

Innovation key words in the 21st century

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Key Words

Innovation, open innovation & text data mining.

Abstract

In this paper we introduce the most significant topics of scientific output regarding innovation of the last decade. For this purpose we have analysed the "Key Words" of the articles published in the first decade of the century (ISI database) using the technique of text/data mining.

The determination of the current interest and the relative importance of each "key word" (topic) has shaped the innovation construct. Of the 303 topics defined, open innovation is singular in the evolutionary dynamics of the innovation construct, due to its outstanding levels of current interest and relative importance. To study the relationship between open innovation and other topics discussed in the last decade a relationships map was developed.

Introduction

Throughout the last century, innovation has been the focus of numerous works. In 1934, Schumpeter introduced the concept of business-based innovation as an essential element of economic analysis. For Schumpeter, innovation covers the Introduction of a new good or of a new quality of a good, the Introduction of a new method of production, the opening of a new market, the conquest of a new source of supply of raw materials or half-manufactured goods and the carrying out of the new organisation of any industry (Schumpeter, 1934).

Although there are a lot of later definitions, all agree that the concept of innovation is characterised by the Introduction of a novelty, that is to say, the implementation or marketing of something new. The fact that the novelty should be implemented is what differentiates innovation of a simple invention.

Innovation has been widely discussed in scientific literature over the years, through the analysis or development of several concepts around it. In the literature there are different types and classifications of innovation. The most significant types of innovation in the literature are collected in table 1.

In this paper we analyse the articles published in the last decade, through a new perspective. From the article Key Words the innovation construct is configured. The technique of text/data mining provides answers to what are the most current interesting topics in the scientific community, in recent years. Besides analysing the relationships between topics with greater prospects and other topics developed over the early years of this century.

Table 1. Most significant types of innovation in the literature.

Type of innovación	Definition	Authors
technological innovation	According to the OECD (1981) technological innovation was understood as "the transformation of an idea into a new or improved saleable product or operational process in industry and commerce or into a new approach to a social service ". And in 2005 OECD sees innovation from a much broader concept, and reserved	Urbaniak (2001), Diaz and Tomas (2002), He and Wong (2003), Holmen <i>et al</i> (2005), OCDE (2005), Subrahmanya (2005, 2007), Pisano (2006), Su <i>et al</i> (2007), Tseng <i>et al</i> (2008), Hwang <i>et al</i> (2009), Lin (2009), Kim and Lee (2009), Krishnaswamy <i>et al</i> (2009), Liu and Chaminade (2010), Evangelista and Vezzani (2010)

	technological innovation to product innovation and process innovation.	
social innovation	<i>"refers to innovative activities and services that are motivated by the goal of meeting a social need and that are predominantly diffused through organizations whose primary purposes are social"</i> (Mulgan, 2006)	Mulgan (2006), Simms (2006), Froud et al (2010), Linton (2008), Hanke and Stark (2009), Perrini et al (2010), Dawson and Daniel (2010), Clements and Sense (2010), Lettice and Parekh (2010), Witkamp et al (2011)
environmental innovation	<i>"A special class of advanced manufacturing practices, referred to here as environmentally conscious manufacturing (ECM), which include practices such as source reduction, recycling, pollution prevention, and green product design"</i> . (Florida et al, 2001)	Florida et al (2001), Beise and Rennings (2005), Kammerer (2009), Biondi et al (2002), Brunnermeier and Cohen (2003), Rehfeld et al (2007), Horbach (2008), Brouillat (2009a, 2009b)
eco-innovation	Any form of innovation that reduces the impact on the environment and / or optimize the use of resources (European Comision)	Pujari (2006), Falk and Ryan (2007), Belis-Bergouignan and Levy (2010)
financial innovation	<i>"new products and services created by the finance industry (including exchanges and securities firms) to satisfy the growing and ever more diverse needs of its clients, from the smallest private investor to the largest corporation"</i> (Chou and Chin, 2004)	Lerner (2006), Massa (2002), Calvet et al (2004), Chou and Chin (2004) Instefjord (2005), Akhavein et al (2005), Chou (2007), Engelen et al (2010)
radical innovation (breakthrough innovation, discontinuous innovation, disruptive innovation)	<i>"(...) is linked to high risk, high uncertainty projects with the potential to vastly influence the marketplace and bring returns to the firm(...) We ultimately defined a radical or breakthrough innovation as the creation of a new line of business – new for both the firm and the marketplace (O'Connor and McDermott, 2004 with Industrial Research Institute)</i>	O'Connor and Veryzer (2001), Sorescu et al (2003), O'Connor and McDermott (2004), O'Connor and Ayers (2005), Lettl et al (2006, 2008), Robeson and O'Connor (2007), Di Benedetto et al (2008), Chao and Kavadias (2008), Keizer and Halman (2009), Varadarajan (2009), Golder et al (2009), Reinders et al (2010), Moller (2010), Schwery and Raurich (2004); Phillips et al (2006); Bessant et al (2005, 2010), Sapsed et al, (2007), Lettice and Thomond (2008), Figueiredo (2010)
incremental innovation and continuous innovation	<i>"Incremental innovations manifest as adaptations, refinements, enhancements, or line extensions, incorporating new features that offer additional benefits"</i> (Varadarajan, 2009)	Varadarajan (2009), Baker and Sinkula (2007), Bessant et al (2001), Chao and Kavadias (2008), Verona and Rabasi (2003), González-Álvarez and Nieto-Antolín (2007), Magnusson and Martini (2008), Soosay and Hyland (2008), Ribeiro-Soriano and Urbano (2009), Xu et al (2010), Shang et al (2010)
induced innovation	<i>"The impact of market forces on the rate and direction of innovation"</i> (Jakeman et al, 2004)	Hicks (1932), Liu and Shumway (2009), Jakeman et al (2004), Funk (2002), Armanville and Funk (2003), Taylor et at (2005), Frondel and Schmidt (2006), Popp, (2006), Boland et al (2007)
open innovation	<i>"a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology."</i> (Chesbrough, 2003)	Chesbrough (2003 ^a , 2003b, 2004), Henkel (2005), Cooke (2005), West and Gallagher (2006), Chesbrough and Crowther (2006), Chesbrough and Appleyard (2007), Chesbrough, and Garman (2009), Lichtenthaler (2008a, 2008b, 2008c, 2008d, 2009, 2010a, 2010b, 2010c), Lichtenthaler and Lichtenthaler (2009), van de Vrande et al (2009)
strategic innovation	<i>"(...) involves a fundamental or radical reconceptualization of the business. (...) often leads to dramatically different ways of competing and creating wealth. Strategic innovation can encompass product, process, and administrative innovations"</i> . (Wright et al, 2001)	Wright et al (2001), Govindaran and Trimble (2004, 2005), Kodama (2003a, 2003b), Choi and Pérez (2007), Farjoun (2008), Ren (2009), Moenaert et al (2010)

Innovation construct

The “Web of Science” database has bibliographic references of approximately 11,000 international publications and is integrated in the ISI “Web of Knowledge” platform. The ISI “Web of Knowledge” platform includes databases that provide us with information on performance evaluation, article citations, references, Key Words, Abstracts, origin of researchers, etc. The “Web of Science” database is supported by authors such as Dant and Brown (2009) or He et al (2009). According to Chang et al (2011), ISI is credible, and widely used and accessible, even though the data set is complete we must take into account that there are a number of magazines which are not included (Pillania, 2011).

In our study we have selected all articles collected in the “Web of Science” database related with business management innovation that were published between 2001 and 2010. The search criteria presented in table 2 were applied when choosing the articles.

Table 2: Search criteria of samples

1. Publications whose “Topic” is INNOVATION
2. Publications on the following fields of study: Management, Business, Economics, Operations Research & Management Science
3. Publications that are papers
4. Papers published between 2001 and 2010
5. Papers written in English

We have therefore selected those papers containing the word “innovation” in their title, their “Key Words” or “Abstract”, furthermore the database has been filtered to exclude a priori publications which are not related with business management or that are not papers. Those papers in the English language have also been selected given that, within the scientific community, these publications gain higher qualifications according to ISI.

Table 3 shows the result of the initial choice and the consequent revision of the magazines to fit the purpose of the study. Articles that were not related to business management innovation were removed.

Table 3: Search results

Initial paper choice	9437
Initial magazine choice	507
Papers not selected	70
Magazines not selected	11
Valid papers	9368
Valid magazines	496

The large amount of papers and publications obtained permits a transverse analysis of the scientific output including diversity of authors, sources of the work, schools, etc. to be carried out using the technique of text/data mining. Avoiding bias choices of samples will lead to valid and credible results. The scientific production on the innovation concept has grown steadily over the decade, so it is an open and attractive theme for study within the scientific community.

A common practice in scientific paper publication is the association of a series of Key Words to each paper. Each of these Key Words provides thematic or technical information that allows identification of the nature of the paper, understand the general content of the article, carry out specific searches within the database, classify papers, etc. (Gil-Leiva y Alonso-Arroyo, 2005).

Key Words can be grouped from resulting topics. The relationships between topics originate the dimensions that structure the innovation construct.

To perform the analysis of the "Key Words" we have proceeded to refine the sample. The number of papers in the sample has been reduced 29% due to the absence of "Key Words" in 2,718 papers. Following this refinement, the sample holds a remaining 6,650 valid papers, characterised by 31,342 "Key Words", 13,433 of which are different.

Some of the "Key Words" are used in a number of papers equal or less than 14, which only represents 1% of the total sample, meaning that it is a "key word" used by authors only in very particular occasions. These "Key Words" are useful to identify specific works rather than to identify large scope thematic areas, hence they are excluded from the analysis. Additionally, it was also considered that the words innovation or innovations, which appeared in 1,497 occasions, shall be excluded from the group of "Key Words", as they were the dependent variable of the study. Therefore, the final count of "Key Words" included in the text categorisation is 4,857 grouped in 303 topics (table 4).

Table 4. Subjects, "Key Words" selected for analysis.

<p>"PURE KEY WORDS": ABSORPTIVE CAPACITY; ADOPTION; ALLIANCES; APPROPRIABILITY; ASIA; AUTOMOTIVE INDUSTRY; BIOTECHNOLOGY; BRAZIL; BUSINESS MODEL; BUSINESS PERFORMANCE; CAPABILITIES; CASE STUDY; CHANGE; CHANGE MANAGEMENT; CHINA; CLIMATE CHANGE; COMMERCIALIZATION; COMMUNICATION TECHNOLOGIES; COMPETITION; COMPETITIVE ADVANTAGE; COMPETITIVE STRATEGY; COMPETITIVENESS; COMPLEMENTARY ASSETS; COMPLEXITY; CONCURRENT ENGINEERING; COOPERATION; COORDINATION; CORPORATE ENTREPRENEURSHIP; CORPORATE GOVERNANCE; CREATIVITