study however, yielded significant changes earlier than expected in the Internet, cellular communications and the convergence between them in a global market. Sreenath, Vali and Susiarjo (2002) present in their paper a discussion of the Nile problem as a hypothetical situation, using a methodology to study the formulation of policies between 2000 and 2050 for the development of Egypt and the upstream country of Ethiopia, limited by growing population, increasing global pressure for economic development and annually shared finite water resources. Jovane, Koren and Boër (2003) map the different paradigms of social and market controllers that enables process technology to show a consistent paradigm development model. This model links the product and process to the appropriate business model in the footwear sector, through a mapping methodology, capable of mapping all past, present and future production paradigms. Bezold (2010) mentions the main lessons of foresight studies in the six continents, such as for governments, corporations, organisations, companies and professionals, that lead to understanding each other's needs.

Semetsky and Delpech (2011) analyse, specifically from Gilles Deleuze's unorthodox approach to epistemology, the orientation towards a creative future, and emphasise his attention to experimental changes. The emerging field of educational futures and educational research also

explores the issues of globalisation and the knowledge economy, employing methods of future studies such as scenario planning. Keppo and Van Der Zwaan (2012) analyse the uncertainties that exist about technologies such as CO₂ capture and storage, and studied a set of scenarios that cover a range of different climate objectives and technological futures.

Madaeni and Sioshansi (2013) examine the effect of delays in consumer response to price signals on the benefits of demand response in mitigating the costs of wind uncertainty. Masys, Yee and Vallerand (2015) contribute to the discourse on the "Dragon Kings" towards predictability and suppression of extreme events from all hazards through modelling and simulation. They advocate for continuous and concerted efforts to explore domains where governments and owners of critical physical and digital infrastructures can benefit from analysis, tips and exercises involving predictable and surmountable extreme events of the "Dragon-King" type with high probability and extremely high consequences, as well as the use of recent advances in the theory of complex networks, ultimately improving resistance.

Wright and Kanudia (2015) present the case of a U.S. policy regulating the presence of mercury and toxins in the air, that used a model to compare scenarios for possible restrictions on the rate of emissions and carbon quality. One of the main conclusions they came to was that carbon policy increases rapidly after air quality compliance decisions are made. Bontoux et al. (2016) developed a serious game for the application of a 2x2 matrix to help players engage in systemic thinking and create alternative futures, and create new commitments among stakeholders. The game was developed over a period of four months and consisted of ten prototyping sessions involving players from various services of the European Commission and other organisations (industry, civil society, academia, etc.). Finally, Horner et al. (2016) used quantitative metrics to trace the unique history that leads to Brazil's leadership in renewable energy and identifies a set of meta-scenarios which define the possible future carbon yield. These meta-scenarios provide a context for discussing the specific implications of energy policy both on a national scale and from the perspective of Brazil's urban centres.

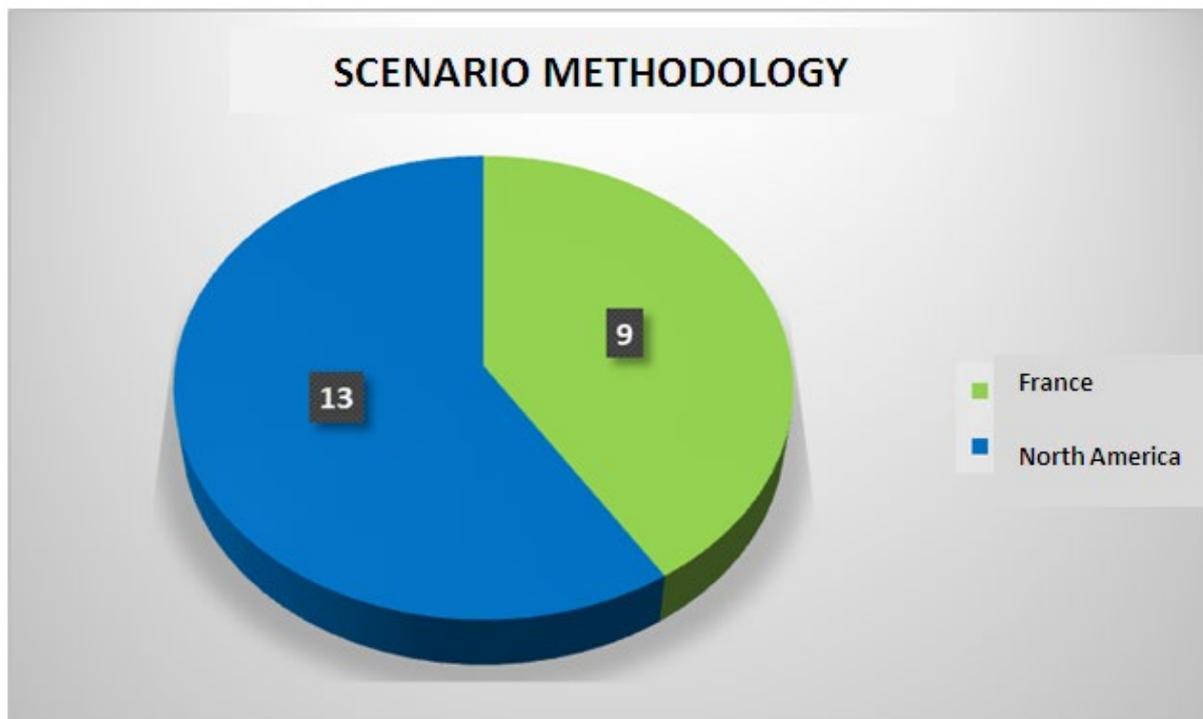
In summary, the North American authors in the papers analysed used the following methods: roadmapping, backcasting, stakeholder analysis, scenario workshop, modelling, scenario writing, and scanning.

In the "other" classification, several countries contributed: papers on short-term agricultural use of sustainably degraded peatlands in Thailand (Surahman et al., 2018); the development of possible environmental sustainability scenarios for technology management in Taiwan (Tung, 2017); and land use and food security in Tunisia in 2050 (De Lattre et al., 2017). There were papers authored on: a description of a course for future thinking skills for industry executives and research groups (Botha, 201); development of a methodology to identify technology groups critical to a low-carbon sustainable energy system in Brazil (De Oliveira et al, 2016); and future

scenarios and policy options for flood risk management Bangkok-Thailand (Nair et al., 2014). And still other contributions were found, such as: a user interface to 2030 of web-based interactive content for children and adolescents to improve their cognitive capacity (Kang et al., 2014); and one seeking to formulate a vision of the city by the age of 25 in Bulungan (North Indonesia) with a vision of "excellence in agro-industry backed by skilled human resources" by 2027 (Mahmud, 2011). North America participates with 17 percent with 18 articles from the USA and two articles from Canada; no articles by Mexican authors were found.

Figure 3 below shows the scenario articles published in France and North America.

Figure 3. Articles published in France and North America



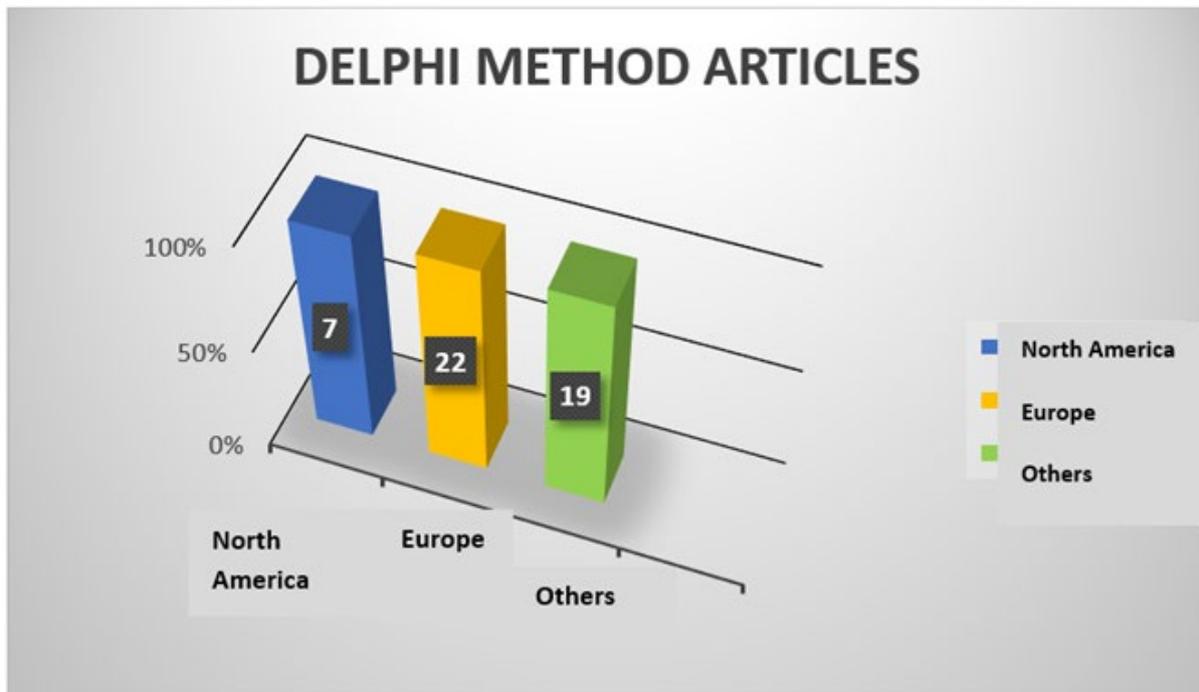
Source: Prepared by the authors

Figure 3 shows how North America outperforms France in terms of scenario papers. This is important since traditionally the scenario school had leading authors in the last decade with conceptual and practical contributions (Berger, Jouvenel, Godet), but with the search equation used in Scopus, it became evident that North America has a 59 percent of publications (four publications more than France).

Delphi

Figure 4 shows the articles published on the Delphi method by geographical location.

Figure 4. Delphi method articles published by geographical location



Source: Prepared by the authors

Graph 4 shows how Europe and countries in other regions outperform North America in the production of case studies and literature reviews on Delphi, however, between Japan, Germany, and North America the number of papers is 20, which represents the highest percentage of applications. The main contributions of European authors found in Scopus are summarised in Yesbolova et al. (2017, 2016), through the use of multiple factor analysis. The authors aimed to predict the possible development of this industry in the medium-term perspective. Prokesch et al. (2015) present in this study an electronic combination of a prediction market and the Delphi methodology in order to create a prospective support system, to identify which is the precision of the market of the sector.

Among the contributions by the North American authors, the studies of Gordon and Pease (2006) stand out in this research. The authors propose the development of a new approach to carry out a Delphi study that does not imply the use of sequential rounds and, as a result, greatly improves the efficiency of the process and shortens the time to carry out these studies, called Real-Time Delphi. Hilbert, Miles and Othmer (2009) aim to show how international foresight exercises, through online and offline tools, can make policy formulation in developing countries more participatory, fostering transparency and accountability in public decision-making.

Smith and Saritas' (2011) paper aims to produce a manual that can be easily reproduced in a suitable and portable format for managers to consult at project meetings, to design foresight processes and select methods, to fill a perceived gap in a foresight professional's toolkit. To do this it is necessary to have an overview of the main methods used in contemporary foresight and quickly and concisely, and some guidance on when and how several methods can be selected or combined within a single project or area of focus to achieve the best results. The aim of their paper is to provide an overview of the main methods used in contemporary foresight and some guidance on when and how several methods can be selected or combined within a single project or area of focus to achieve the best results.

Gary (2012) conducted a real-time Delphi survey study with members of Pentecostal Empowered-21. Their survey gave thirteen projections for the year 2020, ranging from positive statements such as "The church will experience a fresh and historic outpouring of the Holy Spirit", to negative ones, such as "There will be an increase in public moral failures among Spirit-powered leaders". The 38 participants completing the survey reached consensus on eight of thirteen projections. Mankoff, Rode and Faste's (2013) case study intended to systematically address thinking about the future, critically examine multiple potential futures, and address both negative and positive future forecasts in the field of interactive computing and technology research in general, showing how future studies can be incorporated into the Interaction with Human Computers, using the domain of sustainability as an example.

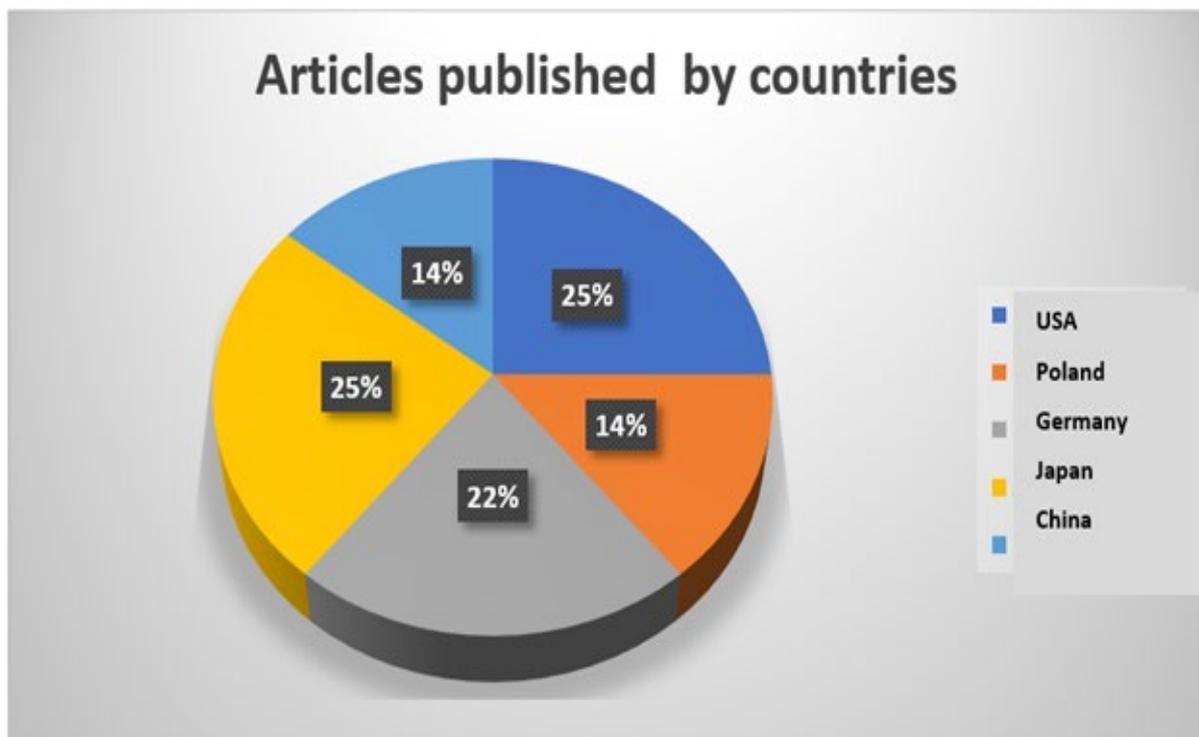
The research of Pereira, Da Silva and Soule (2017) addresses observed uncertainty through a prospective study in which policy alternatives were evaluated in terms of business model innovation, technological adaptation, and market design issues. Pereira, Da Silva and Soule (2018) also present a prospective study, using the Delphi policy method, on business model innovation, technological adaptation and alternative policies for designing a redesigned electricity market, seeking a smarter and more sustainable electricity sector.

The North American authors, in the papers analysed on Delphi, used the following methods and techniques: literature review, panel of experts, panel workshops, stimulating workshops, future workshops, Delphi Survey/questionnaire, Delphi Policy, online survey, focus groups, Delphi in real-time and web tool for Delphi in real-time. In the "others" category studies were found on: resource utilisation and collective wisdom of IT experts and other industry participants to increase the effectiveness of policies and decisions in the area (Sheydaee et al., 2017), and; collateral exploration of the classical Delphi survey method to assess the correction factor related to industrial sustainability using a real field study in Nigeria (Ibiyemi et al., 2017, 2016). Through a prospective study in Taiwan the most urgent problems were identified relating to soil conservation, water and sustainable development of water resources, all due to strong climate change (Huang & Lee, 2016). A Delphi study in the textile sector focuses on functional textiles, an emerging sector of the textile industry with high economic potential

(Eller & Naveiro, 2016); an integrated design of a technological foresight process aimed at creating a social vision of the aging society in Japan, also uses the Delphi method (Ito & Kanama, 2013), and finally; Hsieh (2013) presents a hybrid method to assess the value of the patent and determine the strategy at the initial marketing stage.

Figure 5 below shows the number of country publications on the Delphi method.

Figure 5. Articles published by country on the Delphi method



Source: Prepared by the authors

Some authors (Pereira, Da Silva & Soule, 2018; Mankoff, Rode & Faste, 2017; Gary, 2012; Smith & Saritas, 2011; Hilbert, Miles & Othmer, 2009; Gordon & Pease, 2006) highlight the existence of the Anglo-Saxon school of foresight related to consultation with experts, to differentiate it from the French school of scenarios. According to this perspective, Germany and North America participate with 47 percent of the total papers found on Delphi with the search equation in Scopus.

Discussion

To continue with the more detailed analysis of North American contributions in Scopus papers on scenarios and Delphi, two axes of discussion were chosen. One related to methods, techniques and applications in scenarios, and the other focused on methods and techniques



related to Delphi. For this purpose, comparisons were made with two studies conducted by Popper (2008) and Smith and Saritas (2011) which involve a systematic review of literature.

Methods, Techniques and Scenario Applications

This axis of discussion compares the methods for scenarios found in North American papers and those presented in a paper that includes a literature review of methods and techniques in prospective (Popper, 2008). This author uses Popper's diamond, which uses four axes related to creativity, expertise, interaction and evidence, where it groups 33 methods and techniques. The North American authors used methods such as roadmapping (Jovane, Koren & Boër, 2003), backcasting (Horner et al., 2016), stakeholders (Bontoux, Bengtsson, Rosa & Sweeney, 2016; Bezold, 2010), scenario workshop (Sreenath, Vali & Susiarjo, 2012), modelling (Madaeni & Sioshansi, 2013; Mills, 1981), scenario writing (Wright & Kanudia, 2015; Watson, 1999) and scanning (Bezold, 2010). These methods coincide with those reported by Popper (2008). However, no applications were found with other methods and techniques reported by Popper, such as: literature review, expert panel, interviews, scenario workshop, DOFA, conference/workshop questionnaire, indicators/TSA, relevance tree/logic, multi-criteria analysis, bibliometrics, simulation games, wild cards, essays/strategic planning, key/critical technologies, patent analysis, extrapolation, creative meeting, science fiction, genius forecasting, role play/actuation, citizen panel, morphological analysis, benchmarking, or PESET (political, economic, social, environmental analysis). This may be due to the fact that Popper's diamond has methods, techniques and tools of greater coverage that are not exclusive to the school of scenarios.

Table 1 shows the methods found in the papers by North American authors and their coincidence by those reported by Popper (2008).

Table 1: Methods and techniques for scenarios

Popper's Methods (2008)	Diamond	Methods found in the papers	North American Authors
Roadmapping		Roadmapping	Jovane, Koren & Boër, 2003
Backcasting		Backcasting	Horner et al., 2016
Stakeholders Analysis		Stakeholders	Bontoux, Bengtsson, Rosa & Sweeney, 2016 Bezold, 2010
Scenario Workshop		Scenario Workshop	Sreenath, Vali & Susiarjo, 2012
Modelling		Modelling	Madaeni & Sioshansi, 2013 Mills, 1981
Essay/Scenario Writing		Scenario Writing	Wright & Kanudia, 2015 Semetsky & Delpech-Ramey, 2011 Watson, 1999
Scanning		Scanning	Bezold, 2010

Source: Prepared by the authors

Table 1 shows the seven methods and techniques that coincide with those proposed by Popper (2008), such as roadmapping, backcasting, stakeholders, scenario workshop, modelling, scenario writing, scanning.

The contributions of North American authors in sustainability are summarised in table 2.

Table 2: Foresight applications in sustainability

Sustainability	
Authors	Topic/Tendency
Horner et al., 2016	Renewable energies
Wright & Kanudia, 2015	Clean energy sector
Keppo & Van der Zwaan, 2012	CO2 Capture & Storage
Sreenath, Vali & Susiarjo, 2012	Water Resource

Source: Prepared by the authors

In terms of applications, in an attempt to discover a core of specific themes or areas, sustainability studies were found, highlighting the research of Horner et al. (2016) on renewable energies, Wright and Kanudia (2015) in the clean energy sector, Keppo and Van der Zwaan (2012) on CO2 capture and storage, and Sreenath, Vali and Susiarjo (2012) on water resources. However, sustainability is addressed more broadly by countries such as France, United Kingdom, Singapore, Austria, Slovenia, Spain, Saudi Arabia, Brazil, Tunisia, Taiwan,

Thailand, Indonesia and Russia. These consist of concrete studies on: the complexity of the water management system and its future vulnerability; spatial planning of land use; insurance; flood-resistant construction; sustainability on climate change and CO2 capture and storage; development of future cities towards urban sustainability; policy options for flood risk management in Bangkok, Thailand; sustainability of water services in major metropolises; sustainable innovation policies; urban supply chain management and its role in future city planning; a sustainable low-carbon energy system; land use and food security in Tunisia; environmental sustainability for technology management in Taiwan; short-term agricultural use of relatively sustainable degraded peatlands, and: the sustainability of water systems in Russia.

Analysis of the Methods Used by the Authors Related to Delphi

Comparing the methods of Popper (2008) and Smith and Saritas (2011), new methods were found for prospective studies, shown in the following table:

Table 3: Methods and techniques for prospective studies

Methods used in prospective studies			
	Popper, 2008	Smith & Saritas, 2011	North American Authors
Methods in common	Literature Review	Literature Review	Literature Review (Pereira, Da silva & Soule, 2018)
	Expert Panel	Expert Panel	Expert Panel (Santos, Araujo & Correia, 2017; Gordon & Pease, 2006)
	Lecture / Workshop	Panel workshops	Panel workshops, Stimulating Workshops, future-oriented workshops Mankoff, Rode & Faste, 2013
	Survey	survey	Delphi Survey/survey Hilbert, Miles & Othme, 2009
	North American Authors - NEW METHODS		
New methods	Política Delphi (Hilbert, Miles & Othmer, 2009; Pereira, Da silva & Soule, 2017; Pereira, Da silva & Soule, 2018)	–	Policy Delphi
	Online (Hilbert, Miles & Othmer, 2009)		survey
	Focal groups Mankoff, Rode & Faste (2013)		
	Real-time Delphi		

(Gary, 2012)
Web tool for Delphi in real-time Gordon & Pease (2006)

Source: Prepared by the authors

According to table 3, four common methods and techniques were found, being the literature review, expert panel, panel workshops, future stimulants and Delphi/questionnaire survey. The five new methods and techniques not described by Smith and Saritas (2011) and Popper (2008) are highlighted: Delphi Policy - Policy Delphi, online survey, focus groups, Delphi in real-time and Delphi WEB tool in real-time.

Additional analysis based on WoS documents

Other search equations were used in February 2020 to complement the analysis carried out on Scopus documents and to extend the analysis documents to the Web of Science - WoS database. The equations used are shown in table 4:

Table 4: Other search equations used in Scopus and Web of Science databases

Keywords in search equations used in Scopus and WoS	Number of papers in Scopus	Number of papers in WoS	
		Same as Scopus	New
("Delphi method" AND Foresight AND NOT Scenarios).	61	21	18
Foresight W/1 Scenarios) AND NOT Delphi	59 total - 55 directly related	18	3
Foresight AND "Real-Time Delphi"	57 - directly related	3	1

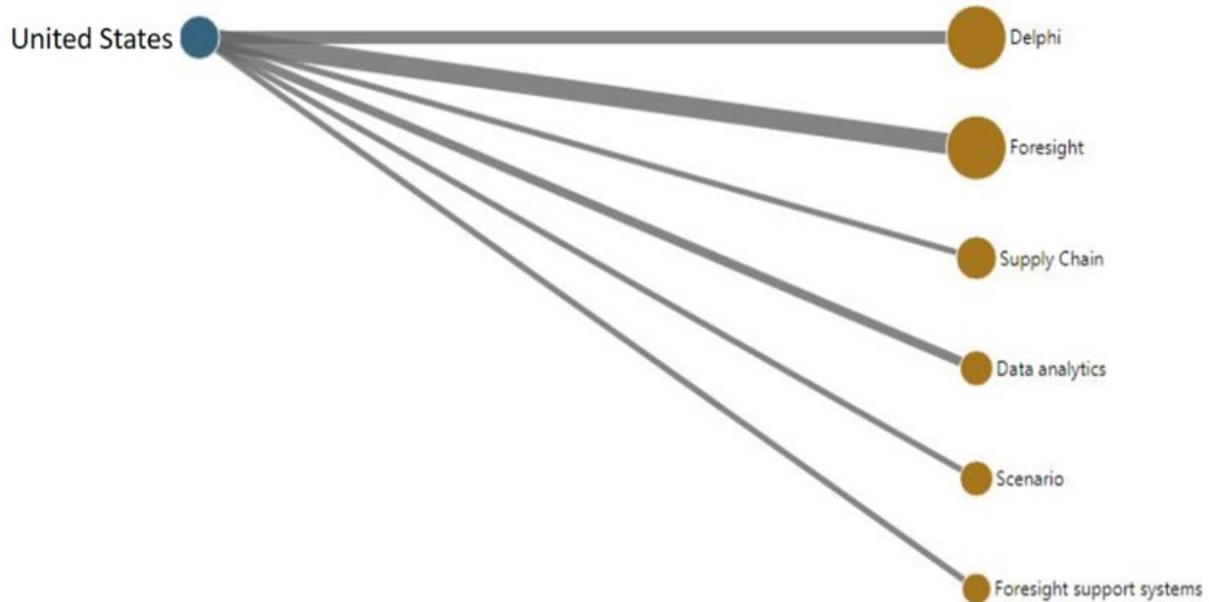
Source: Prepared by the authors

An additional aspect of the analysis chosen was Real-Time Delphi; on this axis was carried out the TITLE-ABS-KEY (foresight) AND "real-time Delphi" search equation in Scopus and Wos databases. Of the 57 documents found, 54 were directly related to "Real-Time Delphi. In the top authors by country, Germany has 22 papers, the United States 7, and the United Kingdom 7. No contributions were found from Canada and Mexico.

The topics on which American authors contributed were: supply chain, data analytics, scenarios, and foresight support systems. Highlighted from the USA are Willian Halal (Zartha, Halal, Hernandez, 2019), Elizabeth Gibson (Gibson et al, 2018), Murray Turoff and Theodore Gordon (Von der Gracht, et al, 2015), Jay (Gary, Von der Gracht, 201 5), Adam Pease (Gordon,

Pease 2006), Alan Porter (Scapolo and Porter, 2007). American authors have published publications with authors from other countries such as Spain, Germany, the United Kingdom, Poland and Colombia, among whom Von der Gracht, Bañuls, and Skulimowski are highlighted.

Figure 6. Real-Time Delphi Keywords on American Authors Paper



Source: Prepared by the authors

It was found that only one new document was obtained in WoS compared to Scopus with the "Real-Time Delphi" equation. This paper was written by Scottish authors and focused on how to design a survey for Real-Time Delphi showing six steps to be taken, as well as the elements for a Delphi survey to be substantiated and defensible.

Of the 18 documents on the "Delphi method" found on WoS with the terms ("Delphi method" and Foresight and Not Scenarios), which had not been found in Scopus, only two correspond to American authors. Tung Bui's (Ondrus, Bui, Pigneur, 2014) paper from the University of Hawaii, co-authored with authors from Switzerland and France, demonstrates the design and use of a support system for prospecting using multi-criteria decision-making methods. The study was applied in Switzerland in "mobile payments". This non-study directly related to sustainability elements and emerging technologies. The second paper found in WoS is by Murray Turoff (Turoff, 2013) of the New Jersey Institute of Technology, co-authored with authors from Belgium and Spain, which relates to multiple perspectives on emergency planning. The authors reviewed several papers focusing on disaster field planning, prospecting and mitigation; the paper is related more to sustainability than to emerging technologies.



Conclusions

In scenarios comparing the contributions of North American papers against Popper's diamond methods, the following are highlighted: serious game, game cards, imaginative narratives and sensitivity analysis. In Delphi the differentiating contributions of North America against Popper and Smith and Saritas were identified as: policy Delphi, online survey, focus groups, Delphi in real-time and WEB Tool for Delphi in real-time. Continuing the analysis on the contributions in scenarios, the North American authors have used methods and techniques similar to those proposed in Popper's diamond (2008) such as roadmapping, backcasting, stakeholders, scenario workshop, modelling, scenario writing, and scanning.

Taking into consideration the focus on the Delphi method, the North American authors have also used methods and techniques studied by Popper and Smith and Saritas, in which they highlight: literature reviews, expert panels, panel workshops, stimulating workshops, future workshops and Delphi survey/questionnaires.

In general, very few papers were found in scenarios focused on sustainability, as only four articles out of thirteen made contributions on that topic. All four papers talk about sustainability: renewable energies, the clean energy sector, CO₂ capture and storage, and water resources. Whereas authors from other countries focus on large river problems and policy formulation, socio-economic and climate change scenarios, climate objectives and technological futures, vision for the development of city-region futures, flood risk management, future planning of cities, critical technology groups for a sustainable low-carbon energy system, competitive human development objectives, meta-scenarios defining possible future carbon performance, and environmental sustainability for technology management. These studies were carried out in other countries such as Tunisia, Egypt, Ethiopia, United Kingdom, Brazil, Russia, Taiwan and Thailand.

