Universidad de Valladolid

Escuela de Doctorado Universidad de Valladolid

PROGRAMA DE DOCTORADO EN

Escuela Técnica Superior de Ingenieros de Telecomunicación

Departamento de Teoría de la Señal y Comunicaciones e Ingeniería Telemática

TESIS DOCTORAL

DETECTION, ANALYSIS AND COMMUNICATION OF EMERGING PHENOMENA

Presentada por Javier Carbonell Pérez para optar al grado de

Doctor por la Universidad de Valladolid

Dirigida por:

Dr. Antonio Javier Sánchez Esguevillas

Dra. Belén Carro

Gracias a mi mujer Carmen y a mis hijos Diego y Sofía por haber estado a mi lado y apoyarme cuando flaqueaban las fuerzas. Ellos son los que han sufrido mi dedicación a la realización de este trabajo sin quejarse nunca por ello.

Gracias a mis padres José y Conchita y a mis hermanos José María y Eva, porque es en la familia donde he aprendido los valores del esfuerzo y la ilusión por conocer cosas.

Gracias a Valentín Conde por creer siempre en mí y por abrir mi mente a campos de conocimiento más allá de la ingeniería.

Gracias a mis directores de tesis Antonio Javier y Belén por saber motivarme, por su paciencia y por su buen hacer en la dirección de este trabajo.

Gracias a todos los que han contribuido en mi formación académica: Hermanos de la Salle, Departamento de Organización Industrial de la Universidad de Valladolid, Instituto de Empresa y Departamento de Teoría de la Señal y Comunicaciones e Ingeniería Telemática.

Gracias a todos los amigos con los que he conversado sobre los temas tratados en este trabajo: Javier y Mabel en cenas; Alberto, Paco, Adolfo, Edwin y José tomando algo; Julio, Nuria, Ana J., Ana P., Alvaro… alrededor del café matutino; José, Alfonso, Daniel V., Daniel G., Daniel B., Jesús… en comidas laborales; Abelardo en innumerables paseos; Javier y Elena en excursiones y numerosas sesiones de cine. En estas conversaciones aprendí muchas cosas y fui perfilando muchos detalles que han sido valiosos para dar forma a este trabajo.

INDICE

I. RESUMEN

El estudio del futuro, "foresight", o la realización de prospectivas es una disciplina que se ha ido forjando a lo largo del siglo XX y que en este siglo XXI está viviendo su auge particular. Así, en la actualidad grandes organizaciones internacionales tienen sus propios grupos de trabajo orientados alrededor de dicho concepto, como ocurre en la Unión Europea (European S&T Foresight Knowledge Sharing Platform), en la OCDE (OECD Technology Foresight Fora) o en la ONU (UN Millenium Project). Se trata de equipos de trabajo que, dada la dimensión de sus organizaciones y la singularidad de su actividad, generalmente funcionan como unidades funcionales autónomas y de las cuales el observatorio se puede considerar el ejemplo más representativo. Este interés por tratar de vislumbrar como pueden desarrollarse los acontecimientos para entender lo que nos puede deparar el futuro no se reduce a las grandes organizaciones internacionales, sino que cada vez es más común en organizaciones de menor envergadura. Así, empresas de diferentes tamaños, organizaciones sectoriales o administraciones de ámbito más local, están también empezando a incluir entre sus actividades estratégicas considerar el futuro de forma que puedan prepararse con antelación ante los nuevos desafíos.

Acorde con este nuevo interés en anticiparse a los cambios, se están empezando a desarrollar un gran número de metodologías y modelos para armar un marco teórico que permita el desarrollo de una disciplina asociada al "foresight" o prospectiva de forma rigurosa. El desarrollo de este marco conceptual y teórico es fundamental ya que permite madurar las metodologías, contrastar su validez, y crear un grupo de expertos en este campo que utilicen planteamientos afines y puedan colaborar en diversos proyectos. No obstante, la mayoría de las metodologías, que se utilizan en este campo no tienen un grado de madurez adecuado e incluso hay confusión respecto a la verdadera naturaleza de la mayoría de los conceptos.

Esta tesis doctoral trata de realizar su contribución al desarrollo de la teoría y metodologías que se utilizan en el mundo del "foresight", mostrando aplicaciones prácticas mediante el desarrollo de casos de estudio. Se ha realizado mediante el formato de compendio de artículos publicados en revistas indexadas JCR. Cada artículo aborda un problema diferente dentro de la teoría y práctica del "foresight" aunque existe una línea argumental que les da coherencia.

El primer artículo de este compendio, "Valorando fenómenos emergentes. Los enfoques interno y externo", se centra en el estudio de los fenómenos emergentes y analiza los diferentes enfoques que se han desarrollado para valorarlos. El primero es el enfoque externo que recurre al concepto de señales débiles o weak signals, y también a las trazas que los fenómenos dejan en Internet y que pueden ser medidas con el uso de un buscador común. El segundo es el enfoque interno y se refiere a los factores relacionados con la interpretación, como cultura y las metáforas reinantes en la sociedad, aspectos aparentemente no visibles pero que tienen una gran importancia en la evolución de los fenómenos emergentes. Este primer artículo muestra los planteamientos y los conceptos que serán utilizados y desarrollados con mayor detalle más adelante.

El segundo artículo, "El papel de las metáforas en el desarrollo da las tecnologías. El caso de la inteligencia artificial", ahonda en el enfoque interno comentado anteriormente y muestra el papel

que tienen las metáforas en la forma en la que se conceptualiza el mundo y en concreto las tecnologías emergentes. Para ello recurre a los estudios de Lakoff y Johnson sobre las metáforas como mecanismo de conceptualización y estudia su relación con la metodología CLA propuesta de Sohail Inayatullah, ampliamente utilizada en el terreno del "foresight" y que considera a las metáforas reinantes en la sociedad en el estudio de su comportamiento y por lo tanto de su evolución. Este trabajo recurre al análisis de diversas tecnologías emergentes a lo largo de los últimos años para estudiar las interrelaciones entre las metáforas utilizadas para conceptualizar las tecnologías y su posterior evolución, llegando a la conclusión de que existe un camino de doble sentido, las metáforas existentes en la sociedad influyen en la evolución de las tecnologías y la evolución de las tecnologías hace redefinir las metáforas que existen en la sociedad. Este hecho muestra un gran potencial para plantear escenarios sobre la evolución de las tecnologías, capacidad que es desarrollada con el caso de estudio de la inteligencia artificial.

El tercer artículo "Del análisis de datos a la creación de historias en la creación de escenarios. Un enfoque semiótico para la escritura de historias acordes a un propósito", continúa profundizando en la creación de escenarios como herramienta de "foresight". En este caso se centra en la fase de comunicación y trata de enlazar los estudios analíticos que se incluyen en las primeras fases de la realización de escenarios con la creación de historias, que son generalmente la forma en la que los escenarios llegan a su público objetivo. Este trabajo vuelve a resaltar la importancia de la interpretación como base fundamental para entender el proceso de creación de escenarios y recurre a los principios semióticos de Charles Sander Peirce para tratar de modelar el paso de la fase analítica a la creación de historias, de forma que dichas historias se adapten al propósito y audiencia. Todo este análisis culmina en la creación de una metodología para facilitar todo este proceso y poder mantener la trazabilidad de la información y dos casos de estudio en el que se aplican estos principios y metodología.

El cuarto artículo, "Facilitando la valoración de tecnologías emergentes por los observatorios tecnológicos. Descubrimientos sobre los patrones de diseminación de las tecnologías emergentes en Internet", utiliza el enfoque externo esbozado en el primer artículo y lo amplía hasta la creación de un modelo de 30 variables de diferentes ámbitos (académico, industrial y público en general) para valorar la madurez de los fenómenos emergentes. Este modelo es probado con las tecnologías incluidas en el Hype Cycle de Gartner del año 2015, muestra sobre la que se realizan diversos estudios estadísticos que permiten analizar la propia coherencia del modelo y las relaciones entre variables. Estos análisis aportan contribuciones al conocimiento del proceso de difusión de tecnologías emergentes.

Este resumen muestra como cada artículo presenta contribuciones en diferentes actividades y etapas de los procesos de "foresight". No obstante, no se trata de estudios desconectados, sino que muestran una gran coherencia argumental, en los enfoques que se utilizan y en los modelos y herramientas que en los que se fundamentan.

II. INTRODUCTION

1 RESEARCH OBJECTIVES

The necessity to better understand the environment and its possible lines of evolution in an increasingly competitive world is rising the interest in foresight, both in the academic and the practitioner environments.

This growth in the interest for foresight has been accompanied by a significant progress in the development of theories and methodologies. Nevertheless, at present, there is not a consensus about how to use them, which is more adequate for each context, or even where their limits are. In addition, the foresight process is complex and goes from the identification of emerging issues to the forecasting and communication of future scenarios. Thus, forecasting cannot be considered as a stand-alone discipline, but as a mix of disciplines in which diverse fields of knowledge converge.

This is the context in which this thesis is devised, and its aim is to dive into the topics that are central to the foresight process and understand the different approaches that are used to cope with them, their validity and their limits.

The detection of "emerging issues" is one of the most difficult activities in foreseeing. It is also a central topic in any foresight activity and consequently, its understanding is crucial. For that reason, in its first stages, this thesis aims to give answers to questions, such as **What is an emerging issue? How can it be detected? Are emerging issues set objectively in the environment, or are they our construal? If they are a construal, is it possible to obtain objective measures of their maturity?**

These questions do not have simple answers, and a holistic perspective, including apparently distant disciplines, such as linguistics, philosophy, or psychology, is required. This thesis turns to these different disciplines to find answers to these questions.

Foresight is considered as a continuous process along this thesis and for that reason it copes with questions related to its different phases: **How do we conceptualize new phenomena? How does this conceptualization influence the creation of scenarios about the future? How can we communicate these scenarios to produce a desired effect?**

Due to the fact that this thesis was developed in the Telecomm Department at the University of Valladolid and that the doctoral candidate was working in the Telefónica Strategy Department, emerging issues were reduced to emerging technologies in particular. Nevertheless, procedures and results can be adjusted to other fields.

2 SURVEILLANCE AND FORESIGHT: CONTEXT OF THIS DISSERTATION AND LITERATURE REVIEW

2.1 Foresight as a subject of research

The study of the future or foresight has been forged along the 20th century. Initially, this labour was carried out by some experts with different backgrounds that acted as visionaries and relayed more on their experiences and intuitions than in any kind of methodology. H. G. Wells, author of the book Anticipations [1] , which was published at the dawn of the 20th century is recognised as the first "futurist" and gave birth to the "future history" (Parrinder, 1995). Another important milestone was the development of the scenario approach for the first time in the 1950s by Herman Kahn for military purposes. Nevertheless, due to the nature of this work that implied confidential information, his methodology was not widely publicised until 1961 in the book entitled On Thermonuclear War (Kahn, 1961).

The work of Bertrand de Jouvenel during the middle of the twentieth century supposes a substantial advance in the study of the future in a more rigorous way: he defined a conceptual framework for thinking about the future, analysed methodologies and other features, and even introduced the concept of "industrialization" in the foresight field. These reflections were embodied by his book The art of conjecture (De Jouvenel, 1967) and subsequently in the journal Futuribles[2].

These initial small beginnings in the development of methodologies and maturation of theories have given place to an intense intellectual activity placing foresight as a recognised subject of research. This fact is corroborated by an intense activity done by organisations and by the launching of several journals during the last decades to foster the debate on foresight methodologies and to propose practical case studies in this field. The first journals launched with this intention were Futures (launched in 1968) and Technological Forecast and Social Change (1970). More recently, other journals such as the Journal of Future Studies (1996), Foresight (1999) and World Futures Review (2009) have promoted this debate.

Thus, foresight field is living an important burst at both research and practise levels in the moment of the elaboration of this dissertation. Nevertheless, there is still an important lack of research in the formalization of theories in this field, as it is explained in the different papers that this thesis is based on. For instance, with respect to the detection of signals in an early stage of a new phenomenon or weak signals (the first step in most foresight models), there is not a general consensus about its limits and some authors even consider the terms "weak signals" and "trends" as synonymous (Groddeck & Schwarz, 2013). The same lack of consensus is observed with respect to the nature and limits of many other concepts, tools and procedures in the foresight field. For instance, regarding scenarios,

[1] Anticipations of the reaction of mechanical and scientific progress upon human life and thought. H.G. Wells, London: Chapman & Hall, Id, 1902

[2] https://www.futuribles.com

probably the most theorised and used foresight tool, there is not a consensus about typologies, terminologies or even its utility (Wilkinson, 2009), and the general opinion among experts is that the scenario field remains under-theorized (Wright et al., 2012).

Therefore, it can be stated that at present, research in the foresight field is undergoing a great deal of activity with a many institutions and a significant amount of research devoted to it. Nevertheless, there is still a low level of maturity in the development of theories that resembles the situation of other disciplines within the social science or economy from one century ago.

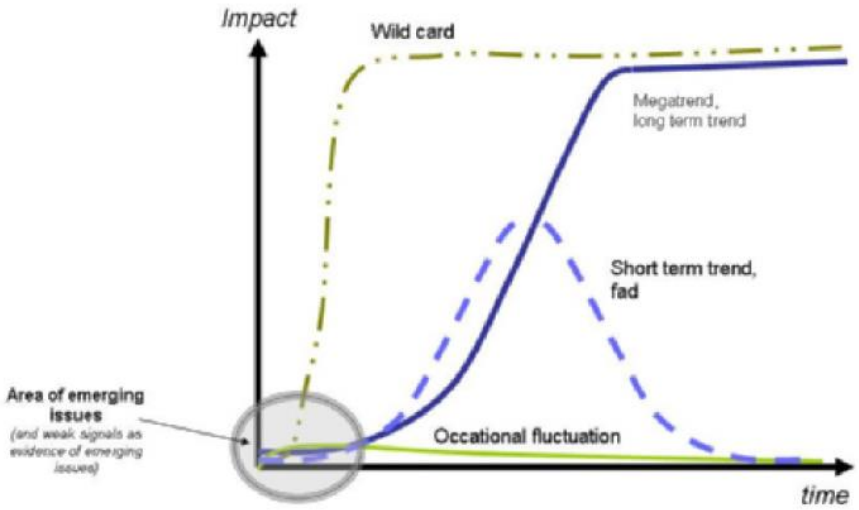
2.2 Emerging issues and their life-cycle

The environment is always changing with new phenomena appearing constantly. Emerging issues refer to these phenomena at very initial stages. The idea of emerging issues was first introduced by Molitor in the late 1950s and early 1960s and developed in his article "How to anticipate public-policy changes" (Molitor, 1977), "…at bottom are certain structural forces that gain momentum over time and give rise to what I term issue environments". Molitor oriented his activity to public-policy and he thought that these authorities should remain vigilant to these new phenomena in order to prepare the new regulation in advance. He continued exploring this concept in later works (Molitor, 1981, 2003).

Nevertheless, as it happens with other terms in the foresight arena, there is not a consensus about the real extent and nature of the emerging issues, and this concept is usually mixed with other terms such as weak signals, wild cards, trends, megatrends. (Hiltunen, 2010; Coffman, 1997; Heijden, 1997).

In this thesis "being in an early phase" will be considered as the distinctive feature that differentiates emerging issues from other concepts referred to forthcoming changes, as shown in.

Figure 1 Emerging issues and their relation to other foresight concepts about forthcoming changes



Source: Hiltunen (2010)

Although many approaches and appreciations about main foresight terms can be found in the literature, Saritas and Smith (2010) definitions are very consensual and are more commonly used in this field.

Table 1 Foresight main terminology

Trends	Are those change factors that arise from broadly generalizable changes and innovation.
Drivers of change	Are those factors, forces or events – developments which may be amenable to changes according to one's strategic choices, investments, R&D activities or foresight knowledge and strategies.
Wild Card	Are those surprise events and situations which can happen but usually have a low probability of doing so – but if they do their impact is very high.
Discontinuities	Discontinuities are those situations – impacts where over time and extending beyond single events, change is rapid and fundamentally alters the previous pathways or expected direction of policies, events and planning regimes.
Weak Signals	They refer to the early signs of possible but not confirmed changes that may later become more significant indicators of critical forces for development, threats, business and technical innovation.

Source: O. Saritas y J.E. Smith (2010)

Understanding the life cycle of emerging issues is key to foresee their evolution and to assess their maturity. Molitor associates this life cycle to a more or less regular S curve or life cycle in which

the different phases are linked to different types of media and public (Molitor 1977, 2003). This idea was also followed by other researchers like Wygant (1988).

At present, most of the models consider that the dissemination process of information related to emerging issues follows a growth curve, mainly any variation of S-curve, like Fisher-Pry and Gompertz. The initial focus of these curves was oriented to substitution and mortality processes and, for that reason, their use is not completely adaptable to emerging phenomena for most of which the final potential is not even intuited. Consequently, although research associating emerging issues and S curves is copious, it is necessary to highlight some limitations that can be found in the literature:

- Fisher-Pry curves are valid from 2% substitution threshold on (Lenz & Lanford, 1972).
- Models giving best fit to the historical data, as measured by mean square error, were in general not the best forecasting models (Martino, 2003).
- If the upper limit is not known, neither the logistic nor the Gompertz, nor any of their variants performs very well (Martino, 2003).

2.3 Assessing emerging issues: weak signals and internal motivations

Detecting and assessing emerging issues is a central aspect to any foresight activity. For that reason, the search of criteria that can help in the achievement of this goal is one important objective for the researchers of this community. The most traditional approaches turn to studying the strength and patterns of its signals dissemination with that intention. In this sense, Molitor's research about public policy is considered the first well-recognized model and lays the foundations for the study of the emergent phenomenon life-cycle. His model depicts the process of dissemination in two axes: the X-axis indicates the movement from intellectual environments to more mainstream ones such as literature or organisations, to end up reaching the governments; the Y-axis indicates that the strength of signals follows an S curve pattern (Molitor, 1977). This is in line with the generally accepted idea expressed previously that any emerging issue "sends out" some signals, which in their early stages are called "weak signals". The other most extended model to assess emerging phenomena based on weak signals is the one proposed by Igor Ansoff, who presented the first version of this idea in 1975 (Ansoff, 1975) and developed it later (Ansoff, 1984). At present this concept is commonly used in the foresight field, sometimes with some adaptations (Holopainen & Toivonen, 2012). Ansoff's model uses a classification of 5 levels according to the signal level of concreteness: (1) Sense of threat/opportunity, (2) Source of threat/opportunity, (3) Threat/opportunity concrete, (4) Response concrete, (5) Outcome concrete.

Both Ansoff and Molitor's models imply an underlying dissemination process of signals before an emerging issue rises. Nevertheless, both models present important differences in their proposals (Table 2).

Table 2 Molitor and Ansoff's signals approaches

	Molitor	Ansoff
Research field	Public Policy	Organizations strategy
Research Aim	Development of public policies in advance	Strategy response in organizations
Emerging Issue approach	Environmental issue	Strategic issue
Strength of signals	Classification according to the whole life cycle	Weak and Strong signals. Five levels
Underlying concept of maturity	Level of dissemination (from elites to the mainstream)	Level of concreteness
Dissemination mathematical model	S-curve	No model

Source: Own elaboration.

In addition to this tendency to analyse the external footprint of emerging issues, there is another important line of thought that minimises the capacity of external aspects to capture the essence of an emerging issue, moving the importance to the study of internal aspects and their interpretation. This matches Peirce's semiotic point of view that remarks the importance of interpretation in the signification process.

In the foresight arena, the most relevant model that considers the deep motivations when analysing trends or emerging issues is the CLA (Causal Layered Analysis) (Inayatullah, 1998). It offers a post-structuralism point of view that turns to Michael Foucault's vision of hidden powers and motivations. CLA considers four layers when analysing any phenomenon. The first level, litany, refers to facts or news as they appear in the media. Weak signals are included in this layer, but they are only the visible part of the emerging issues. The other layers (systemic causes, discourse/worldview, myth/metaphor) dive in the deep motivations that move the behaviours and condition the evolution of emerging phenomena. The analyst must go through the different layers in order to fully understand a problem or situation to use this framework, and for that reason, applying this method requires experience and the access to case studies developed by experts. In this regard, the book CLA 2.0 Transformative Research in Theory and Practice gathers the best practices and case studies using this methodology so far (Inayatullah & Milojević, 2015).

2.4 Emerging technologies

Emerging phenomena referred to technologies in their initial stages are called emerging technologies. Nevertheless, the definition and nature of this concept are not clearly delimited. Porter et al. (2002) emphasise their potential on the economy and society, while others focus on their uncertainty (Boon & Moors, 2008) or their novelty and growth (Small et al., 2014). In recent times a rich debate has been held by the research community in order to clarify the boundaries and the main features of the emerging technologies. Rotolo et al. (2015) gives a comprehensive vision of the emerging technologies nature mentioning five features to define them: (i) radical novelty, (ii) relatively fast growth, (iii) coherence, (iv) prominent impact, and (v) uncertainty and ambiguity.

Martino (2003) proposed also a life cycle for the dissemination of emerging technologies, associating the stages with different fields of knowledge and media sources as well. This model proposes that a technological innovation begins with basic research that is associated with scholars, continues with industrial development that is associated with patents, and ends up with a mainstream social impact that is associated with popular press.

2.5 The environment surveillance: the necessity to develop filters

Getting an in-depth understanding of the environment and its changes is one of the main goals of any organisation, mainly when it is necessary to make decisions with long-term implications, i.e. with a strategic nature. In this context, foresight capability is considered essential for any organisation to be successful (Hines, 2003), which explains why corporate foresight, "the art of the long view", has gained a relevant position in innovative organisations (Schwartz, 1991). Implementing this kind of view in organisations is non-trivial as it requires processes to quickly capture the main trends and change drivers in the environment.

For this reason, a high number of methodologies and theories intending to manage environments of uncertainty have been developed during the last century. The initial models presupposed that it was possible to predict the different alternatives that could happen in the future. These alternatives, usually called "states of nature", are defined as "exhausted and mutually exclusive lifting of those aspects of nature which are relevant to this particular choice problem and about which the decision-maker is uncertain" (Luce & Raiffa, 1958). These models -from which Maximax, Maximin and Laplace's criteria are the most commonly used- manage the uncertainty by estimating a probability for each of the alternatives without questioning their number and nature. They are widely used in planning and construction of scenarios, but during the last years, it has been made clear that organisations cannot continue supposing that they know all the possible future states of nature. For that reason, it is becoming increasingly necessary for organisations the implementation of processes to detect those new phenomena that can affect them in their initial phases. An important research activity about these phenomena, named in a generic way as "emerging issues" is being developed and covers their nature, their detection and their classification.

This activity of capturing issues that can affect organisations is called horizon scanning or environmental scanning, and is one of the tasks that any company has to deal with at some point. One of the first definitions of scanning was "an activity to acquire information" (Aguilar, 1967). This information is gaining importance as it helps focus the strategic and tactical decisions in companies (Albright, 2004). Although there are many methodologies to do this scanning available in the literature such as STEEP (social, technological, economic, environmental, political) or PEST

(political, economic, social, technological), this process suffers from a lack of formalisation. Although there are some attempts to formalize the application of these methods in the strategic analysis (Ho, 2014a), at present, its implementation depends too much on each organisation's work methods and usually fails to understand it as a whole.

Thus, the design of structures and methods to capture and filter properly these phenomena as far in advance as possible is a necessity, which supposes the introduction of the concept of filtering. Igor Ansoff (1984) divided this filtering activity into several levels. Firstly, the surveillance filter, at the environment level, has the objective of filtering the information that enters into the organisation. Later, inside the company, mentality and power filters let pass only the most outstanding information that can be useful to make appropriate decisions.

The gratest difficulty in defining and deploying these filters lies in their subjectivity: a signal can mean something for one actor and lack interest to others because ''Cognitive systems interact with their environments, but it is the cognitive system – and not the environment–that determines how and in what way it interacts" (Seidl, 2004). This is because they depend ultimately on internal cognitive knowledge structures of actors (employees, organisations, etc.). This situation is more common in the cases of unexpected signals as is the case of a weak signal, which is by definition unstructured information and its implications to the organization are at an early stage very hard to define (Ilmola & Kuusi, 2006)

From these three filters, the first one defines what information enters into the company, and for that reason, it acts as the sensor of the organisation with the environment. Thus, its capacity to capture the relevant importance (at least relevant to its cognitive knowledge structures) is critical for the well-functioning of the company as a system. For that reason, sophisticated models about the filters that companies use to deal with the environment have been developed (Ho, 2014b).

2.6 Surveillance structures and observatories

Foresight activities tend to be complex to manage and integrate with the traditional activity of organisations, this is why large institutions are setting initiatives to cope with them. For instance, the European Union that fostered the initiatives "European S&T Foresight Knowledge Sharing Platform[3]" within its policy to enhance the research and innovation in the 6th Framework Programme, and the European Science and Technology Observatory[4]. The OCDE is also carrying out a great number of foresight works about a wide range of issues in different geographical zones and have settled with that intention the OECD Technology Foresight Fora[5] as a space to centralize those studies. At a more global level, the UN Millenium Project[6] backed by United Nations is an initiative that has the goal of monitoring and proposing actions to enforce compliance with the general objectives of the planet on development.

---

[3] http://forlearn.jrc.ec.europa.eu/guide/0_home/about.htm

[4] http://orbit.dtu.dk/en/projects/european-science-and-technology-observatory-esto(0ce24300-6619-4770-a49b-1349f2deac62).html

[5] http://www.oecd.org/internet/ieconomy/oecdtechnologyforesightfora.htm

[6] http://www.unmillenniumproject.org/

The same situation occurs in the administrations, business lobbies and industrial sectors. A growing number of companies are setting specific foresight initiatives or including foresight structures in their strategy departments, i.e. Ericsson, Deutsche Bank, Telefónica, etc. The environment scanning intended to detect "emerging issues" and assess their future impact in the company is a key activity in all of them.

This necessity of structures to scan the environment and carry out other foresight activities was already considered some decades ago. Thus, the model of viable organisations proposed by Stafford Beer (1972) set a subsystem, the subsystem 4 named "intelligent subsystem", in charge of environment surveillance to obtain relevant information to prepare the organisation for external changes.

At present, there is an intense debate about how these structures should be set up and wheter they should be separated units from the rest of the organisation (Battistella, 2014). Diverse models about these structures can be found in the literature and the observatory is gaining importance among them. The observatory is defined as an organisational model that includes specialised tasks addressed internally that can be distinguished from other kinds of units such as think tanks or outsourcers because of culture and management style (Daheim & Uerz, 2008).

2.7 Scenario building

The term "analysis of scenarios" was coined in the 1950s by Herman Kahn as a planning tool to be used in the military field. After that moment, there has been a quick development of methodologies and approaches in the academic and corporate environments and is currently considered a relevant tool for management activities, mainly for those related to strategy and strategic foresight. This interest has led to the development of a number of scenario methodologies and techniques. The boom in the utilisation of the scenario approach is reflected in the high activity in the academic field with several books published, some of them bestsellers (Heijden, 2005; Schwartz, 1991), some theses (Gordon, 2013) and papers compiling and classifying the most relevant methodologies. (Börjeson et al., 2006; Bishop et al., 2007; Amer et al., 2013).

There are many scenario definitions, but they all include to some extent the intention to describe a situation. For instance, the following definitions can be found in the literature: "A description of a 'possible future' based on a set of mutually consistent elements, within a framework of specified assumptions. It will typically encompass both quantitative and qualitative elements" (Foster, 1993), "Internally consistent and challenging narrative descriptions of possible futures (Heijden, 2005)", "An archetypal description of a possible future based on a mutually consistent grouping of determinants (Beck, 1982)", among others.

The possibilities and connections between scenarios in other realms besides strategy have been widely studied, for instance referred to cultural theory (Inayatullah, 2009), to learning environments (Steckelberg, 2015) or to design practice (Selin et al, 2015).

Although purposes, orientations and methodologies of scenario development are varied, they typically include two kinds of activities. In the first group, those activities focused on understanding the environment, context of the organization, studying the evolution of some variables, etc. These activities have a logical, conceptual or mathematical nature. In the second group, activities are

related to the process of describing and communicating the scenario. They have a narrative nature and the resources used to implement them can go from story writing to the elaboration of videos or even films.

3 THESIS FRAMEWORK

The modality of this thesis is the compendium of publications in JCR-indexed journals in the foresight field, in this case three papers published in the journal Futures and one in the journal Technology Analysis and Strategic Management. These papers try to contribute to the foresight theory seeking to address traditional problems for which the present theory does not offer a conclusive answer.

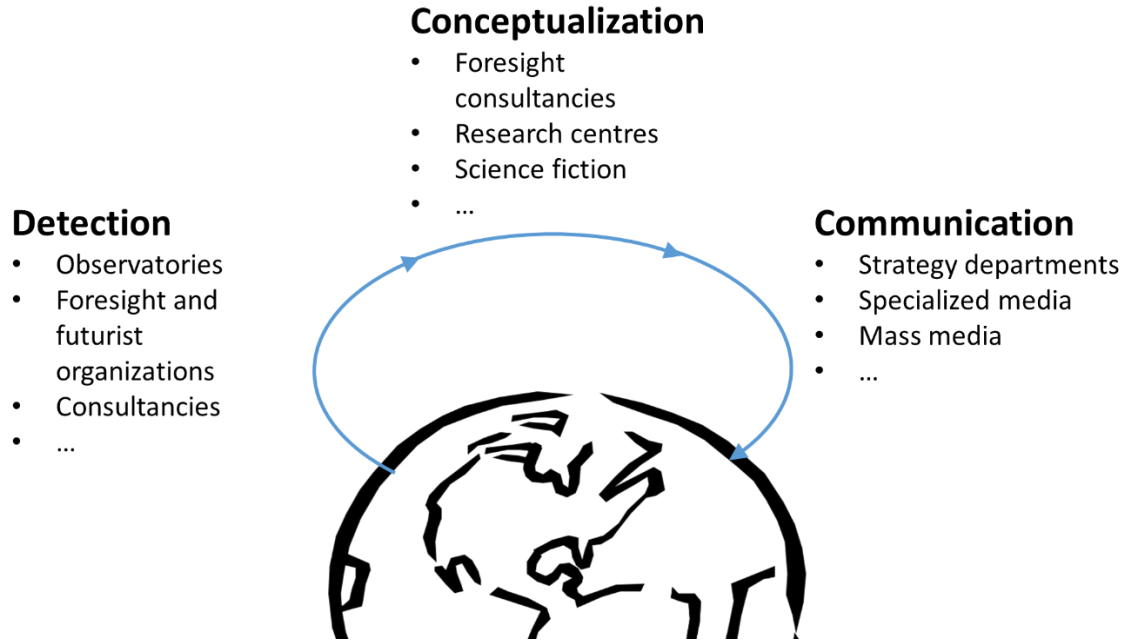
This work is not oriented to a specific and unique activity within the foresight process but to the whole process. In this sense, it considers foresight from an end-to-end point of view and each paper is focused on one stage of the process. In spite of this breadth in the scope, all papers maintain an important and multiple consistency: in the methodology employed, the foresight tools and the approach followed. For that reason, although each paper copes with a different problem, there is an internal link among them that unifies the work.

The practice of foresight embraces many processes, methods, tools and kinds of activities that usually show a lack of maturity. Consequently, each organisation implements its own variations of the methodologies and processes. Therefore, it is not easy to define a general process that can represent the foresight activity. Nevertheless, a general process with the following three stages can be used as reference:

- *Scanning the environment.* This activity tries to capture those phenomena that can have an outstanding importance in the future for the organizations or for the society in general.
- *Conceptualisation of emerging issues.* Any new phenomenon implies a laborious conceptualisation process in order to explain that new reality in terms of other known concepts. This process includes applying cognitive filters and interpretation aspects that are engrained in the individuals and society.
- *Communication process.* It is intrinsic to the dissemination of any emerging phenomena. Features such as which traits of the phenomenon are transmitted, with which approach, in which media, etc. condition the evolution and perception of these emerging phenomena.

Figure 2 shows these three stages that define the framework of this study schematically. As seen in this figure, this process begins and finishes in the environment and several stakeholders play different roles along the process.

Figure 2 Stages of emerging issues management process studied in this thesis and stakeholders involved in them



Source: Own elaboration

Different stages of this process are represented in this figure in a linear and consecutive way for the sake of clarity. Nevertheless, the real process is not so linear and there are multiple interactions and overlaps between them. For instance, the communication process interacts with the conceptualization process and to some extent is simultaneous to it.

4 METHODOLOGY

As mentioned, foresight relies on a big number of tools and methodologies without too much theoretical development supporting them and, in some cases these are very associated to institutions, consultancies or practitioners. Among this assortment of tools and methodologies, some of them have reached more theoretical support and have gained a consensus about their rigor and validity within the research community. The following theories and methodologies fall into the latter category: CLA (Causal Layered Analysis) framework proposed by Inayatullah (1998), Ansoff (1984) and Molitor (1977) approaches about the dissemination of signals, Lakoff and Johnson's (1980) models about the role of metaphors in the conceptualisation of new phenomena, or Charles Sander Peirce's view on semiotics. For that reason, all the papers turn to them in order to ground their rationale and their contributions.

The framework proposed is wide and includes capturing, putting in context, interpreting and communicating emerging issues and activities that can neither be framed in a concrete discipline nor in a single field of research. For that reason, this thesis combines well-accepted theories coming

from strategy field, for instance, Igor Ansoff's model of weak signals, with other disciplines such as semiotics, linguistics or philosophy that are not so commonly used in management and strategy fields. This multidisciplinary focus is necessary as concepts such as perception, interpretation and cognitive models of filters, which are at the core of understanding emerging issues and foresight practice in general, can only be faced using a holistic approach.

The debate about the suitability of approaches from social sciences has always been contentious and led to the fact that some experts divided the sciences into hard (natural) sciences and soft (social) sciences. The inclusion of these multidisciplinary approaches delves into this debate. For that reason, the present study has put a special effort in covering the widest variety of cases and situations, and formalising the steps of the research process with rigor, as proposed by Glaser and Strauss (2009), to create grounded theories in the field of social sciences. Thus, in order to formalize the contributions correctly, the following steps were included in all of them:

- Analysis of the state of the art in the field of study and the limits of present theory
- Formulation of the new proposal: hypotheses or theories
- Formulation of the methodology to contrast these new proposals
- Execution of the contrast of the hypothesis or development of a case study
- Delivery of conclusions

The extent of this approach and the number of disciplines involved in the study make it necessary to combine of some of the research strategies used in social sciences such as experiments, archival analysis, and case studies. All the papers include at least one case study with a twofold purpose: firstly, the case study, even when it is a single-case study, is recognised as one of the most relevant ways of doing social research (Yin, 2013); secondly, it acts as an illustrative example of the application of the contributions of each paper serving as a didactic resource.

A more detailed description of the methodology used to cope with the different goals of this work is included in the next section and in the papers.

5 PAPERS AND THEIR RATIONALE

This thesis is made up of three papers published in the journal Futures and one in the journal Technology Analysis and Strategic Management. Each paper is framed in one of the three stages showed in the previous section, defines one proposal, and develops a rationale to contribute to the state of the art on that issue (see

Table 3).

Table 3 Papers that make up this thesis in chronological order of publication

Stage	Paper number/ Paper title	Journal. Date of publication	Proposal	Tools Used
Scanning the environment	Paper 1: Assessing emerging issues. The external and internal approach	Futures. July 2015	Assessing different approaches to value the potentiality of emerging issues to become trends	Ansoff and Molitor's models of weak signals, web scanning, statistics, CLA, , semiotics, case study
Conceptualization of emerging issues	Paper 2: The role of metaphors in the development of technologies. The case of the artificial intelligence	Futures. March 2016	Understanding the mechanism by which emerging technologies are conceptualized and how the metaphors used with that intention condition their evolution	Bibliometrics, CLA, Lakoff's metaphor model, case study
Communication process	Paper 3: From data analysis to storytelling in scenario building. A semiotic approach to purpose dependent writing of stories	Futures. March 2017	Creating a framework to adapt the communication of scenarios to their purpose	Stories, semiotics, case study
Scanning the environment	Paper 4: Easing the assessment of emerging technologies in Technology	Technology Analysis and Strategic Management. June 2017	Creation of a framework to value the maturity of emerging technologies and to	Bibliometrics, search engines, hypothesis contrast,

Stage	Paper number/ Paper title	Journal. Date of publication	Proposal	Tools Used
	Observatories. Findings about patterns of dissemination of emerging technologies on the Internet		forecast their evolution	analysis of variance, case study

Although each paper is focused on a different stage, they tackle different issues trying to dive into the real motivations that lead emerging issues and trends. Consequently, they give a special importance to the perception of new phenomena and their interpretation. For that reason, semiotics, as conceived by Charles Sanders Peirce and Causal Layered Analysis proposed by Sohail Inayatullah, play an important role in the development of their rationales and give consistency to the whole work.

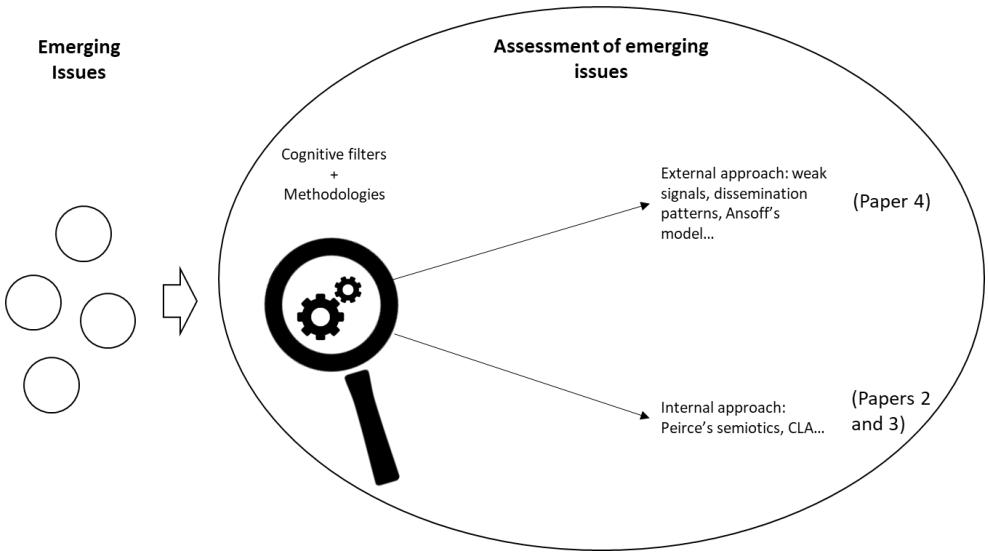
Paper 1 faces the initial challenge that all observatories and experts in foresight have to cope with: the scanning and detection of emerging issues. Although there is a consensus about the importance of this activity, there are still important discrepancies about fundamental aspects related to its implementation and important questions are still posed to the research community without an accepted answer. For instance, which approach should be used to detect them, how to value the first signals of a phenomenon also called "weak signals", or even more operative questions, like which procedures should be used to assess and manage both the emerging phenomena and the weak signals. This paper offers a wide view of these methods, dividing them into two main approaches: the internal and the external one.

With respect to assessing the maturity and the possibilities for an emerging issue to become a consolidated trend, the most traditional approach is the external one, which is based on the strength and patterns of its signals dissemination. Nevertheless, in addition to this trend to analyse the external footprint of emerging issues, there is another important line of thought that minimises the capacity of external aspects to capture the essence of an emerging issue moving the importance to the internal aspects that require interpretation. This is in line with Peirce's semiotic point of view that remarks the importance of interpretation in the process of signification. In the foresight field, CLA methodology as proposed by Sohail Inayatullah is the most outstanding framework that draws on this approach. This paper offers an assessment of both approaches and tests them by means of a case study to deduce their pros and cons and their limits.

Although the external approach seems to be more objective and the internal one more based on preconceived ideas, both approaches assume the existence of cognitive filters (Figure 3). These filters were mentioned and classified by Igor Ansoff (1984) and are currently an assumption accepted by any advanced method related to the management of emerging issues and weak signals.

The papers that make up this dissertation go beyond the process of scanning of emerging issues. Nevertheless, this first paper is key to the dissertation and raises some concepts that will be developed in-depth in the following ones.

Figure 3 Paper 1 general scheme and relationship with other papers



External Approach

Paper 1 proposes assessing emerging phenomena by means of the external signals or weak signals that they emit. At present, almost any activity leaves traces on the Web and for that reason this media is an outstanding source for any scanning activity. The idea underlying the use of the Web to scan the environment is associating these traces to signals and using metrics to assess them.

The number of items retrieved by a search engine is usually considered a good measure of the strength of an emerging issue that allows the differentiation between weak and strong signals. This differentiation between weak signals and strong signals has been regarded by Igor Ansoff (1975) himself and several authors more recently (Holopainen & Toivonen, 2012; Hiltunen, 2010). Nevertheless, it is not clear the threshold to separate weak and strong signals as the dynamics of information dissemination on the web are not clearly known yet (Pentland, 2014).

Paper 4 dives into the possibility of using a mainstream search engine to scan the Web and obtain relevant information about emerging technologies' maturity. This paper widens the proposal showed in paper 1 that used two parameters and proposes a 30 parameter model. These metrics include in the model aspects such as the following ones:

- The relation between the number of traces during the last three years with respect to the total number of traces without time restrictions.
- The dissemination of the traces in three well-delimited fields: the layman, the academic and the industrial ones.
- The interest of the community in each one of these fields.

- Relationships between metrics of the same field or between metrics of different fields.

This model is in line with other studies about the detection of emerging technologies i.e. (Järvenpää et al. 2011; Abercrombie et al., 2012; Jun et al., 2014; Breitzman & Thomas, 2015) but it includes a higher number of aspects. A posterior contrast with real data in a case study allows identifying those parameters that offer more information about emerging technologies' maturity and interesting insights about their dissemination patterns.

Internal approach

Paper 2 follows the internal approach and focuses on the internal mechanisms that underlie the cognition filters. It draws on Lakoff and Johnson's points of view about metaphors and their relation with the cognition processes: "… then the way we think, what we experience, and what we do every day is very much a matter of metaphor" (Lakoff & Johnson, 1980). The point of view that these two authors offer about the importance of metaphors in the way we conceptualise and experience our lives have been widely applied in different fields. There are also many studies that have connected metaphors and technology but, in most cases, they associate metaphors to communication (Kaplan, 1990; Christidou et al., 2004). This paper goes a step beyond that standpoint and dives into the capacity of metaphors to conceptualise new phenomena (in this case, of technological nature) and lead their evolution.

In the field of foresight, CLA offers a framework in which the metaphors engrained in society are the most hidden leaders in the evolution of phenomena. This paper starts from Lakoff's categorisation, which considers three types of metaphors (orientational, ontological and structural metaphors), and connects them with CLA's layers, thus bridging both models. This outlook allows moving some of the ideas around metaphors developed in other fields to the foresight discipline.

This paper analyses the role of metaphors in the conceptualisation of new technologies and how these metaphors shape the evolution of these technologies. It develops a use case showing this two-way process applied to Artificial Intelligence. It also poses several scenarios in the evolution of Artificial Intelligence according to different underlying metaphors that show the potentiality of metaphors in the elaboration of scenarios, one of the most used and powerful tools in the foresight and strategy fields.

Paper 3 dives into the scenario techniques and into the interpretation of emerging issues. For that purpose, it studies the scenario building process and concludes that all methods include to some extent two steps, the first one oriented to the research of data and analysis, and the second one focused on storytelling and communication aspects. This paper studies the transition between them and states that there is an important information reduction when passing from the first step to the second one. This reduction is initially twofold: a loss of uncertainty and a loss of information elements to construct the big picture (entities, relations and delimitation of contour). This situation can cause a loss of consistency and information and make this scenario fail for dissemination purposes (De Geus, 2008; Molitor, 2009).

This third paper turns to Charles Sanders Peirce's points of view in semiotics slightly introduced in the first paper to cope with this reduction. It develops a methodology to build narratives or stories from the data obtained in the first phase with that purpose. This methodology focuses on the purpose of the stories dividing them into different elements that act as sign-vehicles and that must be

modulated according to a purpose previously defined. It comprises four steps: identification of purpose, selection of pertinent traits to be transmitted, selection of sign-vehicles, and creation of stories.

Although the methodology and the case study developed are focused on building scenario activity, the framework defined can be applied to other emerging phenomena studies. The importance of the interpretation and the purpose orientation that this paper proposes can link the communication processes with the conceptualisation ones proposed in paper 2.

This general outline of the thesis through the papers that make it up shows a strong robustness in the approaches used to study emerging issues and other foresight concepts, in the underlying disciplines and theories to face them and in the research methodology. A summary of the proposals, methodology used and conclusions of each paper is shown below.

5.1 Paper 1: Assessing emerging issues. The external and internal approach

Methodology

Methods and tools used to assess emerging phenomena and weak signals are very diverse, processes are difficult to standardise, and the results are hard to validate, and to some extent they include a dose of subjectivity. All these reasons make it difficult to evaluate of these methods and establish a comparison of their suitability and performance.

The work carried out in this paper is focused on finding criteria, as objective as possible, to assess emerging issues' possibilities to become consolidated trends. It draws on both, external (based on weak signals) and internal (based on deep motivations) approaches.

In the case of the external analysis, the two most extended approaches on these signals are considered in this paper: Igor Ansoff's weak signals model and signals presence on the Internet media. In the first case the metric used to measure the maturity is the number of weak signals classified according to the level of concreteness of the signal (Ansoff, 1975, 1984): (1) Sense of threat/opportunity, (2) Source of threat/opportunity, (3) Threat/opportunity concrete, (4) Response concrete, (5) Outcome concrete. In the second case two variables are considered to measure the impact in media: strength and growth.

With respect to the internal approach, the paper turns to the CLA framework with its four layers (litany, systemic causes, discourse/worldview, myth/metaphor).

A case study analysing several emerging issues is used to test the performance of the different models. The elaboration of this case study requied a two-day workshop with the authors of the report as well as carrying out exhaustive study of the weak signals and reasoning included in the report.

Conclusions

In all the cases studied, emerging issues have not been detected by one signal but by the sum of a number of them, creating a system of signals whose rationale is difficult to find. For that reason, a conclusion that can be drawn is that there is not a unique criterion to assess emerging issues but some rules that tend to be met. Although the deconstruction model or internal approach seems to be more subjective, it is proved a more powerful method to dive into the real causes because it considers the relations between "signals", "emerging issues " and "internal motivations".

It is also concluded that each of these approaches and methods has pros and cons (see Table 4), and for that reason, their use in a complementary way is convenient.

Table 4 Pros and cons of different approaches to analyse emerging issues (obtained from the case study)

Approach	Method	Pros	Cons
External	Igor Ansoff's weak signal model	It allows classifying emerging issues easily	It gives more importance to a signal when it is more concrete (this is not always true).
	Impact in media: Strength and growth	It allows to classifying emerging issues easily, very objective	It does not consider the internal reasons. There is not a clear relationship between these factors and emerging issues importance
Internal	CLA	It considers internal reasons, systemic causes and values. It allows detecting relations among emerging issues	It is subjective

5.2 Paper 2: The role of metaphors in the development of technologies. The case of the artificial intelligence

Methodology Used.

The paper relies on technological studies of renowned prestige to pinpoint the relations between metaphors and technologies. It illustrates the metaphors that are used to conceptualise technologies in their earliest stages using the latest Hype Cycle for Emerging Technologies report from Gartner. It also turns to 2004 release of this report to study how metaphors used to define new technologies have had an important role in their evolution and our perception of the reality. It also make use of the studies of the Pew Research Centre to analyse the situations where there are contradictions between metaphors. The working procedure to do this activity is an in-depth study of the descriptions and rationales included in these reports.

The study of the utilization of the concept of metaphor in different fields of knowledge for instance, cognitive psychology (Gibbs, 1994), mathematics (Lakoff & Nuñez, 2000), sociology (Lopez,

2003), politics (Goatly, 2007), neuronal theory (Grady, 1997), marketing (Zaltman & Zaltman, 2008), communication (Steen, 2007), grammar (Ruiz de Mendoza & Mairal, 2007), shows that most of them draw on Lakoff and Johnson's statements about metaphors. In the foresight realm, CLA methodology considers the metaphors engrained in the population as the most internal drivers of society's behaviour. For that reason, the paper addresses the categorization of metaphors proposed by Lakoff and Johnson and links it to the four layers proposed by CLA methodology and bridges them. In order to test the capacity of the metaphors to shape the evolution of technologies, this paper develops a case study of artificial intelligence, posing different scenarios for its technological evolution based on different brain metaphors.

Conclusions

This paper goes beyond the traditional idea of metaphors as a linguistic mechanism and dives into their capacity to shape the way we perceive the world and their role in the evolution of society. It studies this phenomenon in the field of technologies in their initial stages or emerging technologies.

It concludes that the influence of metaphors and technologies takes place in a two-way process: metaphors reigning in society shape the conceptualization of emerging technologies and emerging technologies contribute to shaping our metaphors of the world. For that reason, metaphors reigning in each culture have a paramount importance in the elaboration of future scenarios as it has been proposed in CLA methodology.

5.3 Paper 3: From data analysis to storytelling in scenario building. A semiotic approach to purpose-dependent writing of stories

Methodology

As mentioned above, there is a wide number of scenario building methodologies and techniques with a high variety of tools and approaches that hinder the search for general solutions. In the case of storytelling, the variety of techniques is also huge (narrations, illustrations, user stories, videos, diagram, etc). For that reason, the first step carried out is studying the information reduction considering the widest variety of these typologies to saturate this space, as proposed by Glaser and Strauss (2009) to create grounded theories.

Once the gap or information reduction is studied in depth, the paper looks at Charles Sander Peirce's semiotic concepts, such as the triadic structure of the sign, the semiosis process and the purpose orientation of the sign or the pragmatism, in order to build a methodology that can join both phases and modulate the information reduction.

This methodology comprises four stages: identification of purpose, selection of pertinent traits to be transmitted, selection of sign-vehicles and building the stories. Finally, the methodology is tested with several real case studies taken from Telefónica's strategy department and from the 7th Framework Programme of the European Union.

Conclusions

The reduction of information between the research and analysis phase and the storytelling phase is unavoidable but depends to a great extent on several aspects like the length of the story and the narration mode with long and impersonal stories showing lower information reduction. In all cases, stories are focused on a course of action that the author considers more plausible or wants to emphasise and the uncertainties are eliminated.

Another important conclusion is that the story is not a product but a process with several stages. In the early stages, the gap can be modulated by selecting the pertinent information while in the last stages it is the effect on the audience that is modulated.

The framework proposed allows the storytellers to set the tone of the story, to create numerous versions, and to ease the traceability between the analytic information of the scenario and the final story. Although some methodologies have done attempts to cope with those situations to some extent, none of them has focused on linking R&A and storytelling phases and, for that reason, this framework offers a distinctive and valuable contribution.

5.4 Paper 4: Easing the assessment of emerging technologies in Technology Observatories. Findings about patterns of dissemination of emerging technologies on the Internet.

Methodology

The first step carried out to create the framework was the selection of metrics, in this case metrics that can be accessed for free or that can be calculated from metrics accessed for free. It includes information referred to three well-delimited fields: the layman, the academic and the industrial that can be depicted by the general Web, academic publications and patents. This variety allows to build a general and rich framework.

This framework includes two kinds of metrics: primary metrics that reflect the number of hits retrieved by queries on a search engine, and secondary metrics that show ratios between primary metrics. In the last group calculations are carried out by using metrics from the same field or from different fields. Thus, the model proposed is made up of 30 parameters (twelve directly measured by means of a search engine and 18 calculated from them by using ratios) in order to capture emerging technologies widest diversity of aspects.

The paper also develops a case study calculating these metrics for the 37 emerging technologies included in the Hype Cycle for Emerging Technologies 2015. This case study turns to statistical analyses such as clustering and analysis of variance to highlight relationships and patterns of dissemination. It offers three kinds of insights: characterization of the sample, detection of relations between the metrics of the framework and assessment of dissemination patterns on the Internet

Conclusions

This paper shows how the information disseminated on the Internet correctly processed can deliver important information to characterise new phenomena, in this case emerging technologies, and to

measure their maturity. The paper offers a framework of 30 parameters that can be simplified, enriched or adapted to be applied to other sectors.

It also offers relevant insights about dissemination patterns of emerging technologies on the Internet. These insights are varied and concern different aspects of emerging technologies dissemination: the interest of the different communities along their life cycle, the capacity of patents to anticipate the time to market, the own limits of this approach to forecast emerging technologies, or the factors that capture more the interest of the layman community.

6 GENERAL CONCLUSIONS AND CONTRIBUTIONS

Foresight is consolidating as a new subject of study and research with a dynamic community developing and testing new methodologies and theories. Nevertheless, this is only an incipient interest, theories are not mature enough and there is a great deal of room for new studies and analyses. This thesis deals with this deficit and tries to contribute to reducing it, testing present methodologies and developing new ones.

One general issue derived from the papers is the necessity to dive into the internal roots of the phenomena in order to understand them and forecast their evolution. This necessity means that most challenges that are posed in this field cannot be resolved with a unique approach, and different disciplines and multidisciplinary teams are necessary to face them.

For that reason, the papers that make up this thesis draw on a wide variety of disciplines and make contributions to adapt them to the foresight field. The main contributions that they deliver are the following ones:

Paper 1

- Contribution 1: It analyses different approaches and methodologies to assess emerging issues and identifies pros and cons and the limits of each one.

Paper 2

- Contribution 2: It explores the relation between metaphors and the evolution of technologies and rises a two-way mechanism.
- Contribution 3: It links Lakoff and Johnson's models about metaphors in the conceptualization of reality with CLA methodology commonly used in foresight field.
- Contribution 4: It develops the capacity of metaphors in developing scenarios of the future about emerging technologies.

Paper 3

- Contribution 5: It characterises information loss in the scenario building process when passing from the research and analysis phase to the storytelling one.
- Contribution 6: It develops a methodology to modulate information loss according to the purpose of the stories and their audience in scenario building.
- Contribution 7: It creates a tool to maintain the information traceability through all the stages in scenario building.

Paper 4

- Contribution 8: It develops a framework to help observatories to assess emerging technologies by using information for free on the internet.
- Contribution 9: It carries out statistical analysis to offer insights and contributions to the present theory about dissemination patterns of traces related to emerging technologies in different fields.
- Contribution 10: It develops four case studies that can be used to test different theories and for training purposes.

7 FUTURE LINES OF RESEARCH

At present, foresight is living an important moment in its configuration as a field of knowledge with important challenges at different levels. At the research level, for the time being, there is an important activity that is settling down in some theories and methodologies. Nevertheless, they are not mature enough as shown along this thesis. At the practitioner level, organisations are struggling to apply these methodologies to anticipate the evolution of the environment. This thesis contributes to both levels; however, it must not be considered as a concluded work but as a starting point that opens new lines of enquiry that could be continued with other studies and theses.

Because of the holistic approach of this work that turns to different disciplines, the future lines of research are varied, can affect different sectors and can even go beyond the foresight field.

Related to the foresight field, methodologies and case studies have been developed specifically for the case of emerging technologies. For that reason, adapting the methodologies and case studies to other kinds of emerging issues, e.g. social phenomena like new political movements, can be useful in order to generalise results and is the most obvious line of research.

Moving to basic areas of research and continuing diving into the processes related to perception and interpretation is an interesting line of research that can be tackled from different points of view (psychology, communication, etc.). This knowledge can be interesting in order to understand people and organisation's filters used to capture new phenomena and to forecast their evolution.

The approaches and rationales used in this work can also be applied to other domains beyond the foresight field. For instance, the methodology created in the third paper to connect data analysis and storytelling can initiate an interesting line of enquiry in the communication field, and the analysis of metaphors in the conceptualization of new phenomena developed in the second paper can have applications in politics. Thus, the cross-cutting nature of the approaches used in some papers opens the door to the continuation of the research in other fields that apparently are not related to foresight.

It can be concluded then that there is a two-way connection between foresight and other fields of knowledge that should be explored. On the one hand, concepts coming from other disciplines such as linguistics or aesthetics, such as speech acts as proposed by John Searle, or the gestalt, can enrich foresight theory. On the other hand, foresight concepts and approaches can be useful in other more traditional fields like communication and business. For that reason, multidisciplinary and links between apparently different fields can trigger new lines of research that should be considered in the future.

8 LIST OF REFERENCES

Abercrombie, R. K., Udoeyop, A. W., & Schlicher, B. G. (2012). A study of scientometric methods to identify emerging technologies via modeling of milestones. Scientometrics, 91(2), 327-342.

Aguilar F.J. (1967). Scanning the business environment. Macmillan.

Albright, K. S. (2004). Environmental scanning: radar for success. Information Management, 38(3), 38.

Amer, M., Daim, T. U., & Jetter, A. (2013). A review of scenario planning. Futures, 46, 23-40.

Ansoff, I.H. (1975). Managing Strategic Surprise by Response to Weak Signals California Management Review, Vol. 18, No 2.

Ansoff, I.H. (1984). Using Weak Signals, in: Implanting Strategic Management. Pretince/Hall International Englewood Cliffs, New Jersey. P.20.

Battistella, C. (2014). The organisation of Corporate Foresight: A multiple case study in the telecommunication industry, Technological Forecasting and Social Change, Volume 87, Pages 60-79. DOI: 10.1016/j.techfore.2013.10.022.

Beck, P. W. (1982). Corporate planning for an uncertain future. Long Range Planning, 15, 12-21.

Beer, S. (1972), Brain Of The Firm, Allen Lane, The Penguin Press, London.

Boon, W., Moors, E. (2008) Exploring emerging technologies using metaphors: a study of orphan drugs and pharmacogenomics. Soc. Sci. Med. 66 (9), 1915–1927.

Bishop, P., Hines, A., Collins, T. (2007). The current state of scenario development: an overview of techniques. Foresight, VOL. 9 NO. 1, pp. 5-25.

Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: towards a user's guide. Futures, 38(7), 723-739.

Breitzman, A., & Thomas, P. (2015). The Emerging Clusters Model: A tool for identifying emerging technologies across multiple patent systems. Research policy, 44(1), 195-205.

Coffman, B. (1997). Weak Signals Research. Part II: Information Theory, Journal of Transition Management, MG Taylor Corporation.

Christidou, V., Dimopoulos, K., &Koulaidis, V. (2004). Constructing social representations of science and technology: the role of metaphors in the press and the popular scientific magazines. Public Understanding of Science, 13(4), 347-362.

Daheim, C., Uerz, T. (2008). Corporate foresight in Europe: from trend based logics to open foresight, Technol. Anal. Strateg. Manag. 20 (3) 321–336. DOI:10.1080/09537320802000047.

De Jouvenel, B. (1967). The art of conjecture.

Foster, J. (1993). Scenario Planning for Small Businesses. Long Range Planning, Vol. 26, No. 1, pp. 123 to 129.

de Geus, A. (2008). Tools for foresight. Planning for the unpredictable future. Hardvard Business Press. First published in The living company: Habits for survival in a Turbulent business environment (2002). Hardvard Business School.

Goatly, A. (2007). Washing the Brain Metaphor and Hidden Ideology (Vol. 23). John Benjamins Publishing.

Gibbs, R. (1994). The poetics of the mind. Cambridge, UK: Cambridge University Press.

Glaser, B. G., & Strauss, A. L. (2009). The discovery of grounded theory: Strategies for qualitative research. Transaction Publishers.

Grady, J. E. (1997). Foundations of meaning: Primary metaphors and primary scenes. University of California, Berkeley.

Groddeck, V., Schwarz, J. O. (2013). Perceiving megatrends as empty signifiers: A discourse-theoretical interpretation of trend management. Futures. DOI: 10.1016/j.futures.2013.01.004.

Heijden, K. (1997). Scenarios, Strategies, and the Strategy Process. Center for Organisational Learning and Change.

Heijden, K (2005). Scenarios: The art of strategic conversation (2nd ed.). Chichester, UK: John Wiley & Sons.

Hiltunen, E. (2010). Weak signals in organizational futures learning. Helsinki School of Economics.

Holopainen, M., Toivonen, M. (2012). Weak signals: Ansoff today, Futures 44, 198–205. DOI: 10.1016/j.futures.2011.10.002.

Hines, A. (2003). An audit for organisational futurists: ten questions every organisational futurist should be able to answer, Foresight 5 (1) 20–33.

Ho, J. K. K. (2014b). A research note on the concept of the multi-perspective, systems-based (MPSB) cognitive filter for management. European Academic Research, 2(1), 686-704.

Ho, J. K. K. (2014a). Formulation of a systemic PEST analysis for strategic analysis. European academic research, 2(5), 6478-6492.

Holopainen, M., & Toivonen, M. (2012). Weak signals: Ansoff today. Futures, 44(3), 198-205.

Ilmola, L., Kuusi, O., 2006. Filters of weak signals hinder foresight: Monitoring weak signals efficiently in corporate decision-making. Futures, 38(8), 908-924.

Inayatullah, S. (1998). Causal layered analysis: Poststructuralism as method. Futures, 30 (8): 815–829. DOI: 10.1016/S0016-3287(98)00086-X.

Inayatullah, S. (2009). Questioning scenarios. Journal of Future Studies, 13(3), 75–80.

Inayatullah, S., Milojević, I. (2015). CLA 2.0 Transformative research in theory and practice. Tamkang University Press.

Järvenpää, H. M., Mäkinen, S. J., & Seppänen, M. (2011). Patent and publishing activity sequence over a technology's life cycle. Technological Forecasting and Social Change, 78(2), 283-293.

Jun, S.-P., Yeom, J., Son, J.-K. (2014). A study of the method using search traffic to analyze new technology adoption. Technol. Forecast. Soc. Change 81 (January),82–95.

Kahn, H. (1961). On Thermonuclear War: With Index. Princeton University Press.

Kaplan, S. J. (1990). Visual metaphors in the representation of communication technology. Critical Studies in Media Communication, 7(1), 37-47.

Lakoff, G., and Johnson. M. (1980) Metaphors we live by. Chicago/London, 1980Lakoff, G., & Núñez, R. (2003). Where mathematics comes from. Santa Fe Institute.

Lakoff, G., and Núñez,R. (2003). Where mathematics comes from. Santa Fe Institute.

Lenz R.C, and Lanford H. W. (1972) "The substitution phenomenon: No. 4 technological forecasting." Business horizons 15.1: 63-68.

López, J.(2003). Society and its metaphors: language, social theory and social structure. A&CBlack.

Luce, R.D., and Raiffa, H. (1958). Games and Decisions (New York), pp 276-8.

Martino J, A. (2003). Review of selected recent advances in technological forecasting, Technol. Forecast. Soc. Change (TFSC) 719–733.

Molitor, G.T.T. (1977). How to Anticipate Public-policy Changes, S.A.M Advanced Management Journal, pp. 4-13.

Molitor, G.T.T. (1981). Consumer Policy Issues: GLboal Trends for the 1980's Advances in COnsumer Research, Vol. 8, pp. 458-466.

Molitor, G.T.T. (2003). Molitor Forecasting Model: Key Dimensions for Plotting the Patterns of Change, Journal of Future Studies, 8(1): 61-72.

Molitor, G.T.T. (2009). Scenarios: Worth the Effort?, Journal of Futures Studies, February, 13(3): 81 – 92.

Parrinder, P. (1995). Shadows of the future: HG Wells, science fiction, and prophecy (Vol. 6). Syracuse University Press.

Pentland, A., 2014. From Ideas to actions, in: Social Physics. How good ideas spread. The lessons from a new science. The Penguin Press. New York.

Porter, A.L., Roessner, J.D., Jin, X.-Y., Newman, N.C. (2002) Measuring national emerging technology capabilities. Sci. Public Policy 29 (3), 189–200.

Rotolo, Daniele, Diana Hicks, and Ben Martin. (2015) "What is an emerging technology?." Research Policy 44 (2015) 1827–1843.

Ruiz de Mendoza Ibáñez, F. J., & MairalUsón, R. (2011). Constraints on syntactic alternation: Lexical-constructional subsumption in the lexical-constructional model. In P. Guerrero (Ed.), Morphosyntactic alternations in English: Functional and cognitive perspectives (pp. 62–82). London, UK/Oakville, CT: Equinox.

Saritas, O., Smith, J.E. (2010). The big picture – trends, drivers, wild cards, discontinuities and weak signals. Futures. DOI: 10.1016/j.futures.2010.11.007

Schwartz, P. (1991). The Art of the Long View: Planning for the Future in an Uncertain World, Doubleday Currency, New York, NY.

Seidl, D. (2004). The concept of ‘‘weak signals’’ revisited: a re-description from a constructivist perspective, in: H. Tsoukas, J. Shepherd (Eds.), Managing the Future: Developing Strategic Foresight in the Knowledge Economy, Blackwell, Oxford, pp. 153–170.

Selin, C., Kimbell, L., Ramirez, R., & Bhatti, Y. (2015). Scenarios and design: Scoping the dialogue space. Futures, 74, 4-17.

Steckelberg, A. V. (2015). Orchestrating a creative learning environment: Design and scenario work as a coaching Experience-How educational science and psychology can help design and scenario work & vice-versa. Futures, 74, 18-26.

Steen, G. (2007). Finding metaphor in grammar and usage: A methodological analysis of theory and research. Amsterdam, The Netherlands: John Benjamins.

Wilkinson, A. (2009). Scenarios Practices: In Search of Theory. Journal of Futures Studies, February, 13(3): 107 – 114.

Wright, G., Cairns, G., & Bradfield, R. (2012). Special issue on Scenario method: Current developments in theory and practice. Technology Forecasting and Social Change, 79(1), 198.

Wygant A.C, and Markley O. W. (1988). Information and the future: A handbook of sources and strategies. Greenwood Pub Group.

Yin, R. K. (2013). Case study research: Design and methods. Sage publications.

Zaltman, G., & Zaltman, L. (2008). Marketing metaphoria. What Deep Metaphors Reveal about the Minds of Consumers, Harvard Business School Press, Cambridge, MA.

III. PAPERS

PAPER 1

Futures

Volume 73, October 2015, Pages 12-21

Assessing emerging issues. The external and internal approach

Javier Carbonell[a], Antonio Sánchez-Esguevillas[b], Belén Carro[b]

Show more

https://doi.org/10.1016/j.futures.2015.07.015

Assessing emerging issues. The external and internal approach

Abstract

This article analyses emerging issues trying to find elements to assess the possibility that they become a relevant trend in the future using a twofold perspective for that purpose. On the one hand it considers the external approach, that is, the analysis of visible signals linked to the emerging issues that in an early stage are called "weak signals". On the other hand, it tries to study emerging issues taking into account their internal motivations. In this case the aim is to value the social, economic or other kind of reasons that are hidden under emerging issues. A post-structuralism perspective (CLA, causal layered analysis) is used to address this objective.

This double approach allows to consider emerging issues in a holistic way, taking into account what is visible and what is not so apparent. In order to offer conclusions and results a real use case is included analyzing the emerging issues showed in the report "Informe de la Sociedad de la Información 2013" (one of the references about information society situation and ICT trends in Spain).

Keywords: Emerging issues, weak signals, Igor Ansoff, CLA, SIE2013

0.- Introduction

Getting an in depth understanding of the environment and its changes is one of the main management goals for any organization, mainly when it is necessary to make decisions with long term implications, that is, with a strategic nature. This is a common problem that all organizations have to deal with in one or another moment of its life, though some companies traditionally have not paid

enough attention to it. Growth in competitiveness among the companies and faster changing conditions of the environment due to new technologies irruption is changing this situation, what forces to reconsider environment surveillance processes as a main source of data to feed strategy.

For this reason, foresight capability is seen as one of the aspects that make the difference for the success of any company, in many scholars (Hines, 2003) and corporate foresight "the art of the long view" has become a relevant task in modern organizations (Schwartz, 1991). Though these activities can be considered quite diverse, a holistic approach is necessary grouping them as part of an integrated process. In academic literature this is sometimes referred to as corporate foresight, conceiving it as a set of practices connected to management, organizations, strategy and technology (Pettigrew, 2002). These processes require some kind of structure within the organizations, at least in large organizations, in order to give them support and visibility. There is a debate about the best way to set up this unit and even if it should be a unit separated from the rest (Battistella, 2014), so that diverse models and classifications about its structure can be found in literature. One kind of structure that is gaining importance in the field of corporate foresight is the Observatory, an organizational model that includes specialized tasks addressed internally that can be distinguished from other kinds of units such as think tanks or outsourcers because of culture and management style (Daheim and Uerz, 2008). Nowadays, observatories are springing up in the organizations with the aim to surveillance the environment, activity commonly known as scanning. They can be found in the administration, in sectorial industry lobbies, in big corporations. There are many methodologies to do this scanning such as STEEP (Social, Technological, Economical, Environmental and Political), PEST (Political, Economic, Social and Technological) …, nevertheless it is a process not very formalized that depends too much on each organization's way of working and sometimes they fail to consider how the conjunction of those various angles should be combined into a sense-making whole. One key objective of these observatories is the detection of new phenomena that in Foresight literature are called "emerging issues", a process that is usually informal, even messy and often serendipitous. It is believed that these emerging issues do not occur all of a sudden and they are preceded by some kind of signals usually known as weak signals that are defined as "first symptoms of strategic discontinuities, i.e. symptoms of possible change in the future, acting as warning signs or signs of new possibilities" (Ansoff, 1984).

This paper dives into the process of emerging issues assessment, considering for that their signals and their internal motivations, and establishes a debate to obtain conclusions and orientations to carry out this task. It is organized into 6 sections. The necessity and role of observatories is raised in section one. In the second section, the emerging issues and other foresight concepts are explained. In sections 3 and 4 the external and internal analysis of emerging issues are studied. Section 5 develops the use case of SIE 2013 emerging issues based on the previous approaches. Section 6 summarizes the results and proposes new lines to continue the research.

1.- The Surveillance necessity in organizations: the surge of the observatories

The capacity of an organization to adapt itself to the changing environment is paramount for its survival. For this reason, during the last century a high number of methodologies and theories intending to manage environments of uncertainty have been developed to orientate their activities. First models presupposed that it was possible to know with anticipation the different alternatives that could happen in the future, these alternatives usually called "states of the nature" are defined as

"exhausted and mutually exclusive lifting of those aspects of nature which are relevant to this particular choice problem and about which the decision-maker is uncertain" (Luce and Raiffa, 1958). These models, from which Maximax, Maximin and Laplace's criteria are the greatest exponent, are still used in planning and construction of scenarios. They manage the uncertainty by estimating a probability for each of the alternatives, but they do not deal with the number and nature of the alternatives.

During the last years, it has been made clear that organizations cannot assume that they know all the possible future states of nature. This leads to the necessity of implementing processes to detect new phenomena with the power to change the environment affecting an organization. These phenomena, named in a generic way as "emerging issues" have been acquiring importance as subject of study, which has raised an important research activity about their nature, their detection and their classification. This development has driven to the definition of a great number of concepts and terms, whose boundaries are at current not well defined, giving rise to several debates about the limits and the sense of each one of them.

Once the importance of emerging issues is understood, it acquires special interest to design structures and methods to capture and filter properly these phenomena as far in advance as possible, which implies to introduce the notion of filters. In this case a filter must not be considered as a kind of glasses to pick up pertinent signals objectively placed in the environment. These filters in one way or another rely on internal cognitive knowledge structures so the signals meaning depends to some extent on actor's (person, organization…) mental models: a signal can mean something for one actor and lack of interest to others because ''Cognitive systems interact with their environments, but it is the cognitive system – and not the environment–that determines how and in what way it interacts" (Seidl, 2004). This situation is more common in the cases of unexpected signals as is the case of a weak signal, which is by definition unstructured information and its implications to the organization are at an early stage very hard to define (Ilmola and Kuusi, 2006).

One approach to cope with filtering was developed by Igor Ansoff (Ansoff, 1984) who divided this activity in several levels. In the first place he considered a filter at environment level he called "Surveillance filter" that has the objective to filter the information that enters in the organization. Later, inside the company, mentality and power filters only let pass the most outstanding information so that the organization can make appropriate decisions.

From these three filters, the first has a special importance as it allows the organization to capture from the environment the relevant information (at least relevant to its cognitive knowledge structures) that can be useful for business development, a critical activity that in large organizations is faced with setting up some kind of structure (independent or not). This fact was considered some decades ago, for instance it was proposed in the model of viable organizations from Stafford Beer in 1972. In particular, subsystem 4 in its model named "intelligent subsystem" is in charge of environment surveillance in order to obtain relevant information to adapt the organization to external changes (Beer, 1972).

2.- Foresight, terminology associated to "emerging issues"

At present, there is a considerable standardization activity about foresight theory and concepts. In this field the "The Millenium Project"[7] community stands out with 3,500 members spread out in 49 nodes throughout the planet that address methodological and practical issues offering advice to administrations and corporations. This entity publishes a methodological compendium, "Futures Research Methodology" that in its last edition in 2012 developed 39 methodologies. Though the number and depth in the development of these methodologies, it is manifest that is a field that requires a huge systematization and formalization activity as it happened in the economy field during the XX century.

Emerging issues focuses on phenomena close to the moment they are very first notice. The idea was developed by Molitor in the late 1950s and early 1960s and presented in his article "How to anticipate public-policy changes" (Molitor, 1977), "…at bottom are certain structural forces that gain momentum over time and give rise to what I term issue environments". He considered public-policy authorities should be aware of these phenomena in order to prepare new regulation in advance for future changes in the environment. He continued developing this concept in later articles (Molitor, 1981), (Molitor, 2003).

In literature "emerging issues" term appears generally besides other terms such as: Weak Signals, Wild Cards, Trends, Megatrends, and even in some occasions is mixed with them (Hiltunen, 2010), (Coffman, 1997b), (Heijden, 1997)

Though this lack of definition in the limits and nature of the terms, it can be considered quite consensual the high level definition offered by O. Saritas y J.E. Smith (Saritas and Smith, 2010) about the concepts more commonly used in foresight arena.

Table 5 Foresight main terminology

Trends	Are those change factors that arise from broadly generalizable changes and innovation
Drivers of change	Are those factors, forces or events – developments which may be amenable to changes according to one's strategic choices, investments, R&D activities or foresight knowledge and strategies
Wild Card	Are those surprise events and situations which can happen but usually have a low probability of doing so – but if they do their impact is very high
Discontinuities	Discontinuities are those situations – impacts where over time and extending beyond single events, change is rapid and fundamentally alters the previous pathways or expected direction of policies, events and planning regimes
Weak Signals	They refer to the early signs of possible but not confirmed changes that may later become more significant indicators of critical forces for development, threats, business and technical innovation

This confusion affects other terms too, for example some authors even use in a synonymous way the concepts of weak signals and trends (Groddeck and Schwarz, 2013) when in principle are quite distant.

[7] http://www.millennium-project.org/

There are important differences with regard to the sense of the terms too. Some authors consider "weak signals" as events in themselves, so that there would not be a clear frontier between them and the "emerging issues". This thesis is defended by numerous experts (Coffman, 1997c) (Harris and Zeisler, 2002) and even by Igor Ansoff himself. On the contrary other experts (Brabandere, 2005), (Nikander, 2002) keep more faithfully to the concept of signal and distinguish clearly the event or "emerging issue" and the signal or "weak signal". Weak signals are assimilated to the meaning of "early warnings" (Nikander and Eloranta, 2001) too. Some authors deny the existence of this sense of warning and claim that when thinking about an event that occurred previously people desire to see warnings (Ashley, 1989). This is more in line with the constructivist point of view "Weak signals have to be conceptualized cognitively, i.e. as cognitive phenomena, determined by the structures of the cognitive system (Seidl, 2004)."

Though a wider debate about this theme is out of the scope of this article, the previous enumeration highlights the high number of interpretation differences of terms and concepts, aspect that suppose an implicit problem for their practical usage. A more in detail analysis about conflicts and limits among these concepts can be found in Elina Hiltunen's thesis, Weak Signals in Organizacional Futures Learning, (Hiltunen, 2010)

3.- External analysis of emerging issues: their signals

The traditional method to value the maturity and the possibilities for an emerging issue to become a consolidated trend is to look at its signals dissemination. Molitor in his research about public policy considered that any emergent phenomenon implies a process of dissemination in two axes. Firstly, it begins as events and pass to other fields such as intellectual authorities, literature, organizations to end up reaching the governments. Secondly, in each one of these fields, signals follow an S-curve pattern (Molitor, 1977) so that several of these S-curves take place simultaneously. This is in line with the generally accepted idea expressed previously that any emerging issue "sends out" some signals, called "weak signals" when it is in an early stage. In this analysis two approaches about these signals are considered to reach conclusions from them: Igor Ansoff's weak signals model and signals presence in Internet media.

Igor Ansoff's weak signals model

In order to find the rationale or at least some rules that link emerging issues and weak signals some approaches can be used. The oldest and perhaps the most extended is the classification of these signals according to the model of state of the knowledge under discontinuity proposed by Ansoff, who presented a first version of this idea in 1975 (Ansoff, 1975) and developed it later (Ansoff, 1984).

This model uses a classification of 5 levels considering the level of concreteness of the signal: (1) Sense of threat/opportunity, (2) Source of threat/opportunity, (3) Threat/opportunity concrete, (4) Response concrete, (5) Outcome concrete. The concreteness is in this way the key feature to assess the maturity level of an emerging issue. Though this model seems to show weak signals as objective symptoms, a cognitive valuation is to some extent deducted from Ansoff's ideas as he considers that creativity is required in their detection (Ansoff, 1984). Later some authors have stand out this fact, for instance Coffman claims that weak signals "are new and surprising from the signals receivers'

vantage point" (Coffman, 1997a), or Elina Hiltunen is considering implicitly interpretation when applying semiotics to her vision of weak signal as a future sign (Hiltunen, 2008).

Ansoff's vision shows important similitudes with Molitor's model as it supposes an underlying dissemination process of signals before an emerging issue is risen. Nevertheless, both models present important approach differences (Table 2).

Table 6 Molitor and Ansoff signals approach

	Molitor	Ansoff
Research field	Public Policy	Organizations strategy
Research Aim	Development of public policies in advance	Strategy response in organizations
Emerging Issue approach	Environmental issue	Strategic issue
Strength of signals	Classification according to the whole life cycle	Weak and Strong signals. Five levels
Underlying concept of maturity	Level of dissemination (from elites to the mainstream)	Level of concreteness
Dissemination mathematical model	S-curve	No model

Source: Own elaboration.

Signals presence in Internet media

Ansoff's model is useful to classify weak signals and to have a global vision of the signals associated with an emerging issue but does not consider quantitative aspects like the impact of signals in media. For that reason, new criteria should be added to enrich the analysis. Bibliometric approach has been linked to emerging issues identification by several researches (Schiebel et al, 2010), in this case we propose the utilization of the general Web as source of information. With that aim we will use the number of hits in web searches (i.e. by means of Google search engine), a parameter widely used to measure the impact of any fact. This approach reminds the differentiation between weak signals and strong signals that some authors consider. Strong signals concept is as old as weak signals as they were contemplated by Igor Ansoff himself (Ansoff, 1975). They have been regarded by several authors later (Holopainen and Toivonen, 2012) (Hiltunen, 2007). Nevertheless, it is not clear the threshold to separate weak and strong signals as the dynamics of information dissemination on the web are not clearly known yet (Pentland, 2014), and for that reason this division will not be considered.

In this paper two variables are considered to measure the impact in media: strength and growth. Both are measured by using the number of hits found by the search engine according to equations (a) and (b).

$$(a)\ Strength = Number\ of\ hits\ in\ Period_a$$

$$(b)\ Growth = \frac{(Number\ of\ hits\ in\ Period_a - Number\ of\ hits\ in\ Period_{a-1})}{Number\ of\ hits\ in\ Period_{a-1}}$$

The aim of these equations is to look for any threshold that can help to discriminate an emerging issue with high possibilities of becoming a consistent trend from those that are evanescent. If it is not possible to detect a threshold a confidence interval could be acceptable.

4.- Internal analysis of emerging issues: emerging issues internal motivations

The principle of this approach is that it is not possible to capture the whole importance of a signal by studying its external aspects, and internal aspects and interpretation are required. This statement is in line with Peirce's semiotic principles that consider a sign as a triadic structure with object, representamen (or sign) and interpretant, and highlights the importance of interpretation in the process of signification. In the case of foresight this interpretation is in terms of future impact as shown by the concept of future sign introduced by Hiltunen (Hiltunen, 2008) where the object is the emerging issue, the representament the weak signals and the interpretant is the sense made of the future potentiality. It is interesting to underline the change in the nomenclature from signal to sign. From a semiotic point of view, a signal has a dyadic sense, including signifier and signified (is more similar to the way a computer works). However, a sign has a triadic sense as it includes interpretation. Though from that point of view it would be more interesting to change the name from "signal" to "sign" and from "weak signal" to "weak sign" from now on, the first terms will be used for consistency along the paper.

Considering interpretation immediately moves us to look for the final reasons of this interpretation that are sometimes hidden. A model that fits with this approach is the one offered by Senge (Senge, 1999) that states that when analyzing any situation, the visible aspects must be considered like the tip of the iceberg, and true reasons on which they are based are under the surface.

In the futurist arena, a model with some similarities because considers the deep motivations when analyzing trends or emerging issues is the CLA (Causal Layered Analysis) (Inayatullah, 1998). This method considers a six pillars process approach to the future (mapping the present, anticipating the future, timing the future, deepening the future, creating alternatives, transforming the present), being emerging issues analysis included in pillar 2, anticipating the future (Inayatullah, 2008). It offers a post-structuralism approach that uses a deconstruction methodology based on Michael Foucault's vision of hidden powers and motivations. When analyzing any phenomenon, CLA considers four layers through which the analyst must move in order to truly understand a social situation or a trend. The first level refers to facts or news as they appear in the media. Though this is only the superficial face of any event, is the only type of information that traditional methods consider. CLA goes beyond that and claims that it is necessary to dive into internal causes that rule behavior reaching the engrained myths in society, though it is not obvious to find the link. These four levels are: litany, systemic causes, Discourse/worldview, Myth/metaphor (Table 7).

Table 7 CLA (Causal Layered Analysis) layers

Litany	Quantitative trends, problems, often exaggerated, often used for political purposes — (overpopulation, for example) as usually presented by the news media
Systemic causes	Includes social, technological, economic, environmental political, and historical factors (rising birthrates, lack of family planning, for example)
Discourse/ worldview	Supports and legitimates the systemic causes (population growth and civilizational perspectives of family; lack of women's power; lack of social security; the population/consumption debate, for example)
Myth/ metaphor	These are the deep stories, the collective archetypes — the unconscious and often emotive dimensions of the problem or the paradox

Source: Inayatullah, 1998

Weak signals are included in litany layer but they are only the visible part of the emerging issues. Under them, systemic and deeper motivations must be identified. On the one hand this means that some subjectivity is introduced in the method but on the other hand it implies that it is possible to consider the hidden reasons that drive the change. Another advantage is that once the forces that foster an emerging issue at each level (systemic causes, worldviews and myths) are identified and their relation with it is understood, it is possible to give some kind of objectivity to the subjectivity. In this way, it is possible to assess if an emerging issue has strong drivers or internal motivations that will foster its future development, and also to identify factors that can act in the opposite direction. This analysis shows a reference framework to assess emerging issues considering different layers and different forces within each layer, standing out relations and oppositions among layers and between them. It allows the identification of common internal motivations between different emerging issues and their analysis from different angles widening the perspective of the analyst. It also allows the identification of non-obvious aspects on which to act in order to ease or to hinder an emerging issue. On the other hand, the application of this method requires a holistic approach by the analyst that must have a good understanding of the issue itself, the society challenges, the culture of the country, and the metaphors engrained in people. This supposes to deal with very heterogeneous information, sometimes contradictory and always arguable. For that reason, it requires experience and the access to uses cases developed by experts. In this regard, the book CLA 2.0 Transformative Research in Theory and Practice collects the best practices with this methodology until now (Inayatullah and Milojević, 2015).

5.- Use case: Internal and external analysis of SIE 2013 emerging issues

In this section the emerging issues identified in the Information society report in Spain (Informe de la Sociedad de la Información en España) are considered, in particular the edition of year 2013,

(from now on SIE2013)[8]. These emerging issues are those that were considered by authors as the ones with the highest potential to impact in the future. In this section they are analyzed under the framework developed previously in order to find common elements that could be used to create rules to identify emerging issues with high potential of becoming trends. This analysis was carried out in a two-day workshop with the authors one of whom is author of this article.

Use case description

Firstly, it must be mentioned that SIE2013 has a wide orientation targeting specialist people and the layman. It shows the most important facts in the ITC field that occurred along the year. In this regard it includes hundreds of general data about networks, subscriptions to connectivity, services, implications in people life… and it includes other data more orientated to describe trends in this field too. Within these trends, some are continuation of previous year trends, but it includes the three new trends that are rising that are considered with the highest potential to impact in society, a concept that can be assimilated with the term called "emerging issues" along this paper. The process to select these trends involves several groups of experts from inside and outside the organization and a dense schedule of meetings and think tanks. Reports from cutting edge companies, personal experiences, scenario analysis were considered. After that, analysis of information retrieved by search engines was considered as complementary information.

The following emerging issues are included in SIE2013:

- Wearables: It refers to clothes and complements with process and connectivity capacity so they can participate in PAN (personal area networks)
- Future Manufacturing: It refers to the fact that manufacturing can be considered as a digital process more, so that properties and models of digital world can be applied.
- New educational models: It refers to new educational models, mainly MOOC (Massive Open Online Course), in which ITC play a disruptive role.

The reasons and motivations for the election of these "emerging issues" are well exposed in the report SIE2013[9] and in the presentation of that report[10]. Due to the mainstream audience of this report, these phenomena were emerging during the 2013 first semester but near to take off in the S-curve, as it has been confirmed by the increase in the interest in terms associated to these emerging issues in the following two years (Figure 1), which implies that they have turned into trends.

---

8 http://www.fundacion.telefonica.com/es/arte_cultura/publicaciones/sie/sie2013.htm?soc=twitterpro

9 9 http://www.fundacion.telefonica.com/es/arte_cultura/publicaciones/sie/sie2013.htm?soc=twitterpro, pages 20-24

10 http://www.slideshare.net/FundacionTelefonica/presentacion-del-informe-sie-2013/1, slides 16-24

A description of arguments to choose them is included in the report as there were initially other candidates. In the workshop the descriptions were analyzed with the authors of the report in which 20 weak signals were identified.

Insert here Figure 1

SIE2013 external analysis of emerging issues: Igor Ansoff's weak signals model

Classifying weak signals according to Igor Ansoff's model described previously requires an in-depth scanning activity to ensure that all weak signals are included. In this use case the SIE2013 argumentations of the emerging issues are used as source, as that is the information considered by the authors to select those emerging issues. The next table classifies those weak signals according to Igor Ansoff's model (Table 8):

Table 8 Igor Ansoff's model applied to SIE2013 weak signals

	Type (1) Sense of threat/ opportunity	Type (2) Source of threat/ opportunity	Type(3) Threat/ Opportunity Concrete	Type (4)Type Response Concrete	Type (5) Outcome concrete
Wearables	Wearable boom in media	Base technology development: M2M, SmartCities		• Some eHealth personal devices on the market with good results: Fitbit, Jawbone… • Important manufacturing companies join the movement: Nike+ • Prototypes of clothing including sensors and connectivity: Rest Devices, Sproutling • Smartwatches from first level companies: Samsung, Sony, Qualcomm Toq… • Prototype Google Glass at 1,500 dollars	

	Type (1) Sense of threat/ opportunity	Type (2) Source of threat/ opportunity	Type(3) Threat/ Opportunity Concrete	Type (4)Type Response Concrete	Type (5) Outcome concrete
Future manufacturing	3D manufacturing boom in media	Personalized manufacturing affordable in cost and in time	General electric unleash 1000 patents to be used by inventors	• Big companies using 3D manufacturing, i.e. Boeing producing 200 types of pieces • 3D printers priced under 1,000 dollars • Important robot improvements: baxter, tesla utilization of robots • 48% of US producers are thinking about bringing back production	Forecast about big data application to industry contribution to GDP
New educational models	Boom of MOOC courses in media	New initiatives to digitalize content		• Outstanding educational entities adopting MOOC • MOOC enrolment soar	Pilot testing of digital school bag in 45 schools in Spain, implying a reduction of 80% in cost

The conclusions obtained from this analysis are:

- Most weak signals identified are of type 4, (11 signals, 55%), followed by type 1 and type 2 (3 signals each one, 15%), type 5 (2 signals, 10%), and type 3 (1 signal, 5%).
- Emerging issues are not selected by a unique signal but by a structure of signals that is different in each case. In this use case, all emerging issues have signals of type 1, 2 and 4; a more in depth analysis about if that can be considered a rule of potentiality of an emerging issue would be interesting.
- The fact that a signal is more concrete (higher level) does not mean that it has a greater weight to select an emerging issue. For instance, the weak signal "Forecast about contribution to Europe GDP of application of big data to industry "is classified in level 5 but it has less relevance for authors than "Personalized manufacturing affordable in cost and in time"
- The impact in media is an important factor for all emerging issues that suggests that they are in the point of turning into trends.
- Signals gain importance by accumulation of evidence. For example, in the signal "Smartwatches from first level companies: Samsung smartwatch, Sony smartwatch,

Qualcomm Toq smartwatch…", is the accumulation of companies to this trend that really contributes to the validity of this signal. The same happens with the signals "Some eHealth personal devices on the market with good results: Fitbit, Jawbone…" or "Prototypes of clothing including sensors and connectivity: Rest Devices, Sproutling)".

Though the utility of this classification to obtain a global vision of signals and their maturity is manifest, this approach reveals important limitations as a criterion to select emerging issues. Besides the subjectivity, this example shows that there is not a strong relationship between the degree of concretion of a signal and its relevance to warn that something disruptive will happen. One conclusion that is a limitation too is that the valuation of the potential of an emerging issue does not depend on a unique signal but on an accumulation and a structure of signals whose logic it is not easy to discover.

SIE2013 external analysis of emerging issues: Signals presence in Internet media

Using search engines to quantify the diffusion of concepts in Internet media implies first the effort to find the correct words to include in the query, that is, pertinent terms that capture weak signals main idea. Sometimes, several terms are required to capture it or even the utilization of a semantic ontology. In some cases, a term or combination of terms that capture the specific and differential idea of a signal are not found, which is one of the limitations of this approach. Referred to the SIE2013 use case, the terms used in the queries, the number of hits both in 1S2013 and 1S2012, and the calculated growth are showed in Table 9. Strength and growth are calculated using equations (a) and (b) stated previously where the period considered is the first semester of 2013 (the period when the emerging issues where detected) and the same period of 2012 to calculate the % of change.

Table 9 Strength and growth of signals in the web applied to SIE2013

		Strength of the signal		Growth Pace
	Search Term	Google hits 1S2013	Google hits 1S2012	% Change 1S2013/1S2012
Wearable	"smartwatch"	5.710.000	1.720.000	232%
	"Google glass"	8.980.000	2.260.000	297%
Future manufacturing	"3d printing"	4.790.000	733.000	553%
	"fablab" OR "makerspace"	102.000	40.900	149%
	"industrial internet"	10.300	4.440	132%
	"baxter" AND "robot"	31.700	20.100	58%
	"open hardware"	30.800	22.600	36%
New educational models	"MOOC"	612.000	148.000	314%

Some qualitative conclusions drawn from these data are:

- There is a high range in the number of 1S2013 hits (from 10.300 to 8.980.000) that implies that the number of hits is not a fundamental factor to select an emerging issue. The main statistical values that describe this variable are **μ** = 2,533,350 and **σ**= 3,489,430. This leads to the 95% confidence interval [0; 5,450,590], too wide to be useful
- Related to growth, all signals show a high rate, in some cases over 300%. So there is some evidence that emerging issues weak signals have a high growth rate presence on the Internet, though a high growth rate does not mean that a signal is associated to an emerging issue (think for that in most marketing campaigns of products). In this case the main statistical values are **μ** = 221,4 and **σ**= 168,5, and the 95% confidence interval is [80,53; 362,22]. As appreciated, this variable gives some evidence about if a fact is associated to a high potential emerging issue that is near to become a trend, but it is not conclusive.

So, though presence, strength and growth in Internet media can give some clues about whether an emergent phenomenon has high potential, they are not conclusive to discriminate at least with the data of this research.

SIE2013 internal analysis of emerging issues: post-structuralism approach

The internal analysis of emerging issues has been carried out applying CLA method focusing on the hidden layers (Systemic Causes, Discourse/worldview and Myth/metaphor) and not on the weak signals (litany). So the first task carried out was the identification of causal factors, this is, different myths or narratives, worldviews and systemic causes that can influence the evolution of SIE2013 emerging issues. From these visions it is interesting to highlight those that have a positive influence (Table 6) as they can act as drivers of the emerging issues meanwhile other visions that can work in the opposite direction were also identified in order to best understand the complexity and the frictions of the process.

Table 10 SIE2013 Emerging issues internal drivers using CLA (causal layered analysis) scheme

<table>
<tr><th></th><th>(1) Wearables</th><th>(2) Future Manufacturing</th><th>(3) New educational models</th></tr>
<tr><td rowspan="7">Systemic causes</td><td></td><td>(3)Educational cost soaring</td><td></td></tr>
<tr><td>(1)Health cost soaring</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">(2,3)Economic crisis</td></tr>
<tr><td></td><td colspan="2">(2,3) Market national barriers are blurring</td></tr>
<tr><td></td><td colspan="2">(2,3)Knowledge specialization</td></tr>
<tr><td colspan="3">(1,2,3)New technologies are prepared for the jump</td></tr>
<tr><td colspan="3">(1,2,3) Ageing</td></tr>
<tr><td>Discourse</td><td>(1)Connectivity is progress</td><td></td><td></td></tr>
</table>

	(1) Wearables	(2) Future Manufacturing	(3) New educational models
		(3) Education, a fundamental right	
		(2,3) Local world first	
		(2,3) Self-control of life	
		(2,3) Creative partners between independent human beings	
		(2,3) Constructivist approach of knowledge	
	(1,2,3) My world first		
	(1,2,3) Data as a new material		
	(1,2,3) Technology is nice		
Myth/metaphor	(1,3) Defense of the weak		(1,3) Defense of the weak
	(1) Human-Superpowers		
		(2,3) Defense of tribe	
	(1,2,3) I'm unique		
	(1,2,3) Internet connection is the new food		
	(1,2,3) Free is better		
	(1,2,3,) Open is better		
	(1,2,3) Digital is the new alchemy		

This table of drivers gives valuable information for the strategy analyst to identify non-obvious aspects that must be enhanced to encourage the evolution of the emerging issues. It is also useful to detect relations among them, for instance from this table can be deducted that emerging issue 2 (Future Manufacturing) and emerging issue 3 (New educational models) have a lot of common internal foundations (5 out of 7 systemic causes are shared among them). It is also observed that when one goes to deeper levels, the causal factors are more common, which reflects that the commonalities of these emerging issues are very deep (5 out of 8 Myths are shared by all emerging issues).

As commented previously factors do not act in an independent way and there is a causal effect among layers in the sense that the factors identified in one layer are the foundations of the others placed in layers situated above as suggested by the metaphor of the iceberg. Depends on the point of view of the analyst based on his experience to value that relations and their strength. So, in the use case considered authors have identified as weak signals (the litany) those signals that fit with their conceptual model of the underlying layers. For instance, considering only the positive factors identified in the previous table, the weak signal "Some eHealth personal devices on the market with good results" is related to systemic causes such as "ageing" or "health cost soaring". The same happens from one layer to other, i.e systemic cause "ageing" is related to worldview "self-control of

life", or worldview "My world first" to the Myth "I'm unique". This implies to consider all these factors as a complex structure (a kind of gestalt) where it is also possible to identify contradictions between driver's layers, for instance systemic cause "Market national barriers are blurring" works in the opposite direction than the Myth "Defense of tribe". These drivers also clash with other possible factors within layers reflecting different stakeholder's interests and different worldviews and myths. For instance, the Myth "Open is better" has to fight against "Big brother dystopia" and "Free is better" against "Everything has a price". At the level of discourse or worldviews there are important tensions too, for instance "Education, a fundamental right" against "Education as status" or "Constructivist approach of knowledge" against "University as knowledge keeper". At systemic cause's level the contradictions are clearer and associated with different stakeholder's interests, for instance Administrations are worried by health cost soaring, medical staff by stability of employment, and ICT (Information and communication technology) companies by technology deployment.

In the case analyzed, these two approaches have been used by Telefonica to obtain a big picture of the situation of these emerging issues and the causal factors that drive them. The external approach was useful to understand that these phenomena were near to take out and for that reason to place them in the center of the surveillance radar. The internal approach helped to stand out the drivers and other factors that work in the opposite direction. These tensions and contradictions offered information that was used to see phenomena in a holistic way and to decide action. For instance, it was detected that the tension between "Open is better" and "Big brother dystopia" was able to define the success or failure of these emerging issues. These narratives were contradictory in principle but a solution was proposed at systemic level that consisted of fostering technologies that allow open data but giving the user the possibility to manage their data, to define who can see them, to delete them... This approach gave place to the elaboration of the Digital Manifest[11].

6.- Conclusions, continuation of the work

Surveillance is an activity of increasing importance, and for this reason many organizations have set up their own observatories. Besides this activity carried out by observatories, a branch of knowledge is being developed around foresight. Though observatories and foresight should go together, there is still an important gap between them because there is a great deal of foresight terminology and methodologies and most of them are not mature enough. This paper analyzes the capability of emerging issues to become consistent trends. Two approaches are considered, one external based on measurable signals, and other internal based on social and economic deep motivations. In the first case two methods are considered, Igor Ansoff's weak signals model and signals presence in Internet media. In the second case CLA method (Causal layered analysis) is considered, and a mathematical framework to value the relevance of emerging issues and the relation between them is developed. These methods are illustrated with a practical exercise based on the emerging issues displayed in the report SIE2013. Considering aspects as difficulty in execution, objectivity and reliability, it is concluded that each one of them has pros and cons, which are summarized in), and for that reason, their use in a complementary way is convenient.

[11] http://www.digitalmanifesto.telefonica.com/manifesto/

Table 4.

Table 11 Pros and cons of different approaches to analyze emerging issues (obtained from the use case)

Approach	Method	Pros	Cons
External	Igor Ansoff weak signal model	It allows to classify emerging issues easily	It gives more importance to a signal when it is more concrete (this is not always true).
	Impact in media: Strength and growth	It allows to classify emerging issues easily, very objective	It does not consider the internal reasons. There is not a clear relationship between these factors and emerging issues importance
Internal	CLA	It considers internal reasons, systemic causes and values. It allows to detect relations among emerging issues	It is subjective

It is concluded that the utilization of these approaches and methods in a complementary way is convenient. Though the analysis of signals seems more objective, in all cases emerging issues have not been detected by one signal but by the sum of lots of them creating a system of signals whose rationale is difficult to find. Deconstruction model seems more powerful than the others to dive into the real causes, as it is the only one that considers the relation among "signals", "emerging issues "and" internal causes.

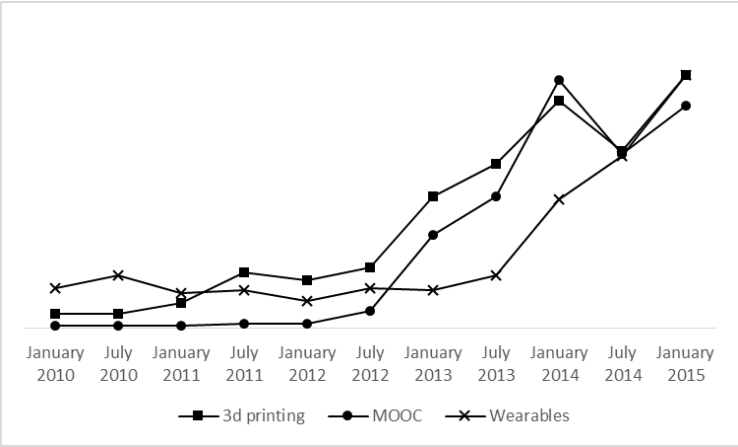
This paper assesses the meaning of these approaches showing their limits. In order that an organization gains the most benefit of them it is recommended to adopt a holistic approach moving between them. Based on the use case developed, it is shown that Ansoff's approach and presence in Internet media offer a good representation of emerging issues level of adoption and some indicators about the stage in which they are, so they should be used in first place to value their maturity and to obtain a big picture of the situation. Diving into the internal motivations as CLA does is very useful to detect drivers, relations between emerging issues, contradictions… therefore to offer a wide picture of change's dynamics and complexity. For this reason this approach is ideal for strategic planning purposes and to foster the internal debate, as it was showed in the case of Telefónica.

However, the interpretation of signals with regard to hidden society motivations makes it to some extent dependent on the preconceived ideas that the analyst has on the future. In this paper a framework to understand the potential of trends has been introduced, but at the end, it is always fed by expert's assessment. For this reason, the utilization of models to raise the structure of values in society would limit or at least identify subjective points in this kind of reasoning. With this aim, the

utilization of Ferdinand de Saussure's structuralism and Jacques Derrida's deconstruction concepts could help and are lines of enquiry for further research.

Figures:

Figure 4 Timeline evolution of searches on Google



Source: Own elaboration. Based on Google Trends Tool

List of references:

Ansoff, I.H., 1975. Managing Strategic Surprise by Response to Weak Signals California Management Review, Vol. 18, No 2.

Ansoff, I.H., 1984. Using Weak Signals, in: Implanting Strategic Management. Pretince/Hall International Englewood Cliffs, New Jersey. P.20

Ashley, D.B., 1989. Project Risk Identification Using Inference Subjective Expert Assessment and Historical Data, The State of the Art in Project Risk Management, International Project Management Association, Proceeding 1989, pp. 9-25.

Battistella, C., 2014. The organization of Corporate Foresight: A multiple case study in the telecommunication industry, Technological Forecasting and Social Change, Volume 87, Pages 60-79. DOI: 10.1016/j.techfore.2013.10.022

Beer, S., 1972, Brain Of The Firm, Allen Lane, The Penguin Press, London

Brabandere, L., 2005. False endings, weak signals; putting together the odd pieces of information that could save your business, Across the Board, 52-55

Coffman, B., 1997a. Weak Signals Research. Part I: Introduction, Journal of Transition Management , MG Taylor Corporation.

Coffman, B., 1997b. Weak Signals Research. Part II: Information Theory, Journal of Transition Management, MG Taylor Corporation.

Coffman, B., 1997c. Weak Signal Research, Part IV: Evolution and Growth of the Weak Signal to Maturity, Journal of Transition Management, MG Taylor Corporation

Daheim, C., Uerz, T., 2008. Corporate foresight in Europe: from trend based logics to open foresight, Technol. Anal. Strateg. Manag. 20 (3) 321–336. DOI:10.1080/09537320802000047

Gordon, A. (2013). Adaptive vs. visionary-advocacy approaches in scenario planning: implications of contrasting purposes and constraint conditions (Doctoral dissertation, School of Business, Faculty of Commerce, University of Cape Town).

Groddeck, V., Schwarz, J. O., 2013. Perceiving megatrends as empty signifiers: A discourse-theoretical interpretation of trend management. Futures. DOI: 10.1016/j.futures.2013.01.004

Harris, D., Zeisler, S., 2002. Weak Signals, Detecting the next Big Thing, The futurist, Vol. 36:6, 2002 pp. 21-29

Heijden, K., 1997. Scenarios, Strategies, and the Strategy Process. Center for Organisational Learning and Change.

Hiltunen, E., 2008. The future sign and its three dimensions, Futures 40, 247–260. DOI: 10.1016/j.futures.2007.08.021

Hiltunen, E., 2010. Weak Signals in Organizacional Futures Learning. Helsinki School of economics. ISBN 978-952-60-1039-7

Hines, A.,2003. An audit for organisational futurists: ten questions every organisational futurist should be able to answer, Foresight 5 (1) 20–33.

Holopainen, M., Toivonen, M., 2012. Weak signals: Ansoff today, Futures 44, 198–205. DOI: 10.1016/j.futures.2011.10.002

Ilmola, L., Kuusi, O., 2006. Filters of weak signals hinder foresight: Monitoring weak signals efficiently in corporate decision-making. Futures, 38(8), 908-924

Inayatullah, S., 1998. Causal layered analysis: Poststructuralism as method. Futures, 30 (8): 815–829. DOI: 10.1016/S0016-3287(98)00086-X

Inayatullah, S, 2008, ‘ Six pillars: Futures thinking for transforming’ , Foresight , Vol 10, No 1. 4– 21. doi:10. 1108/14636680810855991

Inayatullah, S., Milojević, I., 2015. CLA 2.0 Transformative research in theory and practice. Tamkang University Press

Luce, R.D., and Raiffa, H., 1958. Games and Decisions (New York), pp 276-8

Molitor, G.T.T. 1977, How to Anticipate Public-policy Changes, S.A.M Advanced Management Journal, pp. 4-13

Molitor, G.T.T., 1981. Consumer Policy Issues: GLboal Trends for the 1980’s Advances in Consumer Research, Vol. 8, pp. 458-466

Molitor, G.T.T., 2003. Molitor Forecasting Model: Key Dimensions for Plotting the Patterns of Change, Journal of Future Studies, 8(1): 61-72

Nikander, I.O., Eloranta, E., 2001. Project management by early warnings, International Journal of Project Management Volume 19, Issue 7, Pages 385–399. DOI: 10.1016/S0263-7863(00)00021-1

Nikander, I.O., 2002. Early warnings- a phenomenon in Project management, Dissertation for the Degree of Doctor of Science in Technology, Helsinki University of Technology

Pentland, A., 2014. From Ideas to actions, in: Social Physics. How good ideas spread. The lessons from a new science. The Penguin Press. New York

Pettigrew, A.M., Thomas, H., 2002. Whittington, R., Corporate Strategy: Managing Scope and Strategy Content, in: Handbook of Strategy and Management, Sage Publications

Saritas, O., Smith, J.E., 2010. The big picture – trends, drivers, wild cards, discontinuities and weak signals. Futures. DOI: 10.1016/j.futures.2010.11.007

Schiebel, E., Hörlesberger, M., Roche, I., François, C., Besagni, D., 2010). An advanced diffusion model to identify emergent research issues: the case of optoelectronic devices. Scientometrics, 83(3), 765-781.

Seidl, D. The concept of ‘‘weak signals’’ revisited: a re-description from a constructivist perspective, in: H. Tsoukas, J. Shepherd (Eds.), Managing the Future:
Developing Strategic Foresight in the Knowledge Economy, Blackwell, Oxford, 2004, pp. 153–170.

Senge, P. 1990. Prisoners of the system, or prisoners of our own thinking, in: The fifth discipline, Doubleway, New York, Chapter 1.

Schwartz, P., 1991. The Art of the Long View: Planning for the Future in an Uncertain World, Doubleday Currency, New York, NY.

PAPER 2

Futures

Volume 84, Part B, November 2016, Pages 145–153

The role of metaphors in the development of technologies. The case of the artificial intelligence

Javier Carbonell[a], Antonio Sánchez-Esguevillas[b], Belén Carro[b]

Show more

https://doi.org/10.1016/j.futures.2016.03.019

The role of metaphors in the development of technologies

Technology plays a prominent role in configuring the way we live and work. In this paper we go further and think that it is a first level driver in the configuration of our deepest perceptions and has a paramount influence on shaping our worldviews and metaphors, though this aspect goes unnoticed for most of the population.

In this paper we analyze how metaphors take action in the characterization of technologies, mainly emerging technologies, and in their evolution, and furthermore the impact of technologies and metaphors on the way we perceive our daily life. We analyze metaphors underlying brain nature and artificial intelligence, raising the connections between them and showing how metaphors in one of these fields impact on the way we understand the other. This fact has important consequences, for instance it conditions the evolution of computational systems, and we propose two scenarios for this evolution.

This paper relies on the conceptual model and classification of metaphors proposed by Lakoff and Johnson in "Metaphors we live by", from the orientational metaphors that show values and mantras, to the deepest structural metaphors that are reconfiguring how life is conceived. It also relies on CLA (Causal Layered Analysis) and to its reference book "CLA 2.0" in order to insert this analysis in a wider and future oriented framework and to analyze scenarios.

Keywords: CLA, metaphors, artificial intelligence, Lakoff and Johnson

Highlights:

- Metaphors reigning in society shape the evolution of technologies and the evolution of technologies shape metaphors and how we perceive our daily reality in a two way process
- Clash of metaphors conditions the evolution of technologies
- CLA offers an interesting framework to analyze metaphors with a future oriented approach and to build scenarios

0.- Introduction

Lakoff and Johnson (Lakoff & Johnson, 1980) set a milestone in the vision of language and its relation with cognition processes with a reinterpretation of metaphors that considered them as a matter of cognition rather than of language. Some statements as "human thought processes are largely metaphorical", "the most fundamental values in a culture will be coherent with the metaphorical structure of the most fundamental concepts in the culture", "… then the way we think, what we experience, and what we do every day is very much a matter of metaphor", "we have found that most of our ordinary conceptual system is metaphoric in nature"… have changed the way that metaphors and to some extent language and cognition is conceived, giving rise to CMT (Conceptual Metaphor Theory) that has evolved to CTM (Contemporary Theory of Metaphor) (Lakoff, 1993) in the following decade. As any novel researching field, CTM has been subjected to important debates and developments, (Lakoff & Turner, 1989; Lakoff & Johnson, 1999; Gibbs, 1994; Gibbs et al, 1997).

Though Lakoff and Johnson's statements have always raised some controversies and at this moment continue raising them, most of their initial thoughts included in "Metaphors we live by" continue being the reference for the academic and scientific community with regard to metaphor theory and have been widely applied in diverse fields: cognitive psychology (Gibbs, 1994), mathematics (Lakoff & Nuñez, 2000), sociology (Lopez, 2003), politics (Goatly, 2007), neuronal theory (Grady, 1997), marketing (Zaltman & Zaltman, 2008), communication (Steen, 2007), grammar (Ruiz de Mendoza & Mairal, 2007), to mention some of them.

In the futurist arena, the concept of metaphor has played an important role too, receiving an important push when it was included as the "foundation" layer in CLA (Causal Layered Analysis) method (Inayatullah, 1998). This method fits in a six pillars process approach to the future (mapping the present, anticipating the future, timing the future, deepening the future, creating alternatives, transforming the present), being metaphors included in pillar 4, deepening the future (Inayatullah, 2008). CLA considers a deconstruction approach that entails a process of going from the most visible and apparent signals of a phenomenon to the hidden motivations, which are usually engrained in the cultures but most of the time go unnoticed by people. With that purpose it uses a four layers' model (litany, systemic causes, discourse/worldview, myth/metaphor) where litany includes the most visible signals of a phenomena and myth and metaphor the deep motivations that move the behaviors. In this way Inayatullah and Lakoff go beyond the idea that metaphors are critical for understanding our vision of reality and they claim that they create a predisposition for our actions. This approach is to some extent aligned with the Sapir-Whorf hypothesis that the language we speak predisposes the way we think and act.

Metaphors and dominant systems of values in societies are changing as a result of different forces that are continuously shaping their citizen's conceptual models. These forces are very different in nature: scientific discoveries, demographic changes, cultural clashes, weather changes, technologies… Several authors have studied the connections between metaphors and technology, in most of the cases they associate metaphors to communication (Kaplan, 1990; Christidou et al, 2004), but other studies go beyond that and deal with the influence of metaphors in the utilization of technologies (Stevenson, 2008) or the influence of metaphors on defining reality in the deployment of technologies (Walsham, 1991).

In the two first sections of this paper we describe metaphors according to Lakoff and Johnson's categorization and we link them with CLA's layers. In the two following sections we show the relationships among the way we perceive reality, technologies and metaphors and how the clashes among metaphors can condition the adoption of technologies. In the following section we develop a case about the interactions between the metaphors associated to brain nature and artificial intelligence, including a CLA analysis of the future scenarios. The paper finishes with the conclusions and further work section.

1.- Metaphors, a high level categorization

In this paper we will consider the high level classification of metaphors presented in the first edition of "Metaphors we live by" (Lakoff & Johnson, 1980) that classified metaphors as orientational, ontological and structural. Orientational metaphors are those that organize a whole system of concepts with respect to one another and most of them have to do with spatial orientation, ontological ones understand our experiences in terms of objects and substances, and structural ones are those that structure one concept in terms of another.

This classification has not been static over the years or free from controversy. In fact, years later Lakoff & Turner (1989) added a new category, image metaphors, which are those metaphors that map images onto images. Szwedek (2007) has claimed that the distinction between ontological, structural, and orientational metaphors is not correct and for him orientational metaphors are in nature ontological metaphors. Other classifications for instance according to the nature of the source domain, or to the distinction between primary and compound metaphors (Grady, 1997) have been developed. A good assessment of these classifications is gathered by Ruiz de Mendoza and Perez (2011).
Nevertheless, we think that the first classification is valid for our purposes and allows us to understand the different nature of metaphors, from those that are based on spatial orientations to those that imply conceptual structures.

2.- Bridging Lakoff's vision of metaphors and CLA

The previous classification of metaphors offers a good approach to understand their richness and a good starting point to think about the different levels in which they can work. But thinking in terms of future requires considering metaphors approach within a more general and future oriented framework. We consider that CLA can play this role because this method offers a framework to analyze phenomena holistically considering four levels of depth (understating depth metaphorically, more visible is up and less visible is down), myth/metaphors being the deepest layer. On the other

hand, the litany layer includes the most superficial expression of a phenomenon, that is, the visible signals, for instance news or events. In between there are other two levels, systemic causes and discourse/worldview whose nature is described in Table 12.

Table 12 CLA (Causal Layered Analysis) layers

Litany	Quantitative trends, problems, often exaggerated, often used for political purposes — (overpopulation, for example) as usually presented by the news media
Systemic causes	Includes social, technological, economic, environmental political, and historical factors (rising birthrates, lack of family planning, for example)
Discourse/ worldview	Supports and legitimates the systemic causes (population growth and civilizational perspectives of family; lack of women's power; lack of social security; the population/consumption debate, for example)
Myth/ metaphor	These are the deep stories, the collective archetypes — the unconscious and often emotive dimensions of the problem or the paradox

Source: Inayatullah, 1998

In this section we look for the correlations between Lakoff and Johnson's classification of metaphors and CLA layers. Lakoff and Johnson's structural metaphors are related to conceptual models that enable understanding a concept in terms of another. An observation of the examples showed in the book CLA 2.0 Transformative Research in Theory and Practice that collects the best practices with this methodology until now (Inayatullah and Milojević, 2015) shows that most of the metaphors considered in the myth/metaphor layer of CLA are structural metaphors. For instance, in the chapter of this book, Metaphor and Causal Layered Analysis, written by Saliv Bin Larif, the author resorts at Myth/metaphor level to metaphors like the war metaphor, or the identification of concepts (economy, nation) with a body. These are structural metaphors as they define concepts in terms of other concepts which structure is well recognized.

Orientational metaphors coincide to some extent with the CLA layer discourse/worldview, as the most common orientational metaphors have the *up* and *down* nature and are related to *good* and *bad* metaphors, so they indicate our values and our worldview.

Ontological metaphors allow us to consider different elements and abstract concepts as resources and substances, and in this way to operate with them. For that reason, they are important to analyze phenomena from a systemic point of view. For instance, we can say that health cost per inhabitant is climbing because we consider health as a substance, and we can say that there will be an energy breakdown because we consider energy as a resource.

According to this reasoning, three of the CLA layers (system, worldview, myth) relate directly to metaphors, not only the myth/metaphor layer, and that they relate to different kinds of metaphors.

Litany reflects events/issues that happen in society usually filtered by the underlying layers and for that reason by their metaphors, for instance, the piece of news "Life expectancy is rising by three years a decade - and experts warn that could push state retirement age up to 70 by 2050", published by This is Money on September 2015, suppose considering the following metaphors from different

layers: *life as a substance, more life is better* that is based on more is better, *life is a journey with different stages…*

Taking all this in consideration a high-level relation between Lakoff and Johnson's model and CLA can be established as it is shown in Table 13.

Table 13 Relation between CLA and Lakoff and Johnson's metaphor

CLA layer	Lakoff and Johnson's metaphor classification
Litany	Facts, filtered by metaphors from underlying layers
Systemic causes	Based on ontological metaphors
Discourse/worldview	Orientational metaphors
Myth/metaphor	Structural metaphors

Source: own elaboration

In this paper we have used Lakoff and Johnson's categorization of metaphors to feed CLA's layers because it is the most extended model in the researches about metaphors. In the futurist arena, other approaches and classifications linking metaphors and CLA are being debated at present (Kuusi et al, 2015).

3.- Technology metaphors and their impact in the evolution and perception of reality

People perceive reality through the lens of their mind. These lenses or filters in one way or another rely on internal cognitive knowledge structures: a signal can mean something for one actor and lack of interest to others as ''Cognitive systems interact with their environments, but it is the cognitive system – and not the environment–that determines how and in what way it interacts" (Seidl, 2004). In this paper we consider that metaphors play a central role in configuring these filters and thus in our perception of reality.

We can consider technologies, at least when they are emerging technologies, as a new reality. For instance, when the computer was invented, this supposed a new physical element, but as a new concept it was necessary to understand it in terms of metaphors of other concepts well known by people, in this case the brain metaphor as it will be explained in the next sections.

The necessity to resort to metaphors in order to understand technologies, at least when they are emerging, can be illustrated by analyzing the emerging technologies included in the Hype Cycle for Emerging Technologies reports from Gartner. There are two main reasons to select these reports. Firstly, it is a prestigious document well recognized by all innovation and research sectors that reaches the mainstream public. This importance is shown by the fact that the query on Google search engine about items that include the terms "Gartner" and "emerging technologies" carried out on 23

October 2015 retrieved more than 204k results, about 2,5% of all the items retrieved by the query "emerging technologies". Secondly, it considers emerging technologies from the point of view of societal impact. This approach is mentioned at the beginning of the reports: "This Hype Cycle brings together the most significant technologies from across Gartner's research areas. It provides insight into emerging technologies that have broad, cross-industry relevance, and are transformational and high-impact in potential".

We will consider emerging technologies that were included in the 2014 edition[12] for the first time. These emerging technologies are based on metaphors as Table 14 shows. We have identified these metaphors from the descriptions included in the report. They serve as a framework to define and to explain the emerging issues and have influence in the language used to describe them as depicted in the table.

Table 14Emerging technologies included in the Hype Cycle for Emerging Technologies, 2014 for the first time

Emerging Technologies	Metaphors	Expressions on Hype Cycle for Emerging Technologies, 2014 supporting the metaphors
Data science	Data are resources	Voluminous data, data preparation
Software-defined anything	Software is the new construction material	Software-defined storage, infrastructure programmability
Cryptocurrencies	Software is money	Virtual money, coins, value, currency
Hybrid cloud computing	Computing is a cloud; computing is a mixture	Cloud services, integration, Cloud service composition, cloud that is made up of multiple sets
Smart advisors	Computational systems are intelligent	Deliver the best answers to users' questions, individualized recommendations
Connected home	Home is a container of connected devices	Interconnection of multiple devices, homes as silos of services and products
Digital security	Digital is a resource	Digital assets, tractable forms

[12]http://www.gartner.com/newsroom/id/2819918

Emerging Technologies	Metaphors	Expressions on Hype Cycle for Emerging Technologies, 2014 supporting the metaphors
Smart Workspace	Spaces are intelligent	Things can help employee performance, feedback related to mood, stress…

Source: own elaboration. Based on descriptions in Hype Cycle for Emerging Technologies, 2014. Gartner Group

According to this table, a great deal of the metaphors associated with emerging technologies have an ontological character and consider abstract concepts such as data, digital or software as resources and substances making it possible to manage these abstract concepts as if they were materials. This power of new technologies to treat natural elements as substances and resources has been common in past, mainly in the western culture where society is well influenced by rationalism. For instance, the discovery of electricity brought the metaphor *light is a resource*, as "light" became a resource independent of the sun, and for the first time it was possible to buy it, to spend it… The same happened with people after the industrial revolution. This revolution entailed the substitutability of working people in factories and the metaphor *people are a resource* that is considered as one of the most solid foundations of our economic model. This metaphor has impregnated our working language with expressions such as "this activity requires five labor hours" or "we need 2.5 FTE (Full-Time Equivalent)[13] in this department". Other technologies have turned other natural elements into resources, for instance the wind turbines have converted the wind into a resource, or the telecommunications technologies have converted the communication into a substance. We can conclude that the ontological metaphors are paramount in the definition of new technologies and these metaphors have double way implications: they allow to characterize new technologies and to experience reality in a new way, in this case treating natural concepts as materials.

Structural metaphors are also very common in the characterization of emerging technologies, for instance *systems are intelligent* and *spaces are intelligent* give a complex and rich framework to understand smart advisor and smart workspace emerging technologies. This conceptualization based on metaphors is not only useful in the definition of these technologies but it continues as a framework in the development of the technologies and in the perception of the reality. For instance going back again to the Gartner Hype Cycle of emerging technologies, in this case the release of 2004[14], 10 years before the one used previously to highlight their influence, we see that metaphors under emerging technologies that were in the stage "on the rise" at that moment have had a big influence, not only in the evolution of these technologies but in the evolution and our perception of the reality. For instance, the emerging technology Wiki was based on the metaphor *knowledge is open* and the

[13] Ratio of the total number of paid hours during a period (part time, full time, contracted) by the number of working hours in that period

[14] https://www.gartner.com/doc/453677/hype-cycle-emerging-technologies-

emerging technology Augmented Reality was based on other metaphors such as *senses define reality* or *virtual worlds*. Those metaphors sounded strange at that moment but now they are part of our mindset. The proliferation of the wiki approach to knowledge in the first case and the fact that numerous companies and consulting companies consider that we are now living a convergence between online and offline worlds (for instance Microsoft has included Real-redefined that addresses this subject in its analysis of Digital Trends 2015[15]) show how these metaphors have had an in-depth influence in the evolution and perception of reality.

The entailments between technologies and social metaphors go beyond that and some of the dominant metaphors in society have technological foundations too, for instance, *world is a village* is possible because communication and transport technologies have reduced time to go from one place to another, and to communicate with people from the other side of the world. These metaphors are based on the ontological metaphors *time is a resource* and *communication is a resource*, in the last case the resource is a conduit that allows us to be close to people though they are far physically. Other metaphor *society is nature protector* is based on the fact that some technologies have the power to destroy our environment, for instance, nuclear energy, combustion engines emitting CO_2, or technologies to overexploit natural resources, and since they exist, society has the new role of protecting the planet. Though in some cultures nature is considered an ecosystem where mankind is one member more, in Jewish – Christian culture, metaphor *man is the king of nature* is well engrained, in this case the crude reality has forced a change in western mindset.

All these examples show that metaphors work as a kind of framework that allows a two way process: technologies are characterized based on metaphors taken from the reality of the daily life and these metaphors shape the evolution and the perception of this reality.

4.- Influences in the evolution of technologies: clash of metaphors

As mentioned, there are strong entailments between reality, new technologies and metaphors and the relation among these three terms will mark their evolution.
In principle there is a positive attitude to technology in most countries and cultures as few things have had such a high impact on the citizen's standard of life and progress as technologies. For this reason most of the countries and organizations have fostered the use of technologies, for instance according to data from the Broadband Commission for Digital Development from the UNESCO, 148 countries in the world have a national broadband plan[16].

From that point of view the orientational metaphor *technology is up* that is related to *technology is good* has dominated the vision of technology during the last two centuries. These metaphors are aligned with the fact that technology implies improvements in productivity, these improvements imply more quantity and almost in all cultures *more is up* and *more is good* (Lakoff & Johnson, 1980). Nevertheless, this vision has been questioned when there are frictions between these metaphors and other well-established metaphors. For instance, during the Luddite protest at the

[15] http://advertising.microsoft.com/en/digital-trends
[16] The state of broadband 2015. ITU and UNESCO

beginning of XIX century *technology is up* collided with *job is up*. During the dispute "science against religion" at the beginning of the XX century it bumped against *Bible claims are up*. In some communities, for example some monk communities, the metaphor *less is good* is followed. In those cases, technologies are adopted only for certain purposes, for example for health purposes. There are even religious communities that do not accept the use of technologies for that purpose. In this way, cultural differences have an important influence on the grade of adoption or how technology evolves.

This debate about the goodness of technology questions the premise that *technology is up*, at least above a threshold, and continues at present in diverse fields. For example, ICTs (Information and communication technologies) are going through a period of big growth and most experts claim that new services based on them have a high potential to impact on society positively. Nevertheless, their massive utilization raises several concerns about their limits and about possible negative effects on population. We have resorted to The Pew Research Center, an important organization that studies the issues, attitudes and trends shaping America and the world, in order to highlight some of these concerns. We see that from the 29 reports published by this organization about the Internet during the last year, (from September 2014 to September 2015) eight are dedicated to concerns about its use. As it can be seen on Table 15, these concerns are digital divide, harassment and privacy and they are so important that this organization has published several reports centered on each of these issues.

Table 15 Reports published by The Pew Research Center on concerns related to the Internet

Concern	Date	Report Title	Metaphors
Digital Divide	July 28, 2015	15% of Americans don't use the internet. Who are they?	Orientational: equality is up; Ontological: ICTs are walls; Structural: class war
Digital Divide	April 30, 2015	Racial and ethnic differences in how people use mobile technology	
Digital Divide	April 20, 2015	The numbers behind the broadband 'homework gap'	
Digital Divide	September 19, 2014	Census: Computer ownership, internet connection varies widely across U.S.	
Harassment	June 1, 2015	The darkest side of online harassment: Menacing behaviour	Orientational: respect is up; Ontological: ICTs are weapons; Structural: people as depredators
Harassment	November 20, 2014	About 1 in 5 victims of online harassment say it happened in the comments section	
Privacy	May 20, 2015	Americans' Attitudes About Privacy, Security and Surveillance	Orientational: privacy is up; Ontological: ICTs are eyes;

Concern	Date	Report Title	Metaphors
Privacy	April 14, 2015	Why some Americans have not changed their privacy and security behaviours	Structural: big brother dystopia

Source: Own elaboration

The clash between the capacities that the Internet offers and some values well established in society, such as equality, respect or privacy, is behind these concerns. The CLA analysis, see Table 16, offers us a holistic vision of these concerns highlighting their deep motivations, their systemic causes and their external expressions or signals

Table 16 CLA about Internet concerns

Litany	NSA scandals Cyberbullying scandals Initiatives to fight against digital gap WikiLeaks…
Systemic causes	Different speed of adoption of Internet Increasing surveillance power from the governments New dynamics of communication
Discourse/worldview	Privacy is up Respect is up Equality is up
Myth/metaphor	Big brother dystopia People as depredators Class War

Source: own elaboration

This approach implies to consider phenomena as the Internet as gestalts, that is, a form based on a complex structure with different levels of depth, thus allowing us to detect relations and frictions among levels and with other gestalts. For instance, the metaphor *big brother dystopia* clashes with the metaphor *the state as protector*. At the end, a kind of negotiation appears when two metaphors clash, for example a Telefonica report claims "Sharing data on the Internet is the price to pay for the benefits of Internet usage, if you want to be in this world, you have to enter into the game"
These clashes happen at other levels too, for example at worldview level the metaphor *equality is up* clashes with *market is up*. A detailed analysis of these frictions and relations in the case of ICT trends is required to understand the dynamics of these phenomena and to make decisions (Carbonell et al, 2015).

Though we have centered this analysis on ICTs, an in-depth study on other technologies, for instance genetics or energy technologies, would have also raised ethical or social concerns. In the case of genetics and other fields related to biology the importance of these frictions is so high that they have given rise to a new field of study, bioethics, which tries to discuss and regulate the clash of metaphors that these technologies can provoke. More than 80k references in the scholar database ProQuest, and several journals on this topic show the relevance of this concept and serves as an example of how frictions among incompatible metaphors shape and limit the evolution of technologies.

5.- Case Study: scenarios for the impact of brain metaphors in the evolution of computational systems

As previously stated, technologies are not only changing our world in a materialistic and pragmatic way but they are a primary factor in defining our conceptual models, influencing the way we understand and perceive our experiences. In this section we will analyze these entailments for the case of Artificial Intelligence technologies. By Artificial Intelligence we mean the capacity of technologies to replicate some features of the human intelligence, a claim that is enunciated by most specialists as "the study and design of intelligent agents" (Russell & Norvig, 2003).

The aim to imitate human behavior is a constant in many ancient mythologies and most religions: the mechanical servants built by the Greek god Hephaestus (Gera, 2003), clay golems in Jewish tradition, Lokapannatti mentions that Buddha's relics were protected by mechanical robots (Strong, 2007). Engineers from all the civilizations tried to create this kind of artificial humanoid. For instance, in XII century al-Jazari's designed a waitress humanoid automata that could serve water, tea or drinks, Leonardo da Vinci (1452–1519) sketched plans for a humanoid robot around 1495, and in Japan complex human automata were built between XVII and XIX centuries. All this evidence reveals that the interest of people in creating devices that replicate human behavior is a constant in the different ages and cultures, which can fit with the metaphor man is the new creator or *man is the new god*.

Digital computers, mainly those developed after the invention of transistors and integrated circuits, made possible high processing capabilities and the implementation of complex algorithms. Many people, both experts and the layman, have considered that these technologies offer the long-awaited capacity to replicate the human intelligence. In this section we will associate artificial intelligence to computational performance without entering into the different computational architectures or approaches of these systems.

Alan Turing marked a milestone studying this capacity of computers to simulate human intelligence (Turing, 1950), posing the famous Turing Test. Nevertheless, the validity of this test to identify intelligence has always been controversial as it was shown by Searle’s counter-argument of Chinese room (Searle, 1982). Metaphors linking mind and computing have also been a matter of research along the time (Arbib, 1989; Gigerenzer et al, 1996; Würtz, 2008; Ramscar, 2010), and they have raised controversies too, offering sometimes important criticisms to those models (Carello et al, 1984; Harvey, 1992). The aim of this case is not to dive into these never ending discussions but propose different metaphors about brain functioning and use a future oriented approach to raise possible implications of considering one or another.

Computational systems and brain metaphors

The new reality of computers has had an important impact in widespread metaphors about artificial intelligence. Besides the traditional orientational metaphor *intelligence is up*, the capacity to measure computational performance has stimulated the ontological metaphor *intelligence is a resource*. But undoubtedly, the structural metaphors related to artificial intelligence show the higher transformational power in society. The acceptation in society of the metaphor *computational systems are brains* is proved by its big influence in language, so expressions such as, the computer is thinking, it broke down, the software came up with a solution, this application is context aware, … are usual when we refer to computers. These kinds of terms proceeding from the mind field are even used to name specific trends related to computerization, for instance machine learning or neuronal networks.

As mentioned previously, metaphors act as a framework that ease the interaction in a double way, not only helping to define an emerging technology in terms of a reality but also impacting in the evolution and perception of reality. Thus, besides the metaphor *computational systems are brains* we find that the metaphor *brain is a computer* that has been born in language with expressions like, I'm on stand-by, I'm processing the information, I will save it in my hard disk, … This situation leads us to the fact that the metaphors *thinking is computing* and *computing is thinking* are used interchangeably that reinforce the relationship between the concepts brain and computer as the foundation of Artificial Intelligence. In this case we consider brain and computational systems as the physical support and thinking and computing as the functional activity.

The widespread vision "mental processes are similar to computer algorithms" that can be assimilated to the metaphor *computational systems are brains* was dominant in the 80's though recently it has lost a lot of support (Searle, 1997). Among people who have opposed this vision Roger Penrose (1999) and Gerald Edelman (2001) stand out. Penrose referred to mathematical and physics principles such as Gödel's incompleteness theorem and quantum mechanics, while Edelman developed an in-depth neuronal framework for mind functioning, the Theory of Neuronal Group Selection (TNGS). We will rely on the theory of this latter author as a source of new metaphors about computational systems as it offers an alternative in-depth functional model of mind. The main tenet of his theory is that the brain is not a computer or an instructional system, but a selectional system (Edelman, 2003). The brain thinks and the computer computes, two concepts that have nothing to do with each other, and it is not possible to implement the first activity in terms of the second.

According to TNGS "brain is a selectional system in which large numbers of variant circuits are generated epigenetically, following which particular variants are selected over others during experience…circuit variants that match novel signals are differentially selected through changes in synaptic efficacy" (Edelman, 2003). This means that each brain has a different architecture, genetic factors define the initial architecture but it is the experience that shapes it. From that point of view we can consider the metaphor *brain is a sculpture shaped by experience*.

Though TNGS offers a complex model about neuronal groups and consciousness, in a broad approximation Edelman considers the neuronal group as the functional unit that is connected with thousands of other neuronal groups. Experiences are continually modulating these connections, the more variety and richness of these groups the more capacity a person has to understand the

environment. He uses for this vision the metaphor of comparing these neuronal groups with antibodies and their capacity to fight against elements that have never been found before. This metaphor can be described as *brain is an army of neuronal groups* or taking into account that neuronal groups are associated to categorization (Edelman, 2003), *brain is an army of categories* and to some extent *brain is an army of experiences*.

Edelman's model supposed a shift from considering brain as an instructional system to considering it as a selectional system that gives more importance to experiences and diversity in the process of understanding the environment. We think that this approach can have an important influence on the way we conceive education or team building in organizations, favoring experiences and diversity over traditional aspects. In this paper we will focus on the implication of this vision in the design of computational systems taking into account that the imitation of people behavior and more concretely of intelligence capabilities has been pursued by technology developments in all cultures. For that reason, we can assume that metaphors about the brain functioning will define the evolution of Artificial intelligence and computation.

Scenarios of evolution of computing systems

We consider then two scenarios, in the first brain is an instructional system and in the second brain is a selectional system. The goal of them is to understand how the metaphor used will influence the development of computing systems, taking into account that researches and developers try to replicate brain and human intelligence. We use the CLA method in order to analyze them holistically. (see Table 17).

Table 17 CLA for AI and other computational systems developments under different approaches to brain functioning

	Scenario 1: Brain is an instructional system	**Scenario 2: Brain is a selectional system**
Litany	Optimization software: CRM (Customer Relationship management), Just in Time, ERP (Enterprise resource planning) Intelligent systems based on speed of computation like chess machines	Assistants based on experience Software based on crowdsourcing Intelligent systems based on big corpus of experiences like Watson
Systemic causes	Health and education costs soaring Ageing Unemployment Scarcity of natural resources	Health and education costs soaring Ageing Unemployment Increasing complexity in the interactions and information
Discourse/worldview	Intelligence is up/good Computation is up/good	Intelligence is up/good Experience is up/good Diversity is up/good

	Scenario 1: Brain is an instructional system	Scenario 2: Brain is a selectional system
Myth/metaphor	Brain is a processor Thinking is computing	Brain is a sculpture shaped by experience Thinking is comparing with experiences

Source: own elaboration

As commented in the previous section, this difference in the approach supposes different metaphors and these metaphors imply different worldviews. The computation speed prevails in the first case as the main metaphors are *thinking is computing* and *brain is a processor*, and in the second, the capacity to capture experiences prevails as the main metaphors are *brain is a sculpture shaped by experience* and *thinking is comparing with experiences*. The systemic causes gather the structural factors that affect or even limit the development, factors such as health and education costs are soaring, ageing, or unemployment will condition the development of computational systems and artificial intelligence in both cases. Though, most of the systemic causes that computational systems must face are the same in both scenarios, they are perceived differently in each one of them. In scenario 1, systemic causes are considered from the point of view of optimization of resources, in scenario 2 as complex systems that must be tackled with systems based on experiences. Some systemic causes are more suitable to be managed in one of these scenarios, for instance *scarcity of natural resources* fits better in the first scenario while *increasing complexity in the interactions and information* fits better in the second.

If metaphors refer to the why, the litany refers to the what. There is a clear difference in the nature of computational systems developed in both cases. In the first case, systems are focused on computation speed, definition of complex rules and optimization trying to develop systems that offer a unique and true solution to any problem. This vision has always been predominant perhaps because these systems have been developed mainly in the western world. According to Lakoff & Johnson (1980) in western cultures the metaphor *problems are puzzles* is dominant but in the Middle East the dominant metaphor is the *chemical* that claims that "there is a solution containing all of your problems, either dissolved or in form of precipitates, with catalyst constantly dissolving some problems and precipitating out others…so problems are not the kind of things that can be made to disappear forever". In the second case, systems based on comparing experiences will prevail, for instance virtual assistants based on experience that give advice instead of unquestionable answers, intelligence based on crowdsourcing or corpuses based on experiences.

Though in these scenarios we have presented these two options as sheer, some artificial intelligence and other computational systems include metaphors of both of them. Nevertheless, the relevance of these technologies in the evolution of economy and the whole society shows the importance of the metaphors chosen as predominant when thinking about the future.

6.- Conclusions and further work

The influence of technologies on people's lives goes beyond their instrumental role to improve the "performance" of activities. New technologies, mainly those with a disruptive potential, change the

rules of society, people's behavior and ultimately the way people perceive life. This paper goes beyond that idea and shows how metaphors reigning in society shape the evolution of technologies and the evolution of technologies shape metaphors in society in a two-way process, relying on artificial intelligence and brain functioning to show this process. We can see to some extent similitudes between this process and Marshall Mcluhan thought that technologies give rise to new structures of feeling and perception, so that according to this philosophy we can state "we create technology and thereafter technology creates us".

It also integrates this metaphor approach with a more general methodology, CLA (Causal Layered Analysis), to give a more holistic vision and a future orientation to phenomena, connecting internal motivations, systemic causes and external signals in order to raise scenarios of evolution and to ease foresight activities.

Nevertheless, we think that this is only a starting point in the study of the potential of metaphors when thinking of the future. In further studies it would be interesting to consider other metaphor categorizations besides Lakoff and Johnson's one that could fit with CLA, and it would be advisable to dive more into the relations between Myth/metaphor (internal motivations) and other layers as systemic causes, worldviews, or external signals (litany). The study of internal mechanisms about the influence of metaphors reigning in a culture on society development and society development influence on metaphors could give an insight about metaphors creation and evolution and we think it is a promising line of enquiry

List of references

Arbib, M. A. (1989). The metaphorical brain 2: Neural networks and beyond. John Wiley & Sons, Inc..

Carbonell, J., Sánchez-Esguevillas, A., & Carro, B. (2015). Assessing emerging issues. The external and internal approach. Futures, 73, 12-21.

Carello, C., Turvey, M. T., Kugler, P. N., & Shaw, R. E. (1984). Inadequacies of the computer metaphor. In Handbook of cognitive neuroscience (pp. 229-248). Springer US

Christidou, V., Dimopoulos, K., &Koulaidis, V. (2004). Constructing social representations of science and technology: the role of metaphors in the press and the popular scientific magazines. Public Understanding of Science, 13(4), 347-362

Edelman, G. (2001). Consciousness: the remembered present. Annals of the New York Academy of Sciences, 929(1), 111-122.

Edelman, G. (2003). Naturalizing consciousness: a theoretical framework. Proceedings of the National Academy of Sciences, 100(9), 5520-5524.

Gera, Deborah Levine. Ancient Greek ideas on speech, language, and civilization. Oxford University Press, 2003.

Gibbs, R. (1994). The poetics of the mind. Cambridge, UK: Cambridge University Press.

Gibbs, R., Bogdonovich, J., Sykes, J., & Barr, D. (1997). Metaphor in idiom comprehension. Journal of Memory and Language, 37, 141–154.

Gigerenzer, Gerd, and Daniel G. Goldstein. "Mind as computer: Birth of a metaphor." Creativity Research Journal 9.2-3 (1996): 131-144.

Goatly, A. (2007). Washing the Brain Metaphor and Hidden Ideology (Vol. 23). John Benjamins Publishing.

Grady, J. E. (1997). Foundations of meaning: Primary metaphors and primary scenes. University of California, Berkeley.

Harvey, I. (1992). Untimed and misrepresented: Connectionism and the computer metaphor

Inayatullah, S. (1998). Causal layered analysis: Poststructuralism as method. Futures, 30(8), 815-829.

Inayatullah, S. (2008). Six pillars: futures thinking for transforming. foresight, 10(1), 4-21.

Inayatullah, S., Milojević, I., 2015. CLA 2.0 Transformative research in theory and practice. Tamkang University Press

Kaplan, S. J. (1990). Visual metaphors in the representation of communication technology. Critical Studies in Media Communication, 7(1), 37-47.

Kuusi et al, 2015 UPDATE DATA OF PUBLICATION

Lakoff, G., & Johnson. M.(1980) Metaphors we live by. Chicago/London, 1980Lakoff, G., & Núñez, R. (2003). Where mathematics comes from. Santa Fe Institute.

Lakoff, G., & Johnson, M. (1999). Philosophy in the flesh. New York, NY: Basic Books.

Lakoff, G. (1993). The contemporary theory of metaphor. In Ortony, A. (Ed.), Metaphor and thought (2nd ed., pp. 202–251). Cambridge, UK: Cambridge University Press.

Lakoff, G., & Turner, M. (1989). More than cool reason: A field guide to poetic metaphor. Chicago, IL: The University of Chicago Press.

Penrose, Roger. The emperor's new mind: Concerning computers, minds, and the laws of physics. Oxford University Press, 1999.

Ramscar, M. (2010). Computing machinery and understanding. Cognitive science, 34(6), 966-971.

Ruiz de Mendoza Ibáñez, F. J., & Perez Hernandez, L. (2011). The contemporary theory of metaphor: Myths, developments and challenges. Metaphor and Symbol, 26(3), 161-185.

Ruiz de Mendoza Ibáñez, F. J., & MairalUsón, R. (2011). Constraints on syntactic alternation: Lexical-constructional subsumption in the lexical-constructional model. In P. Guerrero (Ed.), Morphosyntactic alternations in English: Functional and cognitive perspectives (pp. 62–82). London, UK/Oakville, CT: Equinox.

Russell, S., & Norvig, P. (2003). Artificial Intelligence: A Modern Approach.

Searle, J. (1997). The Mystery of Consciousness, Nueva York. New York Review of Books.

Searle, J. R. (1982). The Chinese room revisited. Behavioral and brain sciences, 5(02), 345-348.

Seidl, D. The concept of ‘‘weak signals’’ revisited: a re-description from a constructivist perspective, in: H. Tsoukas, J. Shepherd (Eds.), Managing the Future: Developing Strategic Foresight in the Knowledge Economy, Blackwell, Oxford, 2004, pp. 153–170.

Steen, G. (2007). Finding metaphor in grammar and usage: A methodological analysis of theory and research. Amsterdam, The Netherlands: John Benjamins.

Stevenson, I. (2008). Tool, tutor, environment or resource: Exploring metaphors for digital technology and pedagogy using activity theory. Computers & Education, 51(2), 836-853.

Strong, John. Relics of the Buddha. MotilalBanarsidassPublishe, 2007.

Turing, A. M. (1950). Computing machinery and intelligence. Mind, 433-460.

Walsham, G. (1991). Organizational metaphors and information systems research. European Journal of Information Systems, 1(2), 83-94

Würtz, R. P. (Ed.). (2008). Organic computing. Springer Science & Business Media.

Zaltman, G., & Zaltman, L. (2008). Marketing metaphoria. *What Deep Metaphors Reveal about the Minds of Consumers, Harvard Business School Press, Cambridge, MA*.

PAPER 3

Futures

Volume 88, April 2017, Pages 15–29

Original research article

From data analysis to storytelling in scenario building. A semiotic approach to purpose-dependent writing of stories

Javier Carbonell[a], Antonio Sánchez-Esguevillas[b], Belén Carro[b]

Show more

https://doi.org/10.1016/j.futures.2017.03.002

From data analysis to storytelling in scenario building. A semiotic approach to purpose-dependent writing of stories

Abstract

Scenario building is one of the activities that companies frequently carry out in order to understand and communicate aspects or strategies about the future. Methodologies related to scenario building include, in one way or another, two phases, one oriented to the research of data and analysis, and the storytelling focused on communication. This paper identifies the transition from one phase to the other as a cause of loss of consistency and information that can jeopardize the whole process. It also develops a framework to build narratives or stories from the data obtained in the first phase, turning to diverse semiotic concepts in order to bridge this transition. This methodology is illustrated with an example obtained from Telefonica technology scenarios.

Keywords: scenario building, storytelling, semiotics, Peirce

0.- Introduction

Analysis of scenarios has become a relevant tool for management activities, mainly for the staff related to strategy and strategic foresight, and to internally and externally communicate strategies and the company's vision of the future. The term was used for the first time in the 1950s by Herman Kahn for military purposes, to simulate consequences using a wargaming approach. Since then, there

has been a quick development of methodologies and approaches in the academic and corporate environments, and it can be stated that nowadays the scenario analysis plays a significant role in the foresight field. This role can be seen in the diagram known as diamond, edited by Dr. Popper (2008), it places "Essay/Scenario writing" as one of the creative methods, and scenario workshop as one of the most interactive in a classification of the main foresight techniques with respect to two axes: creative-evidence and expertise-interaction. Although both techniques are classified as qualitative, it must be taken into account that there is not a clear barrier between scenario analysis and other techniques such as Delphi, Cross-impact/structural analysis and the like, and they are commonly used together.

At present, a plethora of scenario methodologies and techniques can be found, some books have become a reference (Heijden van der, 2005) (Schwartz, 1991) and some papers offer a good overview of their evolution (Börjeson et al, 2006), (Bishop et al, 2007). The possibilities and connections between scenarios in other realms besides strategy have been widely studied, for instance referred to cultural theory (Inayatullah, 2009), to social ecology (Ramírez, Selsky, & van der Heijden, 2010), to learning environments (Steckelberg, 2015) or to design practice (Selin et al, 2015). Nevertheless, there is not a consensus about typologies, terminologies or even its utility (Wilkinson, 2009) and the general perception is that the scenarios field remains under-theorized (Wright et al 2012). There is even the confusion about the extent of the concept of a scenario which gives rise to the terms ''scenario planning'' and "scenario development" (Bishop et al 2007) with important differences between them. The first is associated with a complete foresight study and the second with creating stories about the future. We will refer to the whole process of making scenarios and call it "scenario building", a long and varied process in which lots of actors, approaches and types of information meet. This article dives into the information heterogeneity in different phases of the process and highlights it as an important drawback that all scenario developers should take into account to avoid disappointing results. It develops a framework to bridge and maintain the consistency between the analytic approach in the research phase and the narratives used to disseminate and explain the scenarios.

This paper adopts the following structure: the first and second sections introduce the definition of scenario and that all kinds of scenarios include two phases: research and analysis which will be referred from now on as "R&A", and storytelling. The next section shows how these two phases involve different types of information and the transition from one to the other implies a loss of information that this paper refers to as the transformational information reduction. After that, it resorts to semiotic concepts to analyse storytelling signification and interpretation processes in order to create a framework that can help link the analytical information with the narratives and stories, giving more consistency to the scenario building process. This approach is illustrated with one example based on Telefonica activity. The paper finishes with a conclusion and further research section.

1.- What is a scenario?

There are lots of definitions of scenario that usually have many similarities and also some differences. For instance, the following list offers some definitions picked from relevant literature.

- An archetypal description of a possible future based on a mutually consistent grouping of determinants (Beck, 1982)
- A qualitative or quantitative picture of a given organization or group, developed within a framework of a set of specified assumptions (McNulty, 1977)
- A device for ordering one's perceptions about an environment in which one's decisions might be played out (Huss and Honton, 1987)
- A description of a 'possible future' based on a set of mutually consistent elements, within a framework of specified assumptions. It will typically encompass both quantitative and qualitative elements (Foster, 1993).
- Internally consistent and challenging narrative descriptions of possible futures (van der Heijden 2005).

Though there are strong similarities among them, the differences may suppose implications in relevant aspects: the objectives, the process of elaboration, the actors involved, etc. It can be observed that the most common word in those definitions is "description". In one case it is substituted by "picture" or by "narrative", words with some similarities with the term "description", and in another by "device", an abstract word that in some contexts may also mean "description". So, they all assume that a scenario must describe a situation in the future and that it constitutes its real essence. Nevertheless, many difficulties can be found when examining the extension of "description" because a narration is a description, but also a diagram, a picture or even a mathematical formula may be descriptions.

For instance, the Millennium Project (perhaps the most relevant collection of methodologies oriented to deal with the future) defines a scenario as "a story with plausible cause and effect links that connects a future condition with the present, while illustrating key decisions, events, and consequences throughout the narrative" (Glenn, 2000). In this case "description" is substituted by story and the narration is the legitimate vehicle to transmit the information. Nevertheless, the United Nations Environment Programme (Global Environment Outlook) claims: "Scenarios can be told in many ways. The two most common methods used in scenario analysis have been descriptive, written narratives (qualitative scenarios) and tables and figures incorporating numerical data, often generated by sophisticated computer models (quantitative scenarios)". This implies a wider interpretation of description, including figures, tables and computer models.

In this paper we will use a wide approach to scenarios, without limiting them to the description of possible future states, and including all the rationale to reach them. We will consider not only text narratives but also other media such as illustrations, diagrams, tables or videos because they are commonly used by organizations to create and to disseminate their scenarios. We also distinguish between scenarios, a comprehensive tool to think about the future, and other isolated tools used to anticipate the future and to communicate it with different intentions and approaches: contingency planning, sensitive analysis, or computer simulations.

2.- Two phases in developing scenarios

Although there are many methodologies related to scenario development, each one of them including different stages, by and large, two kinds of activities can be found. On the one hand some are oriented to understand the environment, context of the organization, analyse evolution of some variables, etc.

All these activities can be grouped under the phase “R&A”. On the other hand, other activities are more related to the process of describing and communicating the scenario, they are grouped under the phase “Storytelling”. Although these activities may be mixed or interact along the process of scenario building, in this paper they are going to be considered as two phases separately to facilitate the analysis:

Phase I. R&A: Development of scenarios in a logical, conceptual or mathematical way. It considers the quantitative and qualitative information, commonly divided into four areas: scope, objectives, internal aspects of the company (structure, capacity, resources…), and external context (environment, trends, context, change drivers…). This phase also includes assumptions and forecasts.

Phase II. Storytelling: Outline of the storyline, narrations and other resources to describe and effectively communicate the scenario. It can be oriented to transmit some values or information to the staff of the company, a message to an external audience, or both.

All scenario building exercises include activities from the first and from the second phase, but depending on the goal pursued, the effort dedicated to each of them can vary. If the goal is to support the strategic decision of the company, the first phase will be more important and presumably more time-consuming. If the goal has more to do with promotional or communication purposes, then the second phase will assume a stronger role. This last situation is the case of the hundreds of scenarios sponsored by technology companies that try to create a level of awareness about any technology virtues.

Although all the developments of scenarios include in some way these two phases, it is not always easy to identify them, even in well-known methodologies. For instance Schoemaker (1995) considers the following ten steps in the process for developing scenarios: define scope, identify the major stakeholders, identify basic trends, identify key uncertainties, construct initial scenario themes, check for consistency and plausibility, develop learning scenarios, identify research needs, develop quantitative models, and evolve toward decision scenarios. In this case all the phases seem to be more oriented to phase I, and storytelling is only considered implicitly in some of these steps. For instance, in the step “check for consistency and plausibility” he mentions “compelling story line”, and in “develop learning scenarios” he states “naming the scenarios is also important. A scenario is a story”.

In other cases, the division between phases I and II is more clearly defined. For instance, the Royal Shell methodology showed in Scenarios: An Explorer's Guide (Shell 2008) identifies four stages: research, scenario building, application and dissemination. The first, research, can be identified with phase I; and the other three, scenario building, application and dissemination with the phase II but including some tasks from R&A, as conducting interviews and their analysis.

3.- Two phases, two kinds of information

As previously stated, every scenario development includes some “R&A” and some “Storytelling”, that can be clearly identified, mixed or even hidden in other phases with missing names. Thus, there are two different kinds of activities, with different approaches, and with different types of information. In this section, we analyse this information, its nature and the techniques used to manage it.

3.1.- R&A: information and techniques

The first item of information to consider in this phase is the definition of the scope of the analysis both in terms of timeline and reach. Further, internal and external context must be studied, activity that is known as scanning "the acquisition and use of information about events, trends, and relationships in an organization's external environment, the knowledge of which would assist management in planning the organization's future course of action" (Choo, 2006). Many terms can be found in specialized literature referring to the information to be considered during the scanning activity: uncertainties, change drivers, trends, threats, and other terms more characteristic of the foresight literature like weak signals or wildcards.

These concepts are not synonyms; each one has a specific meaning but the boundaries between some of them are not clearly delimited. By and large, they all try to raise critical aspects that can affect the evolution of the environment in the considered area. Some variables can be very predictable like the number of people over 65 years old in a country in 2020, less predictable like number of drones in that country in that year, or completely unpredictable like an earthquake. They can be represented by an exact number such as the inflation, or be qualitative trends like increasing of people's interest in green issues.

Once the information is selected, there are different approaches in dealing with it, resulting in many methodologies and lots of techniques. Using one or the other depends mainly on the scenario's purpose. In this sense, it is worth mentioning the Börjeson et al model (2006) that distinguishes between three global categories associated with three ways of thinking about the future according to the principal question to be answered: what will happen? what can happen? or how can a certain target be reached? This model proposes several techniques, some of them are more quantitative (i.e. time series analysis), some more qualitative (i.e. workshops), but they are all analytical approaches that need the participation of experts in data analysis and with a deep background in strategy.

There are many other classifications of techniques that can be used in the scenario arena, some of them are not scenario specific and are used in other foresight fields; the next table summarizes the tools included by Project Millennium (Godet et al, 1999) in the document dedicated to scenario tools (Table 18).

Table 18 Research and Analysis (R&A). Information and Techniques

Approach	Technique	Aim	Type of information
Initiating and stimulating the whole process	Strategic Prospective Workshops	To introduce and simulate a complete prospective and strategic process in a group.	All kind of information quantitative and qualitative
Making a complete diagnosis of the firm in relation to its environment	Competence Tree	To represent the company in its entirety without reducing it to products and markets	Diagrams
	Strategic Analysis Tools	To help the manager choose and direct the firm's activities	Life cycle, learning curves, portfolio models, value chain
	Strategic Diagnosis	To understand the strengths and weaknesses of the five fundamental resources of a firm	SWOT (assumptions)
Asking the right questions, identifying key variables	Structural Analysis	To structure the pooling of ideas	Matrix (variables, relations)
Analysing actors' strategies	The Mactor Method	To gauge the balance of power among actors and study their convergences and divergences when faced with a certain number of associated stakes and objectives	Diagrams, tables
Scanning the field of possible futures and reducing uncertainties	Morphological Analysis	To explore possible futures in a systematic way by studying all the combinations resulting from the breakdown of a system.	Table (assumptions)
	The Delphi Method	To highlight both convergences of opinion and consensus on specific topics, by questioning experts through successive questionnaires	Questionnaire (text, data)
	The Régnier Abacus	To question experts and to process their answers in real time or by mail using a scale of colours	Colours
	Cross impact method	To define simple and conditional probabilities of hypotheses and /or events, and the probabilities of combinations of the latter,	Matrices, probabilities
Evaluating strategic choices and options	Relevance Trees	To rationalize the selection of elementary actions or operations with a view to achieving overall objectives	Diagrams

Approach	Technique	Aim	Type of information
	Multipol	To compare different actions or solutions for problems according to multiple criteria and policies	Table (criteria, policies, data)

Again, the same appreciation is reached: these techniques imply a high level of analytical mindset, mathematical background, and at least a high level understanding of concepts related with strategy. Other classification that includes some of these techniques and other new ones is presented in Peter Bishop et al article (2007) .

3.2.- Storytelling: information and techniques

In this phase the experts try to capture all the relevant information raised during the R&A phase and express it by means of powerful communication mechanisms, mainly narrations. As it is usually the final result, this phase can define the success of the whole activity. These narrations must be able to render the most important information discovered during the research, to a format, mainly text, that sometimes is not the most appropriate to describe complex situations. For instance, some kinds of relations, numerical factors and probabilities are not easily transmitted using text narrations. Besides, a narration is a linear description where the information is delivered in little messages one after the other, for this reason the user cannot perceive the general picture until the end. In the narrations it is usually difficult to understand the relations between entities when there are too many, and sometimes, they can be quite time consuming and even boring. In order to overcome this effect, writing narratives requires a lot of experience and the involvement of experts with several profiles. Some papers (Rasmussen, 2008), (Denning, 2006) and even successful books (Walker, 2002) have been written detailing the techniques of storytelling.

Apart from textual narration, other resources such as illustrations, videos and diagrams are increasingly included to enrich the narrative or as a standalone support (Table 19).

Table 19 Storytelling. Information and Techniques

Technique	Aim	Type of information	Example
Narrations	To offer a description of the environment showed in the scenario	Text, sometimes including numbers, tables…	Shell, OECD
Illustrations	To give an elemental message at a glance	Sketches, draws, infographics	Consultancy scenarios
User Stories	To exemplify the scenario by using a real situation	Stories with several characters that exemplify a situation in the future	Research projects in technology (i.e. ePerspace[17])

[17] http://www.ist-eperspace.org/

Technique	Aim	Type of information	Example
Videos	To impact the mainstream market, sometimes viral	Multimedia representation of narrations or user stories	Nokia, Microsoft
Diagrams	To highlight relations among entities	Visual representation of the relations, sometimes using systems models	Simulations

4.- Transformational information reduction

The previous analysis highlights the big differences in the nature of information between R&A and storytelling phases. Moving from the first phase rich in data and analysis-oriented to the second, which is more descriptive and oriented to the communication means that some information vanishes. This effect will be referred to, henceforth, as "Transformational Information Reduction" or simply "Information Reduction".

This phenomenon must be taken into consideration to avoid good research leading to a mediocre storyline, and to understand the limitations of storylines. In these cases the scenario building activity is useful for internal purposes, the involved staff obtain a deep understanding about the company's situation, its future challenges, how trends should be considered by business, but it fails to communicate to other staff members who are not involved in its elaboration and for dissemination purposes. This situation happens very frequently and managers take it for granted sometimes, "scenarios were designed to oblige managers to question their assumptions and reorganize their mental maps of reality" (De Geus, 2008).

Other authors reach the same conclusion, for instance G.T.T. Molitor (2009) questions the usefulness of scenario analysis. He offers a negative valuation about the interest of scenario analysis, but points the benefits obtained in R&A: "one saving value is that the process gets some participants thinking in uninhibited and creative ways", "there is always some value in surveying and studying matters", "makes participants more fully aware of what needs to be done to survive and thrive." Angela Wilkinson (2009) from Oxford University answered this article stating that "the lack of systematic and scholarly study into futures practices, in general, and scenario practices in particular, means it is not possible to confirm or reject, on any statistically valid or otherwise basis."

This debate reinforces the hypothesis that in the rendering process, information suffers some losses. This is nothing new as it is something characteristic for any communication action (Shannon, 1948). The first observation from the experience is that during the analysis of information hundreds of variables can be considered. In the storytelling only the most relevant are included in order to make it acceptable from the communication point of view. Though this situation could be theoretically solved creating longer narratives, other losses are practically unavoidable and an information reduction occurs. The losses are twofold:

- *Passing from R&A to storytelling implies a loss of uncertainty associated to the information removed and this process is irreversible*. In the first phase, models include probabilities and other uncertainties that cannot be included, at least completely, when editing the story, so that in the end each story is an estimated story with no uncertainty. This process is irreversible because one expert can go from the first phase to the second but it is impossible to do the inverse journey.

- *Passing from R&A to storytelling implies the loss of information necessary to construct the big picture.* Storytelling is usually implemented by using text format what imposes several restrictions. The first is that due to its linear nature it is necessary to read the whole story to reach a conclusion. Sometimes stories are long and time consuming, so many people consider that the reading is not worth it. For that reason, editors of stories need to discard part of the content obtained in the R&A phase in order to create stories with an acceptable length. This reduction in the quantity of information affects the scenarios in several levels:
    - *Entities used in the scenario.* Usually not all the entities considered in the R&A phase are mentioned on the stories. There is a decrease in the number of entities that appear, and those mentioned suffer a reduction in the associated information, so that only properties and characteristics that are considered essential for the explanation are included.
    - *Relations between these entities.* Entities are not isolated, a dense net of relationships between them is so important to define the system as the entities by themselves. Most of these relations are usually missed during the storytelling process.
    - *Delimitation of the contour.* Delimitation of the context, premises that are used, and other aspects to understand the contour of the reality described by the scenarios are poorly or even not included in the stories.

The existence of this reduction is intuitive and scenarios practitioners know about it to some extent. Table 20 shows this reduction for the scenario "A day in the van Epers Family: a busy day" included in Appendix A and extracted from the project ePerspace IST Project N° 506775 financed by the 7th Framework Programme (European Union), in which elaboration the first author of this paper was involved.

Table 20 Information reduction in Scenario 1, scene 1, (D1.1 Service Scenarios and Specifications, ePerspace IST Project N° 506775)

	Information missed
Loss of uncertainty	This scenario was edited in 2004 considering a period of 10 years ahead. In the introductory workshop, it was estimated that concepts such as automated personalization, automated detection of people, or transferring video to the mobile phone would be likely implemented with that horizon, while others like virtual reality or brain-computer interface would be unlikely implemented. Features seen as more probable were included and those less probable were discarded and, consequently, information about subjective probabilities is not included in the text

		Information missed
Loss of information about the big picture	Entities	Only the most relevant entities are included, no information is provided about sensors, personalization engines, traffic optimization systems, video rendering systems, etc.
	Relations between entities	The relationships between entities are not mentioned, at least explicitly. For instance, the mobile phone (in 2004 the smartphone concept was not used yet) required the installation of several components and the communication with the ePerSpace video module, and the same happened with the television. The relations with the authentication systems were also not included
	Delimitation of contour	Although this is a technological scenario that tries to be self-contained, it lacks relevant information to define the contour. For instance, regulatory aspects (crucial to allow accessing to the city cameras), economic evolution and prices, new habits of millennials, evolution in telecom infrastructures, relations between telecom companies and content providers, technological assumptions, etc.

In order to assess this reduction, a variety of stories associated to different typology of scenarios are analysed in this section. This analysis has several difficulties that come from the variety of the typology in both formats and elaboration approach, and by the fact that the public information refers mainly to the stories and not to the previous R&A activity. In spite of these apparently difficult barriers, we will study this reduction through a sample of scenarios that tries to cover the widest variety of these stories' typology, trying to saturate this space as proposed by Glaser and Strauss (2009) to create grounded theories. To cope with this variety, we make a first division according to the narration mode considering impersonal narration or report and representational narration or play, that includes some characters and that may be narrated in first or third person, corresponding to Plato's original poetic dichotomy of diegesis and mimesis (Plato, 2003). Another aspect we considered is the length, as this is a limiting aspect to include the richness of the R&A analysis. The following sample tries to cover this variety:

- Stories in multimedia format for massive divulgation of scenarios. The stories that appeared in the top positions on YouTube when searching the query "life in the future" (as the query a "day in 2020" gave not good results) have been chosen, excluding those repeated and the ones that did not have a story structure (interviews, documentaries…). The search query was carried out on June 5th 2015.

- Stories included in research projects of the 7th Framework Programme (European Union). In this case ePerSpace[18], and Value-it[19]. The motivation to use them is that these projects document all the R&A activity done to reach the stories considering both technical and environment aspects.
- Stories well known by the scenario building community. In this case the scenario Mountains, published by Shell in the document "New Lens Scenarios[20]" and "Not Yet Uhuru" published by South Africa Government in "South Africa Scenarios 2025"[21].

In order to avoid an unintentional possible bias from the preconceived ideas of the authors, in all the cases the first scenario of the documents is selected. Table 3 summarizes all the stories analysed and their categorization.

Table 21 Sample of scenarios' stories

Story	Creator	Title	Mode	Format	Length/ Duration
1	Siemens	The Crystal Future Life Video	Play (the scenario is recreated)	Multimedia	4:25
2	Corning	Watch your day in 2020	Play (the scenario is recreated)	Multimedia	5:32
3	imec	Life in 2025 - imec's vision on future technologies in daily life	Play (the scenario is recreated)	Multimedia	6:32
4	SciShow	The Future of Life in the Solar System	Impersonal narration	Multimedia	3:41
5	Shell	Mountains	Impersonal narration	Text	23 pages
6	South Africa Government	Not Yet Uhuru	Impersonal narration	Text	18 pages
7	ePerSpace (EU 7th FP)	A day in the van Epers Family: a busy day	Play	Text	2 pages

[18] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.200.3328&rep=rep1&type=pdf
[19] http://cordis.europa.eu/project/rcn/85465_en.html
[20] http://s01.static-shell.com/content/dam/shell new/local/corporate/Scenarios/Downloads/Scenarios_newdoc.pdf
[21] http://www.gov.za/sites/www.gov.za/files/sascenarios2025_0.pdf

Story	Creator	Title	Mode	Format	Length/ Duration
8	Value-it (EU 7th FP)	Integration of Operations Support Systems	Impersonal narration	Text	1 page

In spite of the limitations of the sample, the transformational information reduction, along with some important differences, is observed in all the studied stories (see Table 4).

Table 22 Transformational information reduction characterization

Story	Title	Loss of uncertainty	Loss of entities	Loss of relations among entities	Loss of contour delimitation
1	The Crystal Future Life Video	Yes, completely	Yes, only the most relevant are included	Yes, completely	Yes, though some of the context is defined by means of images, i.e. large futuristic buildings, city layout…
2	Watch your day in 2020	Yes, completely	Yes, only the most relevant are included	Yes, completely	Yes, completely
3	Life in 2025 - imec's vision on future technologies in daily life	Yes, completely	Yes, only the most relevant are included	Yes, almost completely, though narration links some services utility	Yes, though some of the context is defined by means of images and narration, i.e. sustainability
4	The Future of Life in the Solar System	Some courses of action included	Yes, only the most relevant are included	Some loss, although important relations are included	Some loss, though define well the big picture
5	Mountains	Some courses of action included	Additional entities to enhance description are included	Some loss, though important relations are included	Defines well the context

Story	Title	Loss of uncertainty	Loss of entities	Loss of relations among entities	Loss of contour delimitation
6	Not Yet Uhuru	Yes, completely	Additional entities to enhance description are included	Some loss, though important relations are included	Defines well the context
7	A day in the van Epers Family	Yes, completely	Yes, only the most relevant are included	Yes, completely	Yes, completely
8	Integration of Operations Support Systems	Yes, completely	Yes, only the most relevant are included	Yes, almost completely, though explanation links some services connections	Yes, completely

This analysis shows important conclusions about the information reduction:

- There are important losses of information in all the categories that are attenuated only by editing very long scenarios in an impersonal style, for instance, only the scenarios Mountains (23 pages) and Not Yet Uhuru (18 pages) retain an important part of the R&A richness.
- The scenarios usually do not include uncertainty, and when they do they show it superficially.

Besides these similarities there are also some differences that depend on the typology of the scenario:

- Multimedia scenarios usually employ a play approach while written scenarios use an impersonal narration approach.
- Scenarios with a play approach have much losses of information since they are focused on producing impact on people.

So, we can conclude that this reduction is always present, as the story cannot absorb the whole complexity of the previous analysis. Nevertheless, the final nature of this reduction depends too much on the approach of the story creator and the length of the scenarios. For instance, in the case of Value-it project, the R&A analysis output consisted of documents such as STE Techno-vision report and Final Demand Driving Mapping Report, 122 and 128 pages length respectively, while each story is just one page length. The information reduction must be considered then as a necessary fact to reduce the complexity according to the purpose of its creator, and not only a mere loss of data. Although there are some studies about focusing

storylines depending on the particular scenario (Rounsevell and Metzger, 2010), this reduction has not been faced in an integral way yet.

5.- Semiotic approach to storytelling

We will turn to to semiotics, the discipline that links signification, representation, reference and meaning, to deal with this information reduction. The utilization of semiotics in storytelling is recurrent in different fields such as science (Wickman, 2015) or organization studies (Marsen, 2014). Nevertheless, we think that none of them is focused in the losses of information previously described.

Although semiotics has been a subject of important intellectual activity for the last century, the contributions of its father, Charles Sander Peirce, are distinctive and are still the main reference. Peirce was a complex thinker, whose ideas underwent continuous changes, including the nomenclature of concepts, but the general structure of signs and signification he proposed remained uniform throughout his life, which is showed in his definition: "I define a sign as anything which is so determined by something else, called its object, and so determines an effect upon a person, which effect I call its interpretant, that the latter is thereby mediately determined by the former" (Peirce, 1894). This approach to a sign is complemented by the action of the sign that he called semiosis: "by 'semiosis' I mean an action, or influence, which is, or involves, a cooperation of three subjects, such as a sign, its object, and its interpretant, this tri-relative influence not being in any way resolvable into actions between pairs" (Peirce, 1898).

Taking into account this approach, we will consider throughout this paper the story as a sum of signs and the storytelling as the semiosis process, which lead us to identify the three elements of Peirce's triadic approach to a sign in the next way.

- Object: It is the situation to be described (a future situation of the world), let us say it is the signified thing.
- Representamen (also known by Peirce with other terms such as "sign", "representation", "ground"): It is each part of the story itself, the text and other resources used for the narration.
- Interpretant: It is the effect that each part of the story produces on the audience.

6.- Coping with the transformational information reduction. A semiotic approach

The aim of this section is to develop a framework to help storytelling editors maintain the coherence and traceability with the analysis carried out during the first phase, capturing the maximum information from it according to their purpose. The framework we propose internally uses the semiotic principles defined in the previous section. In this framework we consider two main activities, the selection of what is going to be transmitted and the selection of how it is going to be transmitted.

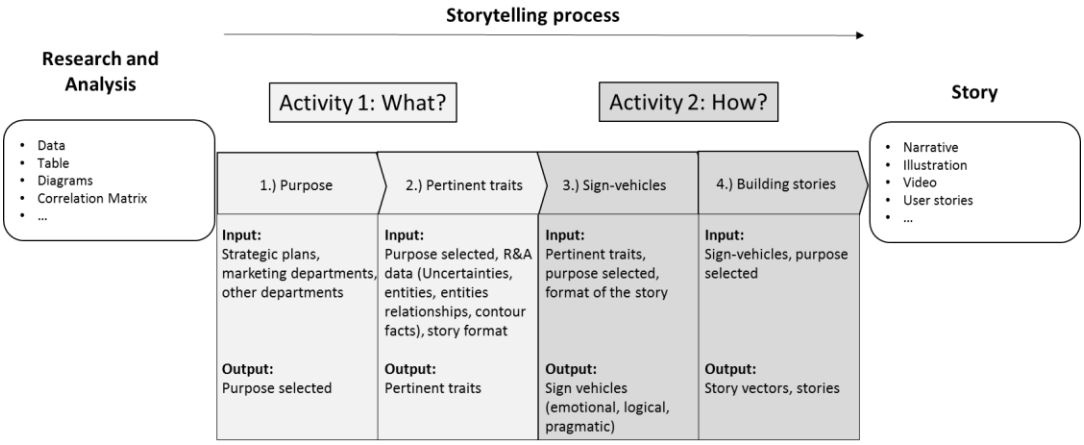
- *What it is going to be transmitted*. It is oriented to select the adequate information to be transmitted taking into account the purpose and the aspects of the scenario that the editor of the story wants to transmit. As previously stated, the information reduction is always going to exist because stories contain less information than R&A analysis. During this activity the creator of each story adjusts the information reduction selecting the information that will be

included in the story and the information that will be omitted (which becomes the reduction). This activity is divided into two stages: purpose selection and pertinent traits selection.

- *How it is going to be transmitted*. It is oriented to construct the story, also identifying the communication resources and managing the building of the story. The selection of these communication resources must take into account the desired effect on the audience, which is also related to the story's purpose. This activity is divided into two stages: selection of sign-vehicles and building the stories.

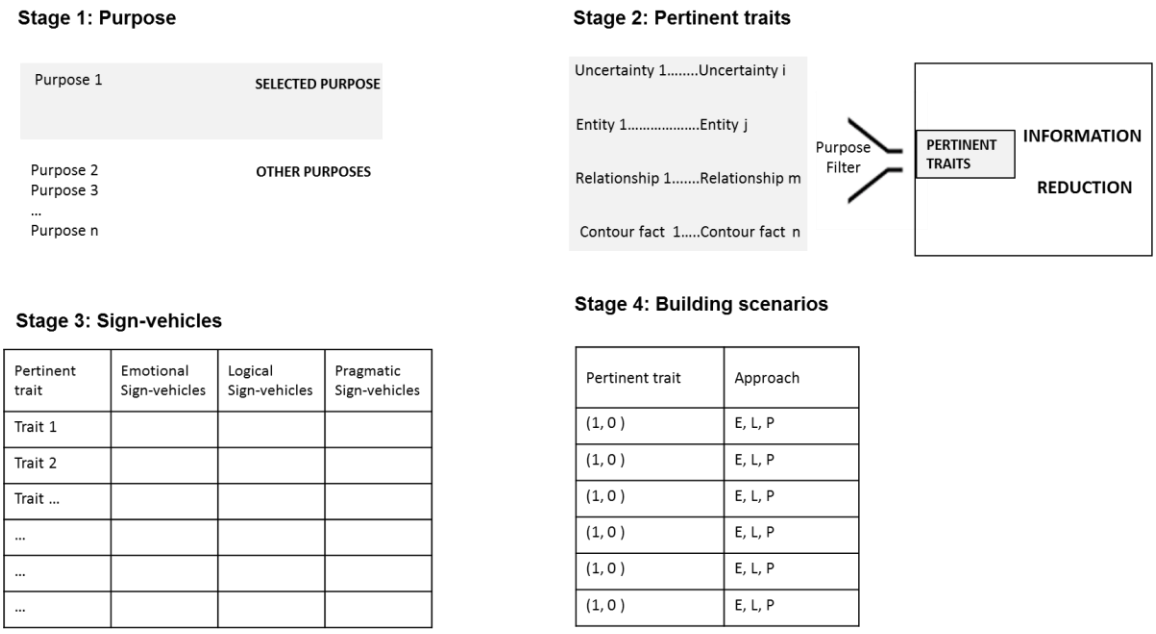
These stages with the main inputs and outputs of each one of them are shown in figure 1.

Figure 1: Stages to cope with the transformational information reduction



In this section we will give content to these stages, using the semiotic principles described in the previous section and including other semiotic insights from Peirce. In order to illustrate the process, figure 2 shows the kind of information that is managed in each stage and contains some tables to help order it.

Figure 2: Information managed on each stage



Pertinent trait	Emotional Sign-vehicles	Logical Sign-vehicles	Pragmatic Sign-vehicles
Trait 1			
Trait 2			
Trait ...			
...			
...			
...			

Pertinent trait	Approach
(1, 0)	E, L, P
(1, 0)	E, L, P
(1, 0)	E, L, P
(1, 0)	E, L, P
(1, 0)	E, L, P
(1, 0)	E, L, P

These stages are:

a) Identification of purpose

Peirce's semiotics has a purpose approach (Short, 2007) by which all semiotic processes lead to determining an effect on someone, which can be a thought or an action. In this way communication and interpretation are two aspects that cannot be separated. According to that idea, the purpose of the story is the first thing that must be clarified. This supposes an in-depth analysis of aspects such as the target audience, the goals or the context. The utilization of guiding images or leitbilds (Gustafsson et al, 2014), can be also very useful in order to envision the purpose of the process.

b) Selection of pertinent traits to be transmitted

During the R&A phase hundreds of variables can be monitored, measured and forecasted. This implies a large amount of analytical information that must be assessed to select the most relevant ones to build a story in the second phase.

Once the purpose of the story has been clarified, pieces of information must be selected in line with this goal. To that end, authors must go over the whole information (tables, charts, diagrams, etc.) gathered in the R&A phase, identifying what pieces of information are pertinent with regard to the selected purpose, and whether the projected evolution of those variables indicates a substantial change that can make a difference. Based on this information, those uncertainties, entities, entities relations and contour facts that are relevant with respect to the purpose of the story are selected.

When these elements have been chosen, it must be taken into account that it is necessary to select from them the features that are relevant with respect to the purpose. This is necessary because the

object to be transmitted is not the whole object but only some traits. For instance, in a scenario designed by Telefonica about technology uses in 2025, the projected data "there will be 25 billion objects connected to the Internet" is associated with the pertinent trait "There will be 3 objects connected to the Internet per person".

The information reduction will appear at this stage since only some elements and traits are selected and, consequently, a significant amount of information will not pass to the next stages (see figure 2, Stage 2: Pertinent traits). The magnitude and character of this reduction will depend on factors like the purpose, format, and length of the story, so at this stage of the storytelling, the authors can modulate it.

c) Selection of sign-vehicles

According to Peirce, the representamen (in our case the story itself) has a "sign-vehicle" consideration and constitutes an instrument to transmit the object's pertinent aspects to the interpreter. This means that a "sign does not signify in all respects and has some particular signifying element" (Atkin, 2013).

The aim of the previous sections was to raise these pertinent aspects, and in this section we will focus on editing pieces of the story that transmit them. Again, we will resort to Peirce's ideas, in this case to the three grades of clearness or understanding that Peirce describes in his article "How To Make Our Ideas Clear". The first grade is a kind of familiarity or impression, the second a logical analysis, and the third a pragmatic analysis. From Peirce's point of view the third grade or pragmatic analysis shows the maximum level of understanding as stated by Peirce's pragmatic maxim "Consider what effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" (Peirce, 1878). Nevertheless, the other two grades are also widely used with communication purposes. So, we will consider the three grades and they will be referred to as the emotional level (first grade), the logical level (second grade) and the pragmatic level (third grade). The main aim in this stage is to find the pieces of the story (representamens) that can work as vehicles to transmit the pertinent traits previously selected moving the audience to an emotional, a logical or a pragmatic level. If the story has the format of narration, these elements will be in the form of texts, but in the case of other formats, for instance multimedia, other resources such as colours, voice tone, images… can be used. At the end of this stage we should have information enough to feed the table "Stage 3: Sign-vehicles" shown in Figure 2.

d) Building the stories

The three previous stages have concentrated on finding the elements (pieces of the story) that are able to transmit some pertinent traits according to a purpose, using emotional, logical or pragmatic orientation. As mentioned, there are lots of studies on storytelling, in this section we will not focus in the elaboration of the final narrative, but in the design of a tool to help the editors use the information gathered in the previous sections and set the tone they want to give the story. This tool will also be useful in maintaining the traceability with the analysis done during the R&A phase and testing different stories considering only subsets of pertinent traits. In order to accomplish these aims we propose the use of the design and traceability table (Figure 2, table "Stage 4: Building Stories"). The use of this table allows us to manage the traits that are included, their approach (emotional, logical or pragmatic) and to code each of the stories. For instance, one story could be represented by

the vector "10001111" (0 represents the pertinent traits that are not included, and 1 those that are included). This notation makes it easy to understand the relation between the stories and the output of the R&A phase. It is also easy to understand the real differences between this story and another coded as "111001111". It is possible to enrich this notation adding the letters "E", "L", or "P" after the figure "1" qualifying whether the pertinent trait is transmitted with an emotional, logical or pragmatic approach. We think that this is a powerful tool for managing the whole process of story elaboration, for setting the tone of the stories for different audiences and also to classify them.

7.- Case of study: "A day in 2020"

In this section, a story building exercise based on a scenario developed by Telefonica is used to illustrate the framework previously explained. The scenario was called "A day in 2020" and tried to predict the impact of technologies in people's lives in the medium term (five years ahead). The data used to carry it out are extracted from consultancy firms' projections of technologies. In this case the four stages of the framework mentioned in the previous section are developed to examine the storytelling process. In order to enrich this exercise, an analysis of the semiotic elements included in multimedia stories that are on the Internet is included too.

Building the bridge between the R&A and stories

Stage 1. Identification of purpose

Inputs: Organization department, in this case Research and Development department of the company, and the objective, in this case to raise the layman's awareness of the benefits that IT technologies will offer in 2020.

Activity Done: Validating the convenience of the objective, limitations, and possible problems

Outputs: The purpose, in this case to create stories about the utilization of IT technologies in 2020, highlighting the impact that these technologies will have on people's daily lives

Conclusions: The clear definition and limitation of this purpose requires consensus, as this will condition the rest of the process. For instance, the story building process would have been different if the goal had been different, such as guiding investors, guiding manufacturers, raising environmental awareness, etc.

Stage 2. Selection of pertinent traits to be transmitted

Inputs: R&A data, in this case mainly technology projections from several technology consulting firms; the format of the story, in this occasion text with a play approach; and the purpose, in our case to the layman's awareness of the impact that technologies will have on people's daily lives.

Activity Done: The mode of operation involved going through all the elements studied during the R&A phase and evaluate if they contained any feature that could be strongly aligned with the purpose. These features were identified as the pertinent traits to be included in the scenarios.

In this case, people involved went through the data projections (2015-2020) questioning if there was any feature that could entail a remarkable difference with respect to present people's way of life. The amount of data included in R&A phase and the length of the story condition the effort necessary to accomplish this stage and the number of pertinent traits selected. Due to the approach chosen for the stories (written play), the most relevant information was the evolution of technological entities

such as wearables, Internet of Things, virtual reality or the relation between these entities and others like broadband. However, uncertainties were not included since the story was to have a play approach with a very lineal development, and the same was done with contour facts, because the purpose was centred on the use of technologies and other external factors weren't considered important for our purposes.

Outputs: The main output was the selection of pertinent traits. Table 5 shows some of the elements studied and the pertinent traits associated with them

Table 23 Example of pertinent traits obtained after the research and analysis (R&A) phase

	Data in 2012	Data in 2020	Pertinent trait from the user point of view (purpose is to obtain the maximum utility from technology)
Smartphone Shipments (million units)	725	1959	Smartphone will be the new personal computer
Wearables Market Value (billion dollars)	0,75	5,8	People will be always connected
Internet of Things (billion units)	3	25	Each person will have 3 connected things
People in the world (billion units)	6,9	9,7	Not pertinent
Mobiles (billion units)	6,2	7,1	Not pertinent
Mobile broadband		Most portable devices will require mobile broadband	Mobile broadband coverage will be a must
TV in developed countries (% of households)	98%	99%	Not pertinent
Pay per view in developed countries (% of households)	25%	52%	People will choose their content
Fixed-telephone subscriptions (million units)	1178	1300	Not pertinent

	Data in 2012	Data in 2020	Pertinent trait from the user point of view (purpose is to obtain the maximum utility from technology)
Android OS Share (% market share)	69%	85%	Not pertinent
Virtual reality (market k million euros)	0	16	Early adopters adopt virtual reality

Conclusions: This stage is the most important and most laborious because in it all the R&A information is filtered with respect to the purpose, and it will not be possible to recover later the information and traits that are missed, we can say that in this stage the information reduction is modulated. Although this framework tries to standardize the process reducing the subjectivity, and really it helps to that aim, the case highlighted that the experience and visions of the story editors involved are crucial factors to success.

Stage 3. Selection of sign-vehicles

Inputs: Pertinent traits, purpose, and format of the story previously selected.

Activity Done: In this stage the main task was to look for signs or representamens that were able to capture the pertinent traits essence, that is, messages that can move the audience on an emotional, logical or pragmatic level.

Outputs: Sign vehicles or represetamens (emotional, logical, pragmatic). Table 6 shows some examples of representamens that capture the pertinent traits in the previous table creating an emotional, logical or pragmatic effect. In this case messages in all three approaches (emotional, logical or pragmatic) were selected for all pertinent traits to better illustrate the process. However, this is not always necessary and depending on the purpose, one or two approaches can be ignored for any pertinent trait.

Table 24 Representamens to capture pertinent traits and create different effects on audience

		Representamens		
	Pertinent trait from the user point of view (purpose is to obtain the maximum utility from technology)	**Emotional approach**	**Logical approach**	**Pragmatic approach**
Smartphone Shipments (million units)	(1) Smartphone will be the new personal computer	The smartphone will be your friend, it will help you when you need it	Mobile phones will be flexible, a battery will not be required	With a smartphone you will be able to check your health records on the fly

		Representamens		
	Pertinent trait from the user point of view (purpose is to obtain the maximum utility from technology)	**Emotional approach**	**Logical approach**	**Pragmatic approach**
Wearables Market Value (billion dollars)	(2) People will be always connected	Don't be afraid, your will never be alone	Your clothes will include sensors and any kind of energy source, you will not be able to wash them in the washing-machine	Your clothes will send you messages using touch
Internet of Things (billion units)	(3) Each person will have 3 connected things	You are the master, things will obey you	Ubiquitous wireless connection required, the smartphone will work as remote	The appliances will send you messages of their activity
Mobile broadband (billion units)	(4) Mobile broadband coverage will be a must	People not having mobile broadband will be like not having air	5 G will be a fact, almost unlimited bandwidth	You will be able to access content and to communicate in all places
Pay per view in developed countries (% of households)	(5) People will choose their content	People will be freer, no time restrictions	People must connect TV to the Internet	You will be able to see any content when you want
Virtual reality (market k million euros)	(6) Early adopters adopt virtual reality	People will be freer, no location restrictions	You need broadband wireless connections, limitations in resolution	You can visit monuments, shops, without leaving home

Conclusions: This stage delivers the pieces that will form the stories, it was necessary to cope with the difficulties to change from a data oriented mindset to a message oriented one.

Stage 4. Building the stories

Inputs: Sign-vehicles and purpose selected previously

Activity Done: The activity in this stage was focused on designing the stories. To that aim, several alternatives considering different pertinent traits, sign-vehicles and their approach (emotional, logical or pragmatic) were taken into account. And effort to set the tone of the final wording was also done.

Outputs: Code vectors showing pertinent traits and sign-vehicles selected for each option. For instance, a story coded with the vector "1EP, 0, 1LP, 1P, 1E, 0" is clearly identified and differentiated from a story coded as "0, 1P, 1P, 0, 1LP, 1LP". A basic example of wording of the first story would be "John feels dizzy, but he doesn't mind, he knows that he can rely on his mobile in order to contact the doctor. He sits on the couch and uses his mobile phone as a remote control to turn off the heating system, which is connected via Bluetooth. He starts an ultra-high definition videoconference with his girlfriend too, and after that he decides to watch the last episode of his favourite TV series". A basic example of the second would be "John feels dizzy; his T-shirt sends him a message that he has a high temperature. He sits on the couch and turns off the heating system from there. He has the TV connected by ultra-broadband so he watches the last episode of his favourite TV series in 4k resolution. He takes these high resolution virtual reality glasses connected to 5G and decides to visit the national museum".

Conclusions: This activity allows trying and saving several configurations of stories. Some experience and some refinements of the versions are required to get the right tone to reach the audience.

Besides the conclusions of each stage, we can state the following conclusions regarding the storytelling process:

- The story is not a product but a process as it can be deduced from the fact that all stages are related and the outputs of one stage are the inputs of the next.
- The information reduction is produced and modulated in the first two stages because therein the information to be transmitted is captured and selected. For instance, more pertinent traits about contextual elements, such as the price of the devices, or about the relation between elements, such as the relation between this price and the savings obtained by using them, could have been included in stage 2 limiting the information reduction.
- The two last stages build the narratives to create different effects on people and for that reason a good command of narrative resources is required.
- This framework allows traceability through the storytelling process despite the different staff groups involved because the whole process is documented as shown in the tables in this section.

These last two points point out that the defined framework acts as a connecting link between the R&A and the storytelling phases, allowing the scenario editor to calibrate the effect on the audience. Sections 2 and 3 of Appendix A show how the scenario previously used to explain the information reduction is methodologically adapted to a dissemination\commercial purpose but for a technician audience. A matrix with the new sign-vehicles to adapt the pertinent traits to the new audience gives consistency and traceability to the process.

Although there are many tools widely used in the scenario field that allow combinations of scenarios, they are focused on the R&A phase. These tools consider the combination of a varying range of

variables, including any criteria in the combination. For instance, a four quadrants matrix links entities with two key uncertainties (Schwartz, 1996), the morphological analysis is focused on their incompatible combinations (Jenkins, 1997) and a cross-impact analysis in the likelihood of occurrence of events. RAND Corporation addresses the idea of generating scenarios in-depth, offering a proposal for massive scenario generation (Davis, 2007). It uses two scenario generators (namely, Analytica[22] and CARs[23]) to develop cases of study but, again, the purpose is "to help understand the full diversity of possible futures and to draw implications for planning." Moreover, it focuses on R&A instead of storytelling. It is true that it studies the possibility to include text with a kind of automatic text generator, but it is not designed to cause an effect on the audience and it acts only as a text combinatory exercise; for that reason, it is discouraged: "these textual stories have limited value. Not only would it take an extremely long time to read 10,000 of them, it is even more difficult to extract broad lessons from such a list."

8.- Conclusions, contributions and further research

The scenario building approach is widely used by many organizations to think of the future and to communicate strategies. Although literature about scenario building is wide and varied, in contrast there is a lack of maturity in the standardization of methods. Besides this, in some organizations serious doubts exist about the aim of scenarios, whether they are worthwhile and not time wasting. This paper claims that one of the main causes for the negative perception that some experts have about scenario building is that the different nature of information along the process of scenario building causes inconsistencies and a lack of information, what we have called the "Transformational information reduction". This paper suggests that this reduction mainly appears when passing from the R&A phase to the storytelling phase. It is unavoidable, though its nature and width will strongly depend on the storytelling approach. This paper proposes a framework to cope with this reduction that turns to C.S. Peirce's semiotics principles as a conceptual guide: the purpose approach, the necessity to identify pertinent traits, the consideration of a representamen as a sign vehicle, or the three grades of the interpretant: emotional, logical and pragmatic.

The application of semiotics to different fields of communication has been widely considered as stated in this paper, there are also different tools to scan the environment when building scenarios and to create narratives. Moreover, the necessity to consider narratives in the process of scenario building is beginning to be taken seriously, for instance in the special issue about scenarios published by Futures Journal about scenarios and design, the creation of narratives was a recurrent topic, i.e. (Milojević & Inayatullah, 2015), (Burnam-Fink, 2015), (Raven & Elahi, 2015). Nevertheless, we think that until now the disconnection between the two main phases when building scenarios has not been addressed at least focusing on the losses of information. We think that in that respect semiotics can offer a distinctive point of view to overcome that issue. Besides this contribution, this paper offers story builders a framework that allows us to set the tone of the story, to create numerous

[22] Analytica® is licensed by Lumina (www.lumina.com). It was originally developed as Demos at Carnegie-Mellon University by Max Henrion and Granger Morgan

[23] CARs® was developed by Evolving Logic (www.evolvinglogic.com), of which one of the authors (Bankes) is a principal

versions, and to ease the traceability between the analytic information of the scenario and the final story. At present, most scenario editors use techniques to raise different scenario variations considering different variables, but they do not link R&A and storytelling phases. We also think that it constitutes a useful tool to share information among the different members of staff involved in the process of scenario building or with new staff who can join at any phase of the process. This situation usually supposes a handicap with the traditional methods as it has been mentioned throughout the paper.

This analysis is a first step in order to incorporate a methodology to a process that tends to be artisanal, however it would seem adequate to test it with scenarios from other fields or sectors and check the results. Other approaches as J. Austin (1962) and J. Searle (1969) "speech acts" may be very useful in the future to tackle mechanisms to create effects on the audience by stories.

The framework proposed could be enriched with techniques coming from creative writing, especially those used in television production or story line creation in science fiction narratives. The study of these techniques could be a promising line of research since the use of science fiction to understand the possibilities of the application of science in people's lives has been widely used during decades (Bleiler & Bleiler, 1990).

Also, the construction of an appropriate manual for users would appear as a useful next step.

List of references:

Atkin, A., 2013. "Peirce's Theory of Signs", The Stanford Encyclopedia of Philosophy (Summer 2013 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/sum2013/entries/peirce-semiotics/>.

Austin, J., 1962. How to do things with words. Urmson JO, editor. Oxford: Oxford UP.

Beck, P. W., 1982. Corporate planning for an uncertain future. Long Range Planning, 15, 12-21.

Bishop, P., Hines, A., Collins, T., 2007. The current state of scenario development: an overview of techniques. Foresight, VOL. 9 NO. 1, pp. 5-25

Bleiler, E. F., & Bleiler, R. (1990). Science-fiction, the early years: a full description of more than 3,000 science-fiction stories from earliest times to the appearance of the genre magazines in 1930: with author, title, and motif indexes. Kent State University Press.

Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, T., & Finnveden, G.. 2006. Scenario types and techniques: towards a user's guide. Futures, 38(7), 723-739.

Burnam-Fink, M., 2015. Creating narrative scenarios: Science fiction prototyping at Emerge. Futures, 70, 48-55.

Choo, C.W., 2006. The knowing organization- how organizations use information of construct meaning, create knowledge, and make decisions, Oxford University Press, Oxford

Davis, Paul K., Steven C. Bankes, and Michael Egner. Enhancing strategic planning with massive scenario generation: Theory and experiments. Vol. 392. Rand Corporation, 2007.

Denning, S., 2006. Effective storytelling: strategic business narrative techniques. Strategy & Leadership, vol. 34 no. 1, pp. 42-48,

Foster, J., 1993. Scenario Planning for Small Businesses. Long Range Planning, Vol. 26, No. 1, pp. 123 to 129

de Geus, A., 2008. Tools for foresight. Planning for the unpredictable future. Hardvard Business Press. First published in The living company: Habits for survival in a Turbulent business environment (2002). Hardvard Business School

Glaser, B. G., & Strauss, A. L. 2009. The discovery of grounded theory: Strategies for qualitative research. Transaction Publishers.

Glenn, J.C., and The Futures Group International. Scenarios. 2000. The Millenium Project V3.0

Godet, M., Monti, R., Meunier, F., Roubelat, F., 1999. A tool-box for scenario planning. Project Millenium V3.0.

Gustafsson, R., Kuusi, O., & Meyer, M. (2015). Examining open-endedness of expectations in emerging technological fields: The case of cellulosic ethanol. Technological Forecasting and Social Change, 91, 179-193.

van der Heijden, K, 2005. Scenarios: The art of strategic conversation (2nd ed.). Chichester, UK: John Wiley & Sons.

Huss, W.F., Honton, E.J., 1987 Scenario planning, what style should you use? Long Range Planning, 20, 21-29.

Inayatullah, S. (2009). Questioning scenarios. Journal of Future Studies, 13(3), 75–80.

Jenkins, L. (1997). Selecting a variety of futures for scenario development. Technological Forecasting and Social Change, 55(1), 15-20.

McNulty, C., 1977. Scenario development for corporate planning, Futures, 9, 128-138.

Milojević, I., Inayatullah, S. ,2015. Narrative foresight. Futures, 73, 151-162.

Marsen, S., 2014. “Lock the Doors”: Toward a Narrative—Semiotic Approach to Organizational Crisis. Journal of Business and Technical Communication, 1050651914524781

Molitor, G.T.T., 2009. Scenarios: Worth the Effort?, Journal of Futures Studies, February, 13(3): 81 – 92

Plato, 2003. Book III Plato: The Republic. Penguin.

Peirce, C.S., 1894. The Essential Peirce. Volume 2. Eds. Peirce edition Project. Bloomington I.N.: Indiana University Press, 1998.

Peirce, C.S., 1898. Reasoning and the logic of things: the Cambridge conferences lectures of 1898. Harvard University Press, 1992.

Peirce, C.S., 1878. How to make your ideas clear, Popular Science Monthly Volume 12 January 1878.

Popper, R. (2008) Foresight Methodology, in Georghiou, L., Cassingena, J., Keenan, M., Miles, I. and Popper, R. (eds.), The Handbook of Technology Foresight, Edward Elgar, Cheltenham, pp. 44-88.

Rasmussen, L.B., 2008, The narrative aspect of scenario building - How story telling may give people a memory of the future, Cognition, Communication and Interaction Human-Computer Interaction Series, pp 174-194

Raven, P. G., Elahi, S., 2015. The New Narrative: Applying narratology to the shaping of futures outputs. Futures, 74, 49-61.

Rounsevell, M. D., Metzger, M. J.,2010. Developing qualitative scenario storylines for environmental change assessment. Wiley Interdisciplinary Reviews: Climate Change, 1(4), 606-619.

Schoemaker, P.J.H., 1995. Scenario planning: a tool for strategic thinking, Sloan Management Review 36 (2) pp.25-40

Schwartz, P., 1991. The art of the Long View: Planning for the Future in an Uncertain World (New York: Doubleday/Currency)

Schwartz, P. (1996). Planning for the future in an uncertain world. The Art of the Long View, 241-248.

Searle, J., 1969. Speech acts. Cambridge: Cambridge UP, 1972.

Selin, C., Kimbell, L., Ramirez, R., & Bhatti, Y. (2015). Scenarios and design: Scoping the dialogue space. Futures, 74, 4-17

Shannon C.E., 1948. A mathematical Theory of Communication. Reprinted with corrections from The Bell System Technical Journal, Vol. 27, pp. 379-423, 623-656

Short, T.L., 2007. Peirce's Theory of Signs. Cambridge University Press. ISBN-13 978-0-521-84320-1

Steckelberg, A. V. (2015). Orchestrating a creative learning environment: Design and scenario work as a coaching experience-How educational science and psychology can help design and scenario work & vice-versa. Futures, 74, 18-26.

Walker, M.C., 2002. Power Screenwriting: The 12 Stages of Story Development, Lone Eagle

Wickman, C., 2015. Locating the Semiotic Power of Writing in Science. Journal of Business and Technical Communication, 29(1), 61-92.

Wilkinson, A., 2009. Scenarios Practices: In Search of Theory. Journal of Futures Studies, February, 13(3): 107 – 114

Wright, G., Cairns, G., & Bradfield, R. (2012). Special issue on Scenario method: Current developments in theory and practice. Technology Forecasting and Social Change, 79(1), 198.

APPENDIX A

Scenario 1, scene 1, (D1.1 Service Scenarios and Specifications, ePerspace IST Project N° 506775)

1.- Original text, pragmatic approach

Paragraph 1

The van Epers family is not very sociable. During weekdays, each member of the family needs to get ready for work, school and other activities. Both Julia and Ian start preparing for their day at their office and the children try to catch up with whatever task they may have left behind the day before.

Paragraph 2

Whilst eating breakfast, Ian peruses his personalised news service on the big house TV. Usually he has the use of the TV in the morning, as he is the first to leave home. The ePerSpace @Home system is set to do exactly that and automatically sets the TV to Ian favourite channel(s). He notices that there is a breaking news story about the ACME Corp. takeover of Roadrunner Enterprises. By selecting a button on the TV remote control, he registers an active interest in the story, thereby informing the system to keep him abreast of any new developments on this topic. Next to the AV news report are sets of links to related material (AV, hypertext etc.). As he drinks his coffee he selects a news item on ACME's recent approach to Yosemite International.

Paragraph 3

As Ian gets ready to leave for work, Julia comes downstairs kisses him goodbye. Ian leaves the house and the system displays Julia's personalised news on the TV.

Paragraph 4

Julia goes into the kitchen and starts preparing the breakfast and packed-lunches for the kids. The TV switches off and the radio broadcasts the audio component of the personalised news.

Paragraph 5

Marc and Lisa come down to get their breakfast. As Julia gets ready to leave, she checks the traffic. My traffic is a service provided by ePerSpace, and Julia has subscribed to it. She checks into the system and can view the live traffic conditions at a number of key points on her TV. She checks the situation in the village where they live and using the split screen facility she can look at a number of points of interest. Having seen the situation, she indicates that she wants the session transferred to her mobile and leaves home with her children.

2.- Pertinent traits and representamens with logical approach

Table 25 Pertinent traits and logical sign-vehicles in Scenario 1, scene 1, (D1.1 Service Scenarios and Specifications, ePerspace IST Project N° 506775)

Number and paragraph	Pertinent trait	Sign-vehicle Logical
1 (paragraph 2)	Personalized TV service with user identification	The system includes an automatic user identification system based on facial recognition. It uses AI algorithms to check an ISO 19794-5 full frontal image with a 97 percent success rate. The first user detected is selected as the main user
2 (paragraph 2)	Machine learning based on preferences and recommendation algorithms	A neural network that uses previous behaviour feeds a recommendation system
3 (paragraph 3)	Auto-detection of main user switching	The facial recognition module continually scans the area in front of the television. If it detects that the main user goes out of this area and another user enters it, it notifies that the main user has changed to the recommendation and personalization system
4 (paragraph 4)	Auto-detection of activity and rendering of information	When there are no people in the TV's visual field, and presence is detected in the kitchen, the ePerSpace system renders the information to format audio
5 (paragraph 5)	Integration of traffic services on TV	ePerSpace uses an open API to integrate other services, such as traffic and surveillance services
6 (paragraph 5)	Multiplatform	ePerSpace service includes an OSGI development to detect multiple devices, rendering and transferring information between them depending on data about the use

3.- New scenario with pragmatic and logical approach (underlined, new text added)

Paragraph 1

The van Epers family is not very sociable. During weekdays, each member of the family needs to get ready for work, school and other activities. Both Julia and Ian start preparing for their day at their office and the children try to catch up with whatever task they may have left behind the day before.

Paragraph 2

Whilst eating breakfast, Ian peruses his personalised news service on the big house TV.

Usually he has the use of the TV in the morning, as he is the first to leave home. The ePerSpace @Home system is set to do exactly that and automatically sets the TV to Ian favourite channel(s) using for that ePerSpace automatic user identification system based on facial recognition. It uses AI algorithms to check an ISO 19794-5 full frontal image with a 97 percent success rate, selecting the first user detected as the main user.

He notices that there is a breaking news story about the ACME Corp. takeover of Roadrunner Enterprises. By selecting a button on the TV remote control, he registers an active interest in the story, thereby informing the system to keep him abreast of any new developments on this topic. A neural network gathers previous behaviour to feed a recommendation system so that recommendations accuracy can be continually improved. Next to the AV news report are sets of links to related material (AV, hypertext etc.). As he drinks his coffee he selects a news item on ACME's recent approach to Yosemite International.

Paragraph 3

As Ian gets ready to leave for work, Julia comes downstairs kisses him goodbye. Ian leaves the house and the system displays Julia's personalised news on the TV. This is possible becasue ePerSpace facial recognition module continually scans the area in front of the television. If it detects that the main user goes out of this area and another user enters it, it notifies that the main user has changed to the recommendation and personalization system.

Paragraph 4

Julia goes into the kitchen and starts preparing the breakfast and packed-lunches for the kids. ePerSpace notes that there are no people in the TV's visual field, and presence is detected in the kitchen, then it renders the information to format audio. The TV switches off and the radio broadcasts the audio component of the personalised news.

Paragraph 5

Marc and Lisa come down to get their breakfast. As Julia gets ready to leave, she checks the traffic. My traffic is a service provided by ePerSpace by means of an open API that allow integrating other

services, such as traffic and surveillance services, and Julia has subscribed to it. She checks into the system and can view the live traffic conditions at a number of key points on her TV. She checks the situation in the village where they live and using the split screen facility she can look at a number of points of interest. Having seen the situation, she indicates that she wants the session transferred to her mobile and leaves home with her children. Multiplaform is possible because ePerSpace service includes an OSGI development to detect multiple devices, rendering and transferring information between them depending on data about the use.

PAPER 4

Routledge
Taylor & Francis Group

Technology Analysis & Strategic Management

ISSN: 0953-7325 (Print) 1465-3990 (Online) Journal homepage: http://www.tandfonline.com/loi/ctas20

Easing the assessment of emerging technologies in technology observatories. Findings about patterns of dissemination of emerging technologies on the internet

Javier Carbonell, Antonio Sánchez-Esguevillas & Belén Carro

To cite this article: Javier Carbonell, Antonio Sánchez-Esguevillas & Belén Carro (2017): Easing the assessment of emerging technologies in technology observatories. Findings about patterns of dissemination of emerging technologies on the internet, Technology Analysis & Strategic Management, DOI: 10.1080/09537325.2017.1337886

To link to this article: http://dx.doi.org/10.1080/09537325.2017.1337886

Easing the assessment of emerging technologies in Technology Observatories. Findings about patterns of dissemination of emerging technologies on the Internet.

Abstract:

This paper considers the Web as a big data container that can be used by Technology Observatories and administrations to track emerging issues and more specifically emerging technologies. It considers information that is available on the Internet for free from different sources, and proposes a framework that can be useful to characterize them and to detect patterns of dissemination. This framework is made up of 30 metrics obtained from different kinds of sources (general web, patents, scholars…). Some of them are obtained directly as the number of hits retrieved by queries on a search engine, and other ones calculated by means of ratios.

This paper contains the development of a complete case that utilizes this framework to characterize emerging technologies included in the well-known Hype Cycle for Emerging Technologies, in this case the 2015 release[24] and to analyze patterns of dissemination of these technologies on the Internet

[24] https://www.gartner.com/doc/3100227/hype-cycle-emerging-technologies-

Keywords: bibliometrics, technology observatory, emerging issue, emerging technology

0.- Introduction

Understanding the environment and its drivers of change to foresee the future is one of the critical points that all organizations must face in order to ensure their sustainability. Implementing this kind of view in organizations is not trivial as it requires processes to capture what is happening in the environment and the main trends and change drivers in it. The need of any kind of structure in charge of capturing the environment was already considered some decades ago. For instance, Stafford Beer proposed, in its model of viable organizations, the existence of a subsystem, named "intelligent subsystem", which is in charge of environmental surveillance (Stafford 1972) and that can be considered the seed of the observatories.

Horizon scanning or environmental scanning, "an activity to acquire information" (Aguilar 1967) is one of the tasks that any observatory has to deal with at some point. In order to be exhaustive, scanning methodologies tend to include a high variety of perspectives and frameworks, for instance STEEP (Social, Technological, Economic, Environmental and Politics), PEST (Politics, Economic, Social and Technological), BICEPS (Business, Industry, community, economy, political and, social) or ICOS (Individual, Communal, Objective and Social), and a wide variety of sources.

This variety in the nature and perspective of the information required along this process is a central difficulty in carrying out scanning activity. Although there are several approaches to assess the scanned emerging phenomena (Carbonell et al. 2015), usually, researchers in this field have drawn on bibliometric and scientometric models as described in the next section, but there is not a consensus on what sources and what metrics should be used to assess emerging technologies (Rotolo et al. 2015). Other lines of inquiry propose to integrate bibliometrics and patent analysis into well-known technology forecasting tools such as scenario planning, growth curves and analogies (Daim et al 2006) in order to improve forecasting.

Studies on this issue stand out the difficulty to define and acquire the information when scanning emerging technologies, and for that reason, many studies make use of the Web as a source of information. This use of the Web is sometimes centered on several relevant webs specialized in the subject being scanned (Douw et al. 2006) or in the Web 2.0 (Lau et al. 2012). Depending on whether the terms searched are preselected or not, some authors distinguish searching from scanning (Palomino et al. 2012).

This paper uses the first approach (i.e. the terms searched are preselected) to dive into the possibilities that the Internet offers to scan the environment to assess emerging technologies finding patterns to understand the dissemination of their signals and to characterize them.

Though there are several approaches to assess emerging technologies that takes into account different techno-scientific (van Doren et al. 2014) and advisory (Forsberg 2014) domains (advisory domains are more or less distinct traditions for assessment of technologies, such as risk analysis, foresight and ethical assessments), this paper is focused on the creation of a framework based on traditional bibliometric approaches to analyze emerging phenomena, using to that aim information that is accessible for free on the Internet. This approach has the advantage that it is easily accessible for any organization, objective and free. Apart from this, the Internet has the advantage of gathering

information from very different perspectives, and directed to very different audience targets, from scholars to general information for the layman.

The overall goal of this paper is to illustrate how any organization can track and analyze emerging phenomena, in this case emerging technologies, with the information sources and search engines that are at hand and free on the Internet, and how traces on the Internet can supply very useful information for Observatories to do their work. This paper is organized into four sections. In the first section some forecasting concepts and literature about the scanning of emerging issues are reviewed. Section 2 develops the variables that are included in the framework and their rationale. A case using this framework is developed and the conclusions obtained from it are shown in section 3. Section 4 delivers some final thoughts and proposes new lines of enquiry to continue the research.

1.- Literature review

In this section the main forecasting concepts that are useful to understand emerging phenomena scanning procedure are explained. These concepts are subject to a constant revision as this is an area that has not reached the mature level and still shows a high research activity. The intention of this section is not to enter into a discussion, which it would be intractable considering the number of concepts and approaches in the research community, but to explain their foundations and their limitations.

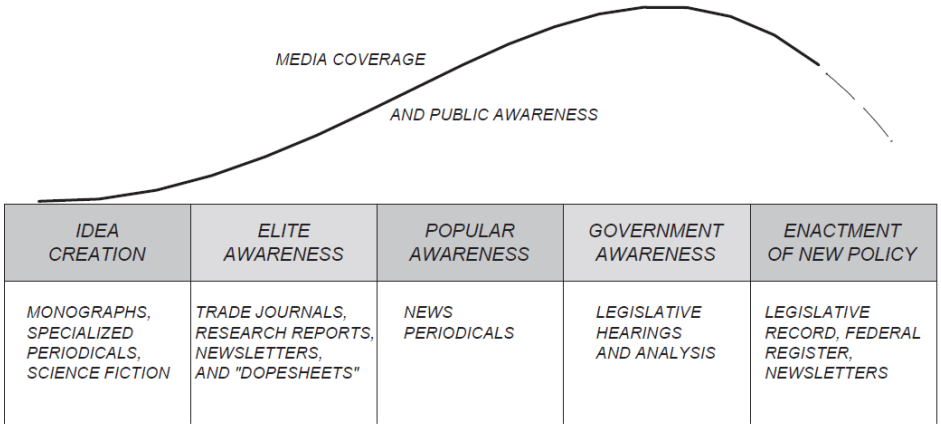
- *Emerging issues. First signals and information life-cycle*

New phenomena in their early stages are called "emerging issues". They have been widely analyzed in literature, mainly by Molitor (1977, 1981, 2003), but it is not a clearly defined concept and appears continuously mixed with other concepts as weak signals, wild cards, trends, megatrends (Hiltunen 2010; Coffman 1997; Heijden 1997). There is even a debate about if emerging issues and their first signals, usually called weak signals, are similar concepts (Coffman 1997), or on the contrary they must be differentiated (Brabandere 2005; Nikander 2002.

Most of the models associate the dissemination process of information related to emerging issues with a more or less regular S curve/life cycle in which the different stages are linked to different types of media and public (Molitor 1977, 2003; Wygant 1988) (see Figure 5).

Martino (2003) proposes a life cycle for the dissemination of emerging technologies information, associating the stages with different types of media sources. In general terms, this model proposes that a technological innovation begins with basic research that is associated with scholars, continues with industrial development that is associated with patents, and ends up with a mainstream social impact that is associated with popular press.

Figure 5 Precursor Monitoring of Emerging Issues



Source: Information and the Future: A Handbook of Sources and Strategies, by Alice Wygant and O.W. Markley (1988); based on Molitor (1977)

- *Emerging technologies*

Emerging technologies can be considered as a specific case of emerging phenomena. As it happens with most of the forecasting processes and methodologies, there is not a clear definition for this concept or at least the limits are not sheer. For instance, some studies emphasize their potential on the economy and society (Porter et al. 2002), others on the uncertainty associated to the emerging process (Boon and Moors 2008) or on the characteristics of novelty and growth (Small et al. 2014). Sometimes this concept is confused with other concepts such as trends in their initial phase, as it is deducted from this definition: "emerging technologies are defined as those technologies that have the potential to gain social relevance within the next 10 to 15 years. This means that they are currently at an early stage of their development process" (Stahl 2011, 61). It is therefore a concept not well delimited that gives place to continuous interpretations about its real meaning, its scope. During the last years a rich debate has been held by the scientific community in order to clarify the boundaries or at least to agree the main features of the emerging technologies. This burst in the activity around this concept is described by Rotolo et al. (2015) who claim, "often no definition of the central concept of an emerging technology is provided".

- *Bibliometrics and scientometrics models*

The term bibliometrics is usually credited to Pritchard (1969) who proposed it to replace the term 'statistical bibliography' and it is defined as the measurement of texts and information (Norton 2000). Bibliometrics is one of the approaches most commonly used to assess the dissemination of concepts in the past and sometimes to forecast their future. In the same period the term scientometrics was coined to describe the study of science: growth, structure, interrelationships and productivity (Nalimov and Mulchenco 1969). Considering these definitions, "much of scientometrics is indistinguishable from bibliometrics, as the immediate and tangible output of science and technology into the public domain is literature (papers, patents, etc.)" (Hood and Wilson 2001, 293). Since then, other disciplines that consider the use of indicators to measure text dissemination in different media have been developed creating a mosaic of overlapping fields: tech mining is defined as the

application of text mining tools to science and technology information (Porter and Cunningham 2005); webometrics, is described as the quantitative study of web-related phenomena (Thelwall et al. 2005); or informetrics proposed Nacke (1979) to cover that part of information science dealing with the measurement of information phenomena and the application of mathematical methods to them.
Social media play an important role too in the dissemination of information, and the conversations in these media are beginning to be seen as a source to detect the relevance of a trend (Thelwall et al. 2013), (Hausten et al. 2014). Nevertheless, heterogeneity, data quality and dependencies and the need of specific APIs are challenges that need to be faced (Haustein 2016)

- *Growth curves, and their limitations*

It is very common to analyze bibliometrics using some growth curves, mainly any variation of S-curve, as Fisher Pry and Gompertz. Though literature associating both concepts is copious, their original concept related to substitution models and mortality is not completely adaptable to emerging phenomena that are in a very incipient state and which final potential is not even intuited. The limitations of these curves with this purpose are highlighted in literature. For instance, Lenz and Lanford (1972) state that Fisher-Pry curves are valid from 2% substitution threshold on, and Martino (2003) also doubt of these approaches asserting that if the upper limit is not known, neither the logistic nor the Gompertz, nor any of their variants, performs very well.

2.- Tracking the web: metrics to assess and characterize emerging issues

The final aim is to create a framework to help Technology Observatories characterize emerging technologies according to their traces on the Web in order to understand them better, with that purpose some metrics are proposed. These metrics consider information referred to three well-delimited fields: the layman, the academic and the industrial that can be represented by the general web, academic publications and patents. This segmentation is consistent with the life cycle of information proposed by Martino (2003), mentioned previously. It also has the advantage that the information on the Web is easy to segment according to it.

This framework includes two kinds of metrics, primary metrics that are obtained directly as the number of hits retrieved by queries on a search engine, and secondary metrics that are calculated by means of ratios between the primary metrics.

- *Primary metrics.*

  Two kinds of them are considered. On the one hand, a relevant indicator to measure the activity in each field: in the case of the layman the number of web hits is used; in the case of the academic, the number of scholar publication hits; and in the case of the industry the number of patent hits. On the other hand, an indicator that reflects in some way the level of interest that a concept raises on each community. The number of anchor hits (when a term is included in a link from a web to other web sites) will be used for the layman, the number of citations for the academic field, and the number of design patents (this kind of patents have

a market orientation that determines if one technology raises interest for its commercialization) for the industry.

The Internet acts as a container that stores information since it came into being, but measurements restricted to the immediate past can be useful to understand the present situation. For that reason, in this model two measurements will be taken for each variable. Firstly, without time restrictions, gathering all the traces on the Web. And secondly, restraining the retrievals to the last three years previous to the report elaboration. These last metrics are named with the same name that the corresponding metric that tracks the entire web but adding the suffix L3Y that stands for Last 3 Years. Three years is usually an appropriate period to get a good picture of recent dissemination activity. Nevertheless, other periods of time could have been chosen without affecting the conceptual model of this framework.

Considering this reasoning, the model considers twelve primary or direct metrics as indicated in Table 26.

Table 26 Primary metrics used to track the web

		Metrics	
		General Activity	**Community Interest**
Without time restriction	**Layman**	**web** = nº web hits	**anchor*** = nº web anchor hits
	Academic	**scholar** = nº scholar hits	**citation** = nº citations hits
	Industry	**patent** = nº patent hits	**designpatent** = nº design patent hits
Last 3 Years	**Layman**	**webL3Y** = nº web hits (2012-2014)	**anchorL3Y** = nº web anchor hits (2012-2014)
	Academic	**scholarL3Y** = nº scholar hits (2012-2014)	**citationL3Y** = nº cite hits (2012-2014)
	Industry	**patentL3Y** = nº patent hits (2012-2014)	**designpatentL3Y** = nº design patents hits (2012-2014)

* anchor means that a term is included in a link from a web site to other web sites. Conceptually this concept has similarities with citation in academic field

- *Secondary metrics.*

The possible number of combinations of primary metrics, by means of ratios is very high. Only simple ratios that capture a relevant aspect of reality are considered. They can be divided into two groups:

A. ***Calculations between metrics in the same field.*** These metrics are calculated as ratios between primary metrics within each field. Two types of metrics are considered.

- *Novelty ratios*. They indicate the percentage of traces of an emergent technology on the Internet during the three previous years with respect to all the traces on the Internet (without time restrictions), revealing if there has been a special interest in that period of time. They are calculated as the number of hits in the last three years divided by the number of hits without restrictions:

$$(a)\ novelty\_web = \frac{webL3Y}{web}$$

$$(b)\ novelty\_anchor = \frac{anchorL3Y}{anchor}$$

$$(c)\ novelty\_scholar = \frac{scholarL3Y}{scholar}$$

$$(d)\ novelty\_citation = \frac{citationL3Y}{citation}$$

$$(e)\ novelty\_patent = \frac{patentL3Y}{patent}$$

$$(f)\ novelty\_designpatent = \frac{designpatentL3Y}{designpatent}$$

- *Effervescence ratios.* They measure the buzz in each field. They are calculated for each field dividing the metric that indicates the community interest by the metric that indicates the general activity. Two indicators are selected for each field, one with the total number of hits without restrictions, and the other with the number of hits in the last three years.

$$(g)\ effervescence\_layman = \frac{anchor}{web}$$

$$(h)\ effervescence\_layman\_L3Y = \frac{anchorL3Y}{webL3Y}$$

$$(i) effervescence\_academic = \frac{citation}{scholar}$$

$$(j)\ effervescence\_academic\_L3Y = \frac{citationL3Y}{scholarL3Y}$$

$$(k) efervescence\_industry = \frac{patentdesign}{patent}$$

$$(l)\ effervescence\_industry\_L3Y = \frac{patentdesignL3Y}{patentL3Y}$$

B. ***Calculations between metrics of different fields***. These metrics are calculated as ratios between metrics from different fields. These relations indicate if an emerging technology is more oriented to the layman, to the academic or to the industry field. In this case only metrics restricted to the last 3 years are used in order to capture the recent positioning of a concept with respect to those fields, which has more interest for Technology Observatories.

$$(m)\ Relation\_Industry\_Academic\_L3Y = \frac{patentL3Y}{scholarL3Y}$$

$$(n)\ Relation\_Academic\_Layman\_L3Y = \frac{scholarL3Y}{webL3Y}$$

$$(o)\ Relation\_Industry\_Layman\_L3Y = \frac{patentL3Y}{webL3Y}$$

$$(p)\ Relation\_Industry\_Academic\_Community\_Interest\_L3Y = \frac{designpatentL3Y}{citationL3Y}$$

$$(q)\ Relation\_Academic\_Layman\_Community\_Interest\_L3Y = \frac{citationL3Y}{anchorL3Y}$$

$$(r)\ Relation\_Industry\_Layman\_Community\_Interest\_L3Y = \frac{designpatentL3Y}{anchorL3Y}$$

Thus, the model proposed is comprised by 30 parameters (twelve directly measured by means of a search engine and 18 calculated from them using different ratios) in order to capture different aspects of the emerging technologies. This model must be considered as a reference that could be simplified or enriched to capture new dimensions of the reality. For instance, metric's segmentation by geographical zone would offer a vision of the poles of development of the emerging technologies. This model is in line with other researches in the detection of emerging technologies that resort to citations and other bibliometric approaches, i.e. Järvenpää et al. (2011) turn to cumulative count of the number of basic and applied research publications, patents, and news, and Abercrombie et al. (2012) turn to publications and citations, patents, and web news. Other analyses include other variables, i.e. Jun et al. (2014) turn to searching traffic (Google trends). These studies use some of the primary metrics included in the framework and in some cases define metrics to detect important increases in a period of time in the citation of any term (Iwami et al. 2014), (Boyack et al. 2014), what to some extent coincides with the concept of novelty described when explaining the secondary metrics. Breitzman and Thomas (2015) consider patents more cited by other patents in the last two years, concept that is similar to the effervescence metrics used in the model. Nevertheless, the model that the framework proposed introduces is distinctive because the number of metrics included, primary and secondary, it uses only free accessible, and all the calculations are easy to be carried out by a small organization.

3.- Case study. The Hype Cycle for Emerging Technologies 2015

Objective

In this section the metrics previously defined will be calculated for a group of emerging technologies. The objective will be threefold: to characterize this sample using the framework previously defined, to analyze the own framework trying to detect relations between metrics, and to find patterns about the dissemination of signals on the Internet.

Selection of the emerging technologies

Many reports about emerging technologies, technology trends, and other concepts that can be assimilated to emerging technologies can be found on the market, and sometimes for free on the web. The Hype Cycle for Emerging Technologies 2015[25] report from Gartner has been used to select the sample of emerging technologies that will serve as case study. There are two main reasons to select it. Firstly, it is a prestigious document well recognized by all innovation and research sectors. Secondly, its approach to "emerging technology" concept coincides with the one that has been used along this article. This approach is mentioned at the beginning of the report: "Gartner's Emerging Technologies Hype Cycle brings together the most significant technologies from across Gartner's research areas. It provides insight into emerging technologies that have broad, cross-industry relevance and are transformational and high-impact in potential" (page 1).

The adequate selection of the sample is paramount to ensure that the results of any research study are reliable. It is out of the scope of this paper to discuss if Gartner's emergent technologies list and categorization is reliable, or if other reports are more accurate. We believe no organization has the monopoly of the truth in a so abstract field. However, this report has the required wide approach to technologies, it includes concepts close to technology research as "quantum computing", others that are technological trends not associated to a unique technology as "smart dust", and others that have a more enterprising or marketing orientation as "neurobusiness". Besides this conceptual diversity emerging technologies offer different levels of specificity, for example "Autonomous vehicle" and "Autonomous field vehicle" are included in this report.

The present analysis considers the 37 emerging technologies included in the Hype Cycle for Emerging Technologies 2015. This report classifies them according to several factors each one with several categories or levels: the factor stage with four levels (On the rise, at the peak, sliding into the Trough, climbing the trough), the factor impact with three levels (transformational, high, and moderate), the factor years to adoption with three levels (from 2 to 5 years, from 5 to 10 years, more than 10 years). The description of the categories of these factors is detailed in page 70 of Gartner's report. The stages refer to the Hype lifespan model. The impact is defined in the next way: transformational enables new ways of doing business across industries that will result in major shifts in industry dynamics, high enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise, and moderate provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise. Years to mainstream adoption is the time required for the technology to demonstrate and accept real-world benefits. In addition to them, the factor New with two levels (yes

[25] https://www.gartner.com/doc/3100227/hype-cycle-emerging-technologies-

and no) is included. It indicates if the emerging technology was included for the first time in this version of the report.

Table 1 in ANNEX shows the emerging technologies considered in this analysis and their description and Table 2 in ANNEX shows their categorization.

Data retrieval method and period of study

The Google Search Engine was used to undertake queries, selecting different options to restrict the search to different sources of information: scholars, patents, citations, web, and anchor. Nevertheless, other search engines could have been used, some of them more specific to these fields. One important reason to use it is that it includes specific options to restrict the searches to one of these fields giving a kind of homogeneity to all the indicators.

In order to ease this reproduction of the analysis and carry out new ones, it is necessary to be able to replicate the mode of operation. The sites utilized for the queries and the options are depicted in Table 27.

Table 27 Sites and query options used in the case

Metric	Site	Query Options
web	www.google.com	No special options
anchor	www.google.com	The operator "allinanchor" is used*
scholar	scholar.google.com	Opting out the option "citations" and "patents"
citation	scholar.google.com	Opting out the option "patents" and taking away the metric scholar
patent	www.google.com/patents	No special options
designpatent	www.google.com/patents	Selecting "design" in the drop-down menu "Any patent type"

* allinanchor operator is widely explained in http://www.googleguide.com/advanced_operators_reference.html#allinanchor

As the report was published in June 2015, it can be assumed that it was elaborated during the first semester of the year, so the searches will be restricted to the timeframe January 2012-December 2014 for the metrics referred to the last three years: webL3Y, anchorL3Y, scholarL3Y, citationL3Y, patentL3Y, designpatentL3Y.

The queries have been carried out on 22nd November 2015. The metrics without time restrictions will change in the future and the same experiment will not be able to be reproduced exactly to give the same results. In the case of metrics with time restrictions, the results could change but slightly, at least in the short term after the date when this experiment has been carried out.

The term used in the queries is the exact term used to name the emerging technologies in the Hype Cycle for Emerging Technologies 2015. When the emerging technology term is in plural the search term utilized includes the plural and singular, for instance in the case of "*Virtual Personal Assistants*" the term used is "*Virtual Personal Assistant" OR "Virtual Personal Assistants"*. The number of hits showed is exact when it is small but an approximation when it is large. The metrics *citation* and *citationL3Y* are calculated as the number of scholar retrievals including citations minus the number of scholar retrievals without including citations. This fact gives an inconsistency for the emerging technologies "Augmented reality" and "Virtual Reality" that offer negative numbers. These emerging technologies have not been included to calculate the metrics that include citations in their formula, using for that metrics a sample of 35 elements instead of 37. All the number of hits retrieved and search terms are included in ANNEX (Table 3 and Table 4).

Some techniques like defining an ontology for a semantic analysis that includes the study of synonyms or trees of dependencies could enrich the query. Nevertheless, the definition of this ontology is not a trivial activity because adding a new term to the query usually implies a redefinition of the concept. For instance, "autonomous vehicle", "autonomous car", "Google Waymo", "autonomous taxi" or even the technology "lidar" are in the same ontological field but cover different approaches. In the case study, it is a key point not to alter the initial approach (commercial, research, industrial) of the emerging technologies selected by Gartner and that fact makes it difficult to use ontologies. In addition, the same criteria to build the ontology should be used for all the terms in order not to distort the results, and that would imply introducing some subjectivity, taking into account the difficulty in putting limits to the words meanings. For all these reasons, although ontologies can be very useful to study particular trends and are widely used in big data analysis, using them has been discarded considering the purpose of this case study. Rather than being problematic, using the sheer term in the query as it is named in the report has the advantage of capturing different approaches and levels of depth of the emerging technologies, which enriches the present research.

Data analysis and conclusions

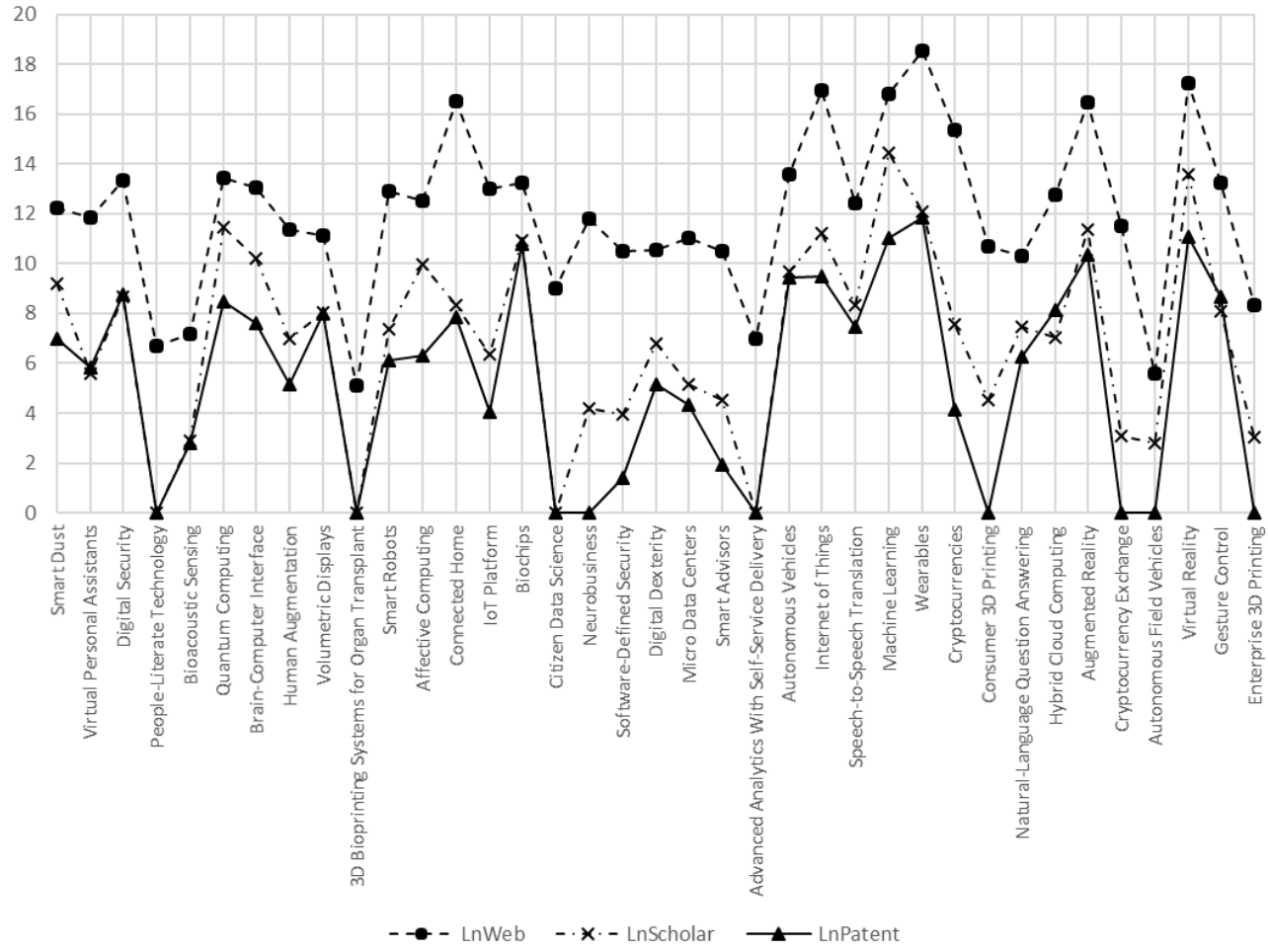
As commented, the objective of this case is to test the framework previously defined characterizing the emerging technologies included in the Hype Cycle for Emerging Technologies 2015, and to obtain conclusions about the framework itself and about the patterns of dissemination of these technologies on the web. The following sections develop these points.

a) Characterization of Hype Cycle for Emerging Technologies 2015 sample

The number of possible analyses and charts that can be constructed by using the model is very high. The format, configuration and metrics of the charts to be included need to be set according to the objectives of the analysis. In this section some possible charts are presented.

The comparison between metrics related to the same emerging technology gives important information about its nature and the comparison with other emerging technologies' metrics gives relative information of its importance in the different fields. (Figure 6).

Figure 6 2015 Gartner's emerging technologies traces on the Web (after Ln transformation)



This figure shows three primary metrics: web, scholar and patent. As the range of variation is very high, from units to millions, and to fit the data better to a normal distribution a Ln transformation has been done. This Ln transformation is applied to all primary metrics throughout this case. The approach of the emerging technology can be deducted from the relations between these metrics. For instance, "citizen data science" or "people-literate technology" are commercial concepts because they show traces on the general web but hardly any in academic or industry fields. Other terms such as "biochips" or "augmented reality" have a wider orientation with important traces on the Internet, patents and scholar fields.

Though one of the premises of this framework is that is suitable for any small company and not special statistics tool is required for the analysis, the use of a very simple statistics software allows the creation of powerful descriptive charts, i.e. clustering can offer new insights. To that aim the Dendrogam chart is useful because it shows the distances between emerging technologies and different layers of aggrupation. Figure 7 shows three clusters based on the effervescence in the last three years and Figure 8 shows the scatterplots associated to those clusters. It suggests that Cluster 3 is formed by those emerging technologies with a special effervescence in the industry field, which

is indicated by the number of design patents (wearables, autonomous vehicles and volumetric displays).

Though there is some overlap, Cluster 1 (smurt dust, digital security…) gathers that technologies with high effervescence in the academic field, and Cluster 2 those with higher effervescence for the layman (virtual personal assistant, brain-computer interface…) that means that they have a more commercial approach.

Figure 7 Cluster analysis (Dendrogram), using metrics effervescence_laymanL3Y, effervescence_industryL3Y and effervescence_academicL3Y

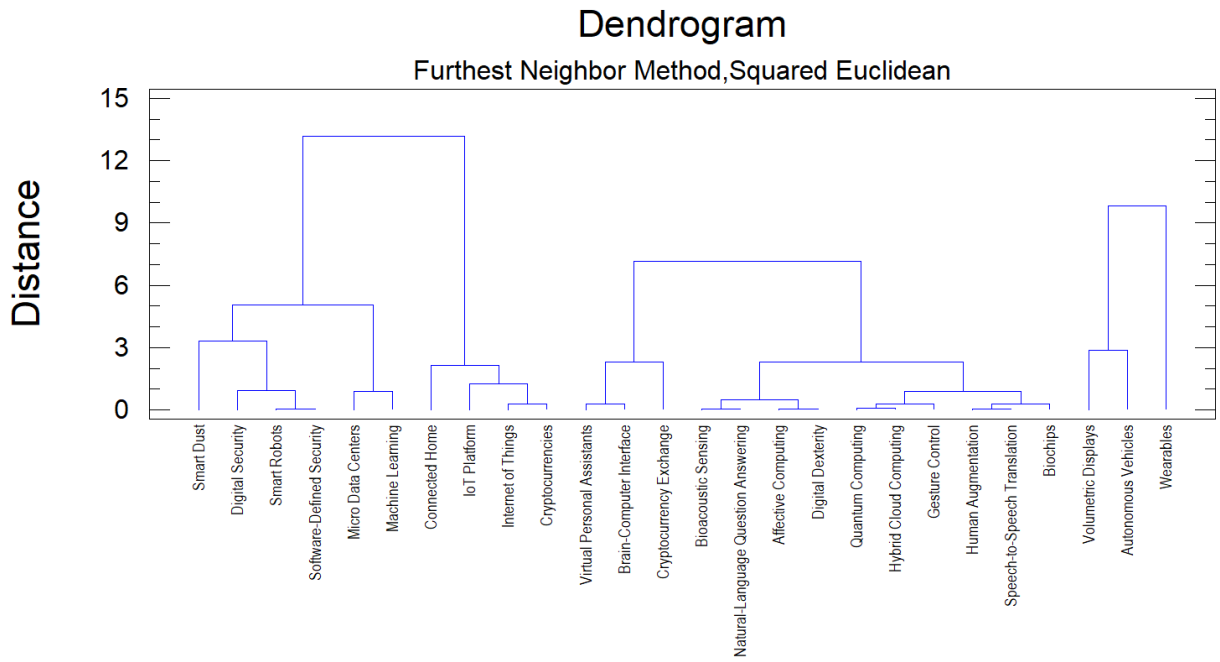
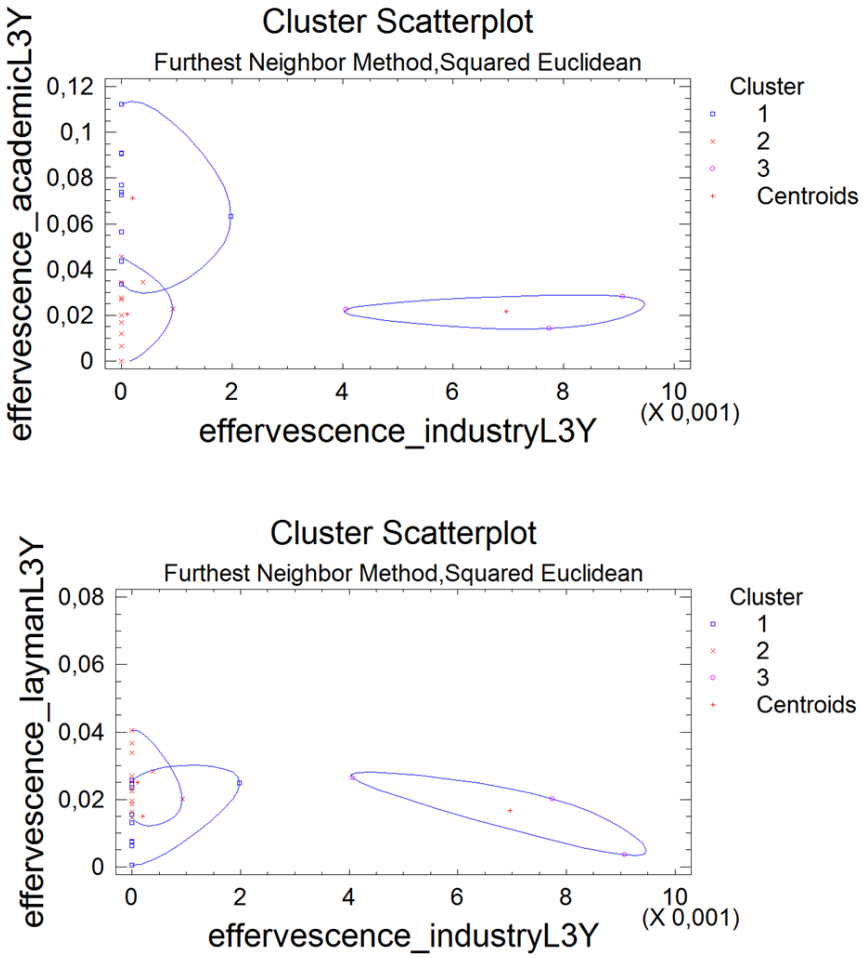


Figure 8 Cluster Scatterplot



b) Detection of relations between the metrics of the framework

A model with 30 metrics has the advantage that is able to capture lots of dimensions or details from reality. Nevertheless, it can be difficult or inefficient to manage. For this reason, it is interesting to look for relations or correlations between them. Clustering techniques to group them are a good option to face this situation. Figure 9 shows how primary metrics can be divided into three groups: designpatent and designpatentL3Y in one group, most of metrics related to the layman field in another, and other metrics related to industry and academic fields in the other, what indicates the strong relationship between these two fields. It is remarkable that anchorL3Y is in the last group, close to citationL3Y metric.

Figure 9 Primary metrics clustering

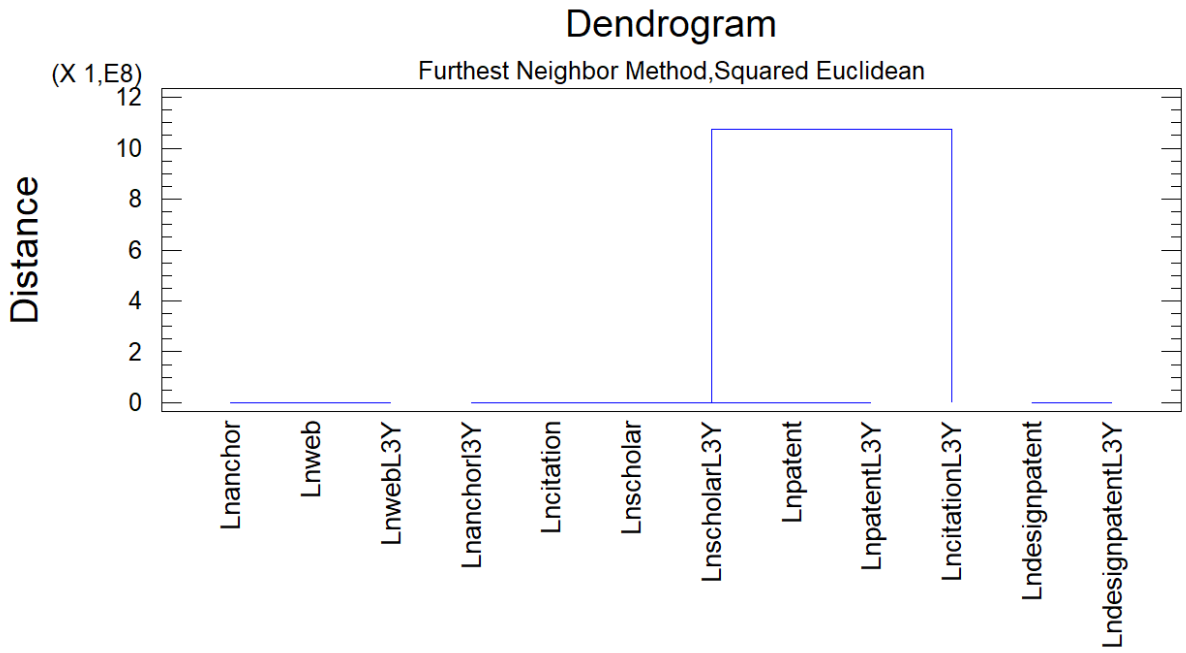
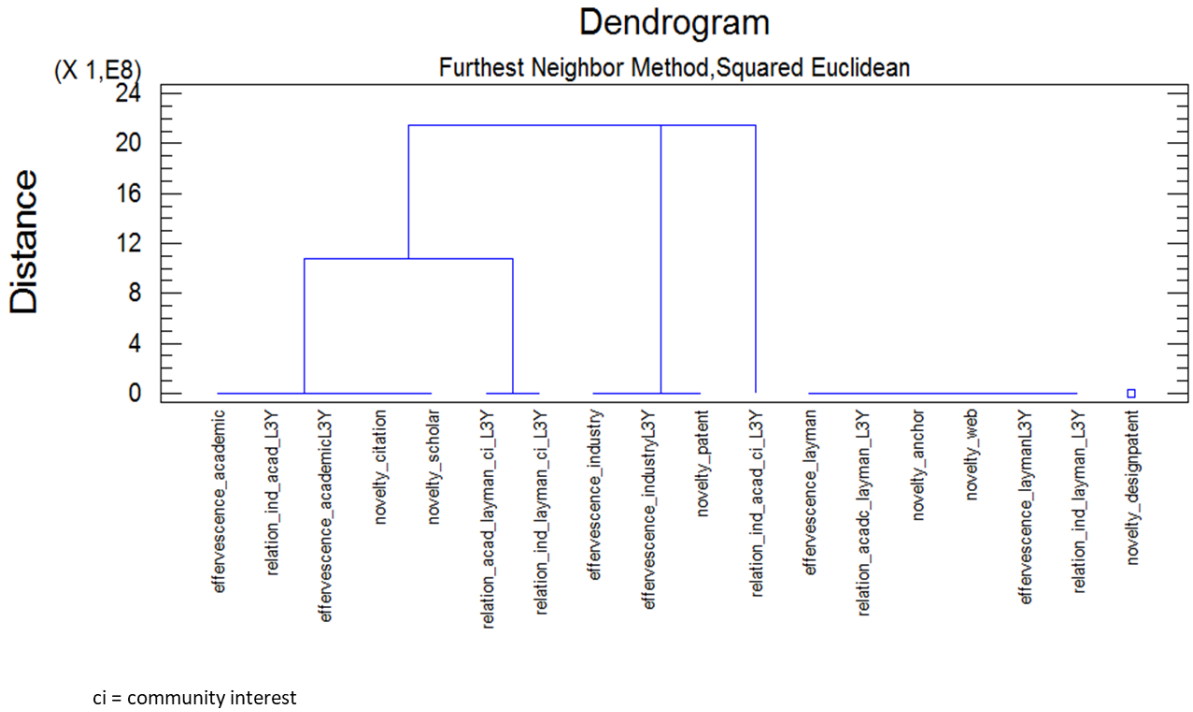


Figure 10 shows that secondary clustering criterion is not so obvious, again metrics related to designpatent are in a cluster, but there is not a clear clustering criterion for the other clusters. The fact that these metrics mix concepts from different fields can be under the blurring of cluster frontiers.

Figure 10 Secondary metrics clustering



ci = community interest

c) Assessment of dissemination patterns on the Internet

The sample used in this case study is categorized according to several factors, each one of them with several levels. Statistical differences in the values of the metrics depending on these levels offer interesting information about how traces of the emerging technologies disseminate on the Internet. For instance, if the number of references in scholars is much higher for those emerging technologies that are at the peak in the hype cycle, this fact gives information about the pattern of dissemination in the academic field. The operating mode in this section will be comparing the values of the metrics for the group of emerging technologies in the different levels detecting statistical significant differences. To that aim, an ANOVA (analysis of variance) analysis has been carried out for each metric with respect to each one of the factors. The p-value indicates if the levels of a factor have significant influence in the values of the metric, if p-value is minor than 0.1 there is a significant influence and if it is minor than 0.05 there is a strong significant influence. In both cases it can be stated that it exists a pattern that should be analyzed. The ANOVA table showing the p-values of all the combinations of metrics-factors is included in ANNEX (Table 5).

Table 28 displays all the relations between metrics and factors that are statistically significant. It shows the p-value and the mean of the metrics for the levels (categories) of each factor. Eighty significant relations have been found, 14 of them strongly significant (p-value < 0.05)

Table 28 Relations between Metrics and factors statistically significant

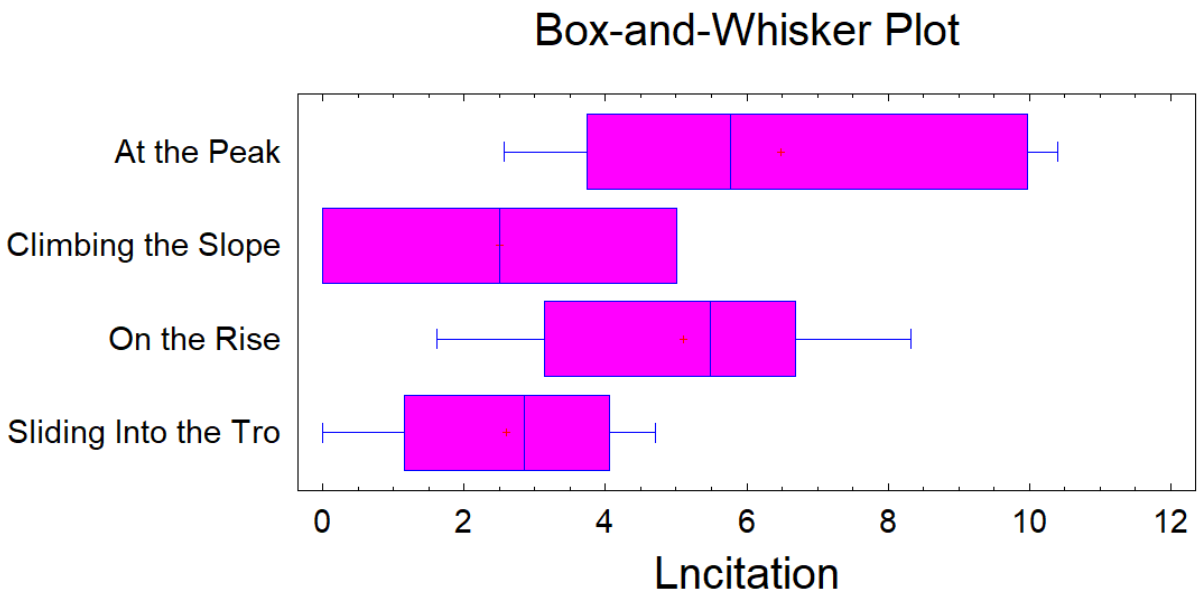
Nº	Metric	Factor	P-value	Mean
1	Lnweb	New	0.0207	μ_{yes}= 9.46; μ_{no} = 12.58
2	LnwebL3Y	New	0.0067	μ_{yes}= 5.36; μ_{no} = 10.22
3	Lnanchor	New	0.003	μ_{yes}= 4.41; μ_{no} = 8.56
4	LnanchorL3Y	New	0.018	μ_{yes}= 3.6; μ_{no} = 6.77
5	Lnscholar	New	0.0435	μ_{yes}= 4.76; μ_{no} = 8.14
6	LnscholarL3Y	New	0.0452	μ_{yes}= 3.86; μ_{no} = 6.81
7	Lncitation	New	0.0436	μ_{yes}= 2.35; μ_{no} = 5.38
8	LncitationL3Y	New	0.0587	μ_{yes}= 1.11; μ_{no} = 3.81
9	Lnpatent	New	0.0019	μ_{yes}= 2.71; μ_{no} = 7.54
10	LnpatentL3Y	New	0.001	μ_{yes}= 1.85; μ_{no} = 6.47
11	novelty_web	New	0.0335	μ_{yes}= 0.05; μ_{no} = 0.13
12	novelty_patent	New	0.0358	μ_{yes}= 0.58; μ_{no} = 0.30
13	effervescency_layman	New	0.0209	μ_{yes}= 0.009; μ_{no} = 0.02
14	Lncitation	Stage	0.0715	$\mu_{ontherise}$= 5.11; $\mu_{atthepeak}$ = 6.49 $\mu_{sliding}$= 2.60; $\mu_{climbing}$ = 2.51
15	LndesignpatentL3Y	Stage	0.0774	$\mu_{ontherise}$= 1.65; $\mu_{atthepeak}$ = 5.52 $\mu_{sliding}$= 4.19; $\mu_{climbing}$ = 2.64
16	effervescency_academicL3Y	Stage	0.0952	$\mu_{ontherise}$= 0.046; $\mu_{atthepeak}$ = 0.047 $\mu_{sliding}$= 0.011; $\mu_{climbing}$ = 0.017
17	novelty_designpatent	Yearsto adoption	0.003	$\mu_{from2to5years}$= 0.07; $\mu_{from5to10years}$ = 0.32 $\mu_{morethan10years}$= 1
18	relation_academic_layman_communityinterest_L3Y	Impact	0.0603	$\mu_{moderate}$= 0.198; μ_{high} = 0.038 $\mu_{transformational}$= 0.091

The main conclusions that can be derived from this table are:

- **Emerging technologies in the first stages (on the rise, at the peak) show high community interest in the academic field and later this community interest passes to the industry field**

Citations are significantly higher for those emerging technologies that are in the first two stages, “on the rise”, and “at the peak” (14) ($\mu_{ontherise}$= 5.11; $\mu_{atthepeak}$ = 6.49 $\mu_{sliding}$= 2.60; $\mu_{climbing}$ = 2.51) that indicates a high interest in the academic field when emerging technologies are in an embryonic phase. Box and Whisker plot of the metric Lncitation with respect to the factor stage shows intuitively this pattern (Figure 11).

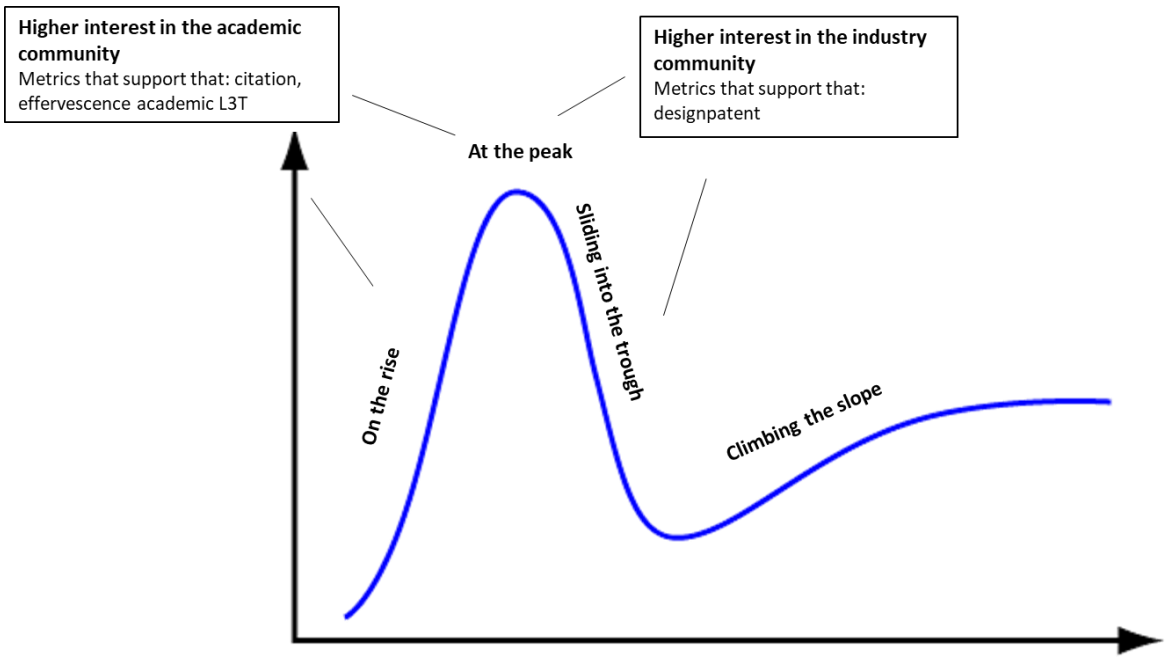
Figure 11 Box-and-Whisker plot for the metric Lncitation with respect to the factor stage



This fact is also captured by the effervescence in the last three years (ratio between the number of citations and the number of scholars) in in the academic field (16) that is three times higher in the two first stages than in the others ($\mu_{ontherise}$= 0.046; $\mu_{atthepeak}$ = 0.047 $\mu_{sliding}$= 0.011; $\mu_{climbing}$ = 0.017).

Later this interest passes to the industry field, so that, the number of design patents in the three years previous to the edition of the report is significantly higher for those emerging technologies that are in the stages "at the peak" and " Sliding Into the Trough" (15). This conclusion and the metrics that support it are shown in the Figure 12.

Figure 12 Relation between stages and community interest in different fields



This conclusion supports the models proposed by Molitor (1977, 2003) or by Martino (2003), that claimed that the information referred to emerging issues reaches first specialized media and after that it starts a process, passing to other media each time less specialized. Besides this, it clarifies some aspects of this process, showing that dissemination traces don't pass from one field to another in well-defined periods of time, and that there is an important overlapping and most technologies in all stages leaves footprints on the three fields (academic, industry, layman) though their strength varies. This data also shows that the general web echoes emerging technologies in all the stages and not only captures traces at the end of the process.

- **The time to market of the design patents is usually very long (more than 10 years)**

  The proportion of design patents in the last three years is higher when the emerging technology is more than 10 years to be mainstream adopted. This is measured by the relation between the metric novelty_desingpatent and the factor years to adoption (17). In this case the dependence is very significant (p-value= 0.003) and the differences in the means are very noticeable ($\mu_{from2to5years}$= 0.07; $\mu_{from5to10years}$ = 0.32 $\mu_{morethan10years}$= 1)
  This means that companies are working with a very long term future orientation with respect these emerging technologies, trying to protect their activity in the long range.

- **It is not possible to detect if a technology is going to become an emerging technology based on dissemination of traces on the Internet (at least with these metrics). The proportion of patents in the last three years with respect to the total (Novelty_patent) is the only metric that offers a clue about that.**

Traces on the Internet are very weak when emerging technologies are in a very initial stage as those just introduced in Gartner's hype cycle. In this sample the mean number of hits is lower for the level "yes" (those that have entered in the last year) for all primary metrics, it does not matter if the whole web is considered or only the previous three years (1), (2), (3), (4), (5), (6), (7), (8), (9), (10). Even novelty (webL3Y/web) (11) and effervescence in the layman field (anchor/web) (13) is significantly lower in the case of the emerging technologies that have been introduced for the first time in the last report. These metrics don`t show higher scores in the case of new emerging technologies, so they don't reflect in advance the emerging potentiality of a technological concept. Only the metric novelty_patent (patentL3Y/patent) (12) indicates that the proportion of patents in the last three years is higher in the case of the emerging technologies that have just been introduced.

This analysis indicates that if a technology observatory is wondering if a technology phenomenon is emerging and will become an emerging technology, resorting to the number of traces on the web is useless except in the case of patents, because novelty_patent is the only metric from the 30 studied that is significantly higher for this segment. This conclusion questions the claims proposed by some studies that consider the growth of traces as the key indicator to discover emergence (Ho et al, 2014), (Jun et al, 2014), at least when emerging technologies are in a very embryonic phase.

- **The layman community interest is focused on emerging technologies with high o transformative potential**

  This situation, that is very intuitive, is captured by the ratio between citation (it measures the interest academic community) and anchor (it measures the interest in the layman community) during the last three years. According to the data calculated this ratio is only higher (lower relative interest in the layman than in the academic field) when the impact of the emerging technology is moderate (18).

4.- Conclusions

The framework defined in this paper has proven useful to characterize emerging technologies in several ways. The number of traces of one emerging technology in different fields gives information about its approach (layman, academic, industry). The number of traces of one emerging technology compared with the number of traces of others gives information about its relative magnitude. The ratios between the different parameters defined in the framework give information about the maturity of the emerging technology and its position in its life cycle.

Although the framework proposed consists of 30 metrics, some relations and correlations between them have been discovered that simplify the operation of the model and help understand the dynamic dissemination on the Web better.

In spite of the differences on the breadth and depth of the emerging technologies used for the study case, some patterns in the dissemination of the traces on the Internet have been raised and some links between these patterns and emerging technologies categorization have been found. The analysis of

these patterns allows us to support previous models of dissemination of emerging technologies as those of Molitor (1977, 2003) or Martino (2003), but clarifying them and adapting them to the Internet environment particularities.

5. Implications and further research

Almost any intellectual activity leaves traces on the Internet speeding up the dissemination of ideas and the interaction among different kinds of media, which has important effects in communication models at all levels. For that reason, any research that contributes to shed light on the possibilities of the web to scan the environment and to assess the emerging technologies is very appreciated by technological observatories. Although there are many studies on this topic, this paper makes some contributions. Firstly, it only uses free sources accessible to everyone. This fact implies a reduction in scanning costs, since many repositories managed by consulting firms are expensive, and it also involves accessing updated information much more easily because of Internet ubiquity. Secondly, it defines a wide and multi-approach framework with 30 metrics that allows characterizing emerging technologies and understanding the dynamics of their evolution better. This knowledge is interesting to value emerging technologies and also to forecast their evolution as proposed by (Daim et al 2006). For all that reasons, the research described in this paper enriches the present state of the art on this topic.

About foreseeing the emergence of a technology, the number of patents shows a certain clue about if a concept is to become an emerging technology, however this preliminary results would need further work. Our approach, should be complemented with others as guiding images "leitbild" (Kuusi and Meyer, 2007).

Further analysis of other emerging technologies samples and other non-technological emerging issues will provide more in-depth analysis of interactions between information on different media, that may offer new insights about the dissemination process of emerging phenomena. New approaches enriched with advanced techniques of data analysis such as big data or ontology models should be considered and are an interesting line of enquiry.

List of references

Abercrombie, R. K., Udoeyop, A. W., & Schlicher, B. G. (2012). A study of scientometric methods to identify emerging technologies via modeling of milestones. Scientometrics, 91(2), 327-342.

Aguilar F.J. (1967) Scanning the business environment. Macmillan.

Boon, W., Moors, E. (2008) Exploring emerging technologies using metaphors: a study of orphan drugs and pharmacogenomics. Soc. Sci. Med. 66 (9), 1915–1927.

Boyack, Kevin W., Richard Klavans, Henry Small, and Lyle Ungar. "Characterizing the emergence of two nanotechnology topics using a contemporaneous global micro-model of science." Journal of Engineering and Technology Management 32 (2014): 147-159.

Brabandere L. De, (2005) False endings, weak signals; putting together the odd pieces of information that could save your business, Across the Board, 52-55

Breitzman, A., & Thomas, P. (2015). The Emerging Clusters Model: A tool for identifying emerging technologies across multiple patent systems. Research policy, 44(1), 195-205.

Carbonell, J., Sánchez-Esguevillas, A., & Carro, B. (2015). Assessing emerging issues. The external and internal approach. Futures, 73, 12-21.

Coffman B, (1997) Weak Signals Research. Part II: Information Theory, Journal of Transition Management , MG Taylor Corporation.

Daim, Tugrul U., et al. "Forecasting emerging technologies: Use of bibliometrics and patent analysis." Technological Forecasting and Social Change 73.8 (2006): 981-1012.

Douw K, Vondeling H, Eskildsen D, Simpson S. (2003). Use of the Internet in scanning the horizon for new and emerging health technologies: a survey of agencies involved in horizon scanning. Journal of Medical Internet Research, 5(1).

Duncan R. and Raiffa H, (1958). Games and Decisions (New York, 1958), pp 276-8

Molitor G.T.T., (1977) How to Anticipate Public-policy Changes, S.A.M Advanced Management Journal, pp. 4-13

Forsberg, E. M., Thorstensen, E., Nielsen, R. Ø., & de Bakker, E. (2014). Assessments of emerging science and technologies: Mapping the landscape. Science and Public Policy, 41(3), 306-316

Haustein, S. (2016). Grand challenges in altmetrics: heterogeneity, data quality and dependencies. Scientometrics, 1-11.

Haustein, S., Peters, I., Bar-Ilan, J., Priem, J., Shema, H., & Terliesner, J. (2014). Coverage and adoption of altmetrics sources in the bibliometric community. Scientometrics, 101(2), 1145-1163.

Heijden K Van Der, (1997) Scenarios, Strategies, and the Strategy Process. Center for Organisational Learning and Change.

Hiltunen E, (2010) Weak Signals in Organizacional Futures Learning. Helsinki School of economics. ISBN 978-952-60-1039-7

Ho, J.C., Saw, E.-C., Lu, L.Y., Liu, J.S., (2014). Technological barriers and research trends infuel cell technologies: a citation network analysis. Technol. Forecast. Soc. Change82 (February), 66–79.

Hood, W., & Wilson, C. (2001). The literature of bibliometrics, scientometrics, and informetrics. Scientometrics, 52(2), 291-314.

Iwami, S., Mori, J., Sakata, I., & Kajikawa, Y. (2014). Detection method of emerging leading papers using time transition. *Scientometrics*, *101*(2), 1515-1533.

Järvenpää, H. M., Mäkinen, S. J., & Seppänen, M. (2011). Patent and publishing activity sequence over a technology's life cycle. Technological Forecasting and Social Change, 78(2), 283-293.

Jun, S.-P., Yeom, J., Son, J.-K., (2014). A study of the method using search traffic to analyze new technology adoption. Technol. Forecast. Soc. Change 81 (January),82–95.

Kuusi, O., Meyer, M., (2007). Anticipating technological breakthroughs: using bibliographic coupling to explore the nanotubes paradigm. Scientometrics 70 (3),759–777.

Lau R. Y, Liao S. S, Wong K. F, Chiu D.K, (2012). Web 2.0 environmental scanning and adaptive decision support for business mergers and acquisitions. MIS Quarterly, 36(4), 1239-1268

Lenz R.C, and Lanford H. W, (1972) "The substitution phenomenon: No. 4 technological forecasting." Business horizons 15.1: 63-68

Madani, F. (2015). 'Technology Mining'bibliometrics analysis: applying network analysis and cluster analysis. Scientometrics, 105(1), 323-335.

Martino J, A review of selected recent advances in technological forecasting, Technol. Forecast. Soc. Change (TFSC) (2003) 719–733.

Molitor G.T.T, (1977) How to anticipate public-policy changes, S.A.M, Adv. Manage. J. Summer 4–13.

Molitor G.T.T., (1981) Consumer Policy Issues: GLboal Trends for the 1980's Advances in Consumer Research, Vol. 8, pp. 458-466

Molitor G.T.T, (2003) Molitor Forecasting Model: Key Dimensions for Plotting the Patterns of Change, Journal of Future Studies, 8(1): 61-72

Nacke, O. (1979), Informetrie: Ein neuer Name für eine neue Disziplin, Nachrichten für Dokumentation, 30 : 212–226. Pritchard, A. (1969), Statistical bibliography or bibliometrics?, Journal of Documentation, 25 : 348–349.

Nalimov, V. V., Z. M. Mulchenco (1969), Naukometriya. Izuchenie Razvitiya Nauki kak Informatsionnogo Protsessa. [Scientometrics. Study of the Development of Science as an Information Process], Nauka, Moscow, (English translation: 1971. Washington, D.C.: Foreign Technology Division. U.S. Air Force Systems Command, Wright-Patterson AFB, Ohio. (NTIS Report No.AD735- 634).

Nikander I.O., (2002) Early warnings- a phenomenon in Project management, Dissertation for the Degree of Doctor of Science in Technology, Helsinki University of Technology

Norton M, (2000) ed. Introductory concepts in information science. Information Today, Inc., 2000.

Palomino, Marco A., Sarah Bardsley, Kevin Bown, Jennifer De Lurio, Peter Ellwood, David Holland-Smith, Bob Huggins, Alexandra Vincenti, Harry Woodroof, and Richard Owen. (2012) "Web-based horizon scanning: concepts and practice." foresight 14, no. 5: 355-373.

Porter, A. L., Cunningham, S. W. (2005) Tech mining: Exploiting new technologies for competitive advantage. New Jersey: Wiley.

Porter, A.L., Roessner, J.D., Jin, X.-Y., Newman, N.C. (2002) Measuring national emerging technology capabilities. Sci. Public Policy 29 (3), 189–200.

Rotolo, Daniele, Diana Hicks, and Ben Martin. (2015) "What is an emerging technology?." Research Policy 44 (2015) 1827–1843.

Small, H., Boyack, K.W., Klavans, R.. (2014) Identifying emerging topics in scienceand technology. Research Policy 48 (8), 1450–1467.

Stafford Beer, (1972), Brain Of The Firm, Allen Lane, The Penguin Press, London

Stahl, B.C. (2011) What does the future hold? A critical view on emerging information and communication technologies and their social consequences. Researching the Future in Information Systems: IFIP WG 8.2 Working Conference, Future IS 2011. Turku, Finland, June 6–8, 2011. Proceedings. Springer, Heidelberg, pp. 59–76.

Thelwall, M., Vaughan, L., & Björneborn, L. (2005). Webometrics. Annual review of information science and technology, 39(1), 81-135.

Thelwall, M., Haustein, S., Larivière, V., & Sugimoto, C. R. (2013). Do altmetrics work? Twitter and ten other social web services. PloS one, 8(5), e64841.

van Doren, D., Forsberg, E. M., & Lindner, R. (2014). Are assessments responding to a dynamic environment? Evidence from four emerging techno-scientific domains. Science and Public Policy, 41(3), 317-331

Wygant A.C, and Markley O. W. (1988). Information and the future: A handbook of sources and strategies. Greenwood Pub Group.