As for the Delphi method in emerging technologies, only one article contributed on the topic, which focused on smart grids in the electricity sector. However, eleven articles focused on other emerging technologies related to nanotechnologies and information and communication technologies. In these, topics included were: robotics; mechatronics; optics and photonics; nanotechnology and its use in the processes of enrichment of natural fibres to give them multifunctional properties; technology of modification of vast fibres with plasma; data mining; nanochips and micro sensors that have control capabilities and external communications and can be integrated into the human body or move through blood vessels; small robots of a single function (small scale function) that cooperate and share tasks to achieve a more complex functionality; promoters of bone growth; technology of human-computer interaction; improved efficiency in the generation of H₂; "high -k" (high kappa) materials of high dielectric constant k; traffic control supported by satellite, and; electronic currency as a method of payment in



multimedia networks. These studies were led by Brazil, Poland, Germany, Japan, China, Spain and Finland.

This research is useful for researchers, university professors, consultants, entrepreneurs, students and decision-makers interested in future studies, since it reveals some of the techniques and methods that the North American authors use regarding the Delphi method and scenarios. It also identifies the contributions in terms of sustainability and emerging technologies either through Delphi applications, scenarios or both. Additionally, it leaves an open question related to the existence of only three prospective schools: French, Anglo-Saxon and Italian, and perhaps suggests that what is observed are applications where multiple methods, techniques and tools are triangulated independently of specific geographical areas.

REFERENCES

- Bezold, C. (2010). Lessons from using scenarios for strategic foresight. *Technological Forecasting and Social Change*, 77(9), 1513-1518.
- Bontoux, L., Bengtsson, D., Rosa, A., & Sweeney, J. A. (2016), The JRC scenario exploration system-from study to the serious game. *Journal of Futures Studies*, 20(3), 93-108.
- Botha, A. P. (2016). Developing executive future thinking skills. In *International Association for Management of Technology (IAMOT) Conference Proceedings* (pp. 951-972).
- De Lattre-Gasquet, M., Moreau, C., Elloumi, M., & Ben Becher, L. (2017). Towards a scenario 'Agro-ecological land use for diversified and quality food and a localized food system' in Tunisia in 2050. *Ocl-Oilseeds and Fats Crops and Lipids*, 24(3).
- De Oliveira, L. P. N., Rochedo, P. R. R., Portugal-Pereira, J., Hoffmann, B. S., Aragão, R., Milani, R., ... & Schaeffer, R. (2016). Critical technologies for sustainable energy development in Brazil: Technological foresight based on scenario modeling. *Journal of Cleaner Production*, 130, 12-24.
- Drew, S. A. (2006). Building technology foresight: Using scenarios to embrace innovation. *European Journal of Innovation Management*, 9(3), 241-257.
- Gary, J. (2012). Outlook 2020: Results from a real-time Delphi survey of global Pentecostal leaders. *Pneuma*, 34(3), 383-414.
- Gary, J., & Von der Gracht, H. (2015). The future of foresight professionals: Results from a global Delphi study. *Futures*, 71, 132 – 145.
- Gibson, E., Daim, T., Garces, E., & Dabic, M. (2018). Technology foresight: A bibliometric analysis to identify leading and emerging methods. *Форсайт*, 12(1), 6.
- Godet, M., & Durance, P. (2007). Prospectiva Estratégica: problemas y métodos. *Cuadernos de LIPSOR*, 104.
- Gordon, T., & Pease, A. (2006). RT Delphi: An efficient, "round-less" almost real-time Delphi method. *Technological Forecasting and Social Change*, 73(4), 321-333.
- Graham, G., Mehmood, R., & Coles, E. (2015). Exploring future cityscapes through urban logistics prototyping: a technical viewpoint. *Supply Chain Management: An International Journal*, 20(3), 341-352.



- Hilbert, M., Miles, I., & Othmer, J. (2009). Foresight tools for participative policy-making in inter-governmental processes in developing countries: Lessons learned from the eLAC Policy Priorities Delphi. *Technological Forecasting and Social Change*, 76(7), 880-896.
- Horner, N., de Paula Oliveira, A. G., Silberglitt, R., Khaled Poppe, M., & Bressan Rocha, B. (2016). Energy foresight, scenarios and sustainable energy policy in Brazil. *Foresight*, Vol. 18(5), pp. 535-550.
- Hussain, M., Tapinos, E., & Knight, L. (2017). Scenario-driven roadmapping for technology foresight. *Technological Forecasting and Social Change*, 124, 160-177.
- Jovane, F., Koren, Y., & Boer, C. R. (2003). Present and future of flexible automation: Towards new paradigms. *CIRP Annals*, 52(2), 543-560.
- Kang, B., Heo, J., Choi, H. H. S., & Lee, K. H. (2014). 2030 Toy web of the future. In *Soft Computing in Intelligent Control* (pp. 69-75).
- Keppo, I., & van der Zwaan, B. (2012). The impact of uncertainty in climate targets and CO₂ storage availability on long-term emissions abatement. *Environmental Modeling & Assessment*, 17(1-2), 177-191.
- Madaeni, S. H., & Sioshansi, R. (2013). Measuring the benefits of delayed price-responsive demand in reducing wind-uncertainty costs. *IEEE Transactions on Power Systems*, 28(4), 4118-4126.
- Mahmud, J. (2011), "City foresight and development planning case study: Implementation of scenario planning in the formulation of the Bulungan development plan. *Futures*, 43(.), 697-706.
- Mankoff, J., Rode, J. A., & Faste, H. (2013). Looking past yesterday's tomorrow: using futures studies methods to extend the research horizon, In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1629-1638). ACM.
- Masys, A. J., Yee, E., & Vallerand, A. (2016). 'Black Swans', 'Dragon Kings' and Beyond: Towards Predictability and Suppression of Extreme All-Hazards Events Through Modeling and Simulation, In *Applications of Systems Thinking and Soft Operations Research in Managing Complexity* (pp. 131-141). Springer, Cham.
- Mills, D. E. (1981). Urban residential development timing. *Regional Science and Urban Economics*, 11(2), 239-254.
- Mojica, F. (2010). Introducción a la prospectiva estratégica para la competitividad empresarial. *Programa Bogotá Emprende de la Cámara de Comercio de Bogotá*.



- Nair, S., Wen, W. K., & Ling, C. M. (2014). Bangkok flood risk management: Application of foresight methodology for scenario and policy development. *Journal of Futures Studies*, 19(2), 87-112.
- Nielsen, G. A. (1996). Preparing for change: Strategic foresight scenarios. *Radiology Management*, 18(2), 43-47.
- Ondrus, J., Bui, T., & Pigneur, Y. (2015). A foresight support system using MCDM methods. *Group Decision and Negotiation*, 24(2), 333-358.
- Pereira, G. I., da Silva, P. P., & Soule, D. (2017). Policies for an EU smarter grid environment: A Delphi study on DSOs. In *2017 14th International Conference on the European Energy Market (EEM)* (pp. 1-6), IEEE.
- Pereira, G. I., da Silva, P. P., & Soule, D. (2018). Policy-adaptation for a smarter and more sustainable EU electricity distribution industry: A foresight analysis. *Environment, Development and Sustainability*, 20(1), 231-267.
- Popper, R. (2008). How are foresight methods selected?. *Foresight*, 10(6), 62-89.
- Proskuryakova, L. N., Saritas, O., & Sivaev, S. (2018). Global water trends and future scenarios for sustainable development: The case of Russia. *Journal of Cleaner Production*, 170, 867-879.
- Scapolo, F., & Porter, A. L. (2008). New methodological developments in FTA. In *Future-oriented technology analysis* (pp. 149-162). Springer, Berlin, Heidelberg.
- Schatzmann, J., Schäfer, R., & Eichelbaum, F. (2013). Foresight 2.0-Definition, overview & evaluation. *European Journal of Futures Research*, 1(1), 15.
- Semetsky, I., & Delpech-Ramey, J. A. (2011). Educating gnosis/making a difference. *Policy Futures in Education*, 9(4), 518-527.
- Smith, J. E., & Saritas, O. (2011). Science and technology foresight baker's dozen: a pocket primer of comparative and combined foresight methods. *Foresight*, 13(2), 79-96.
- Sreenath, S. N., Vali, A. M., & Susiarjo, G. (2002). The Nile River Problematique: An integrated look at the future of Egypt and Ethiopia. *Water International*, 27(4), 517-531.
- Surahman, A., Soni, P., & Shivakoti, G. P. (2019). Improving strategies for sustainability of short-term agricultural utilization on degraded peatlands in Central Kalimantan. *Environment, Development and Sustainability*, 21(3), 1369-1389.



- Tung, C. M. (2016). Using scenario analysis to manage the strategic technology planning for environmental sustainability issues in Taiwan. In *2016 Portland International Conference on Management of Engineering and Technology (PICMET)* (pp. 66-73). IEEE.
- Turoff, M., Hiltz, S. R., Bañuls, V. A., & Van Den Eede, G. (2013). Multiple perspectives on planning for emergencies: An introduction to the special issue on planning and foresight for emergency preparedness and management. *Technological Forecasting & Social Change*, 80, 1647-1656.
- Von der Gracht, H., Bañuls, V., Turoff, M., Skulimowski, A., & Gordon, T. (2015). Foresight support systems: The future role of ICT for foresight. *Technological Forecasting and Social Change*, 97, 1 – 6.
- Watson, G. H. (1999). Back to the future-'Foresight 2020'offers scenarios for quality's next 20 years. *Quality Progress*, 32(12), 41-47.
- Wright, E., & Kanudia, A. (2015). Highly detailed times modeling to analyze interactions between air quality and climate regulations in the United States. In *Informing Energy and Climate Policies Using Energy Systems Models* (pp. 223-246).
- Zartha, J., Halal, W., & Hernandez, R. (2019). Delphi method: analysis of rounds, stakeholder and statistical indicators. *Journal Foresight*, 21(5), 525-544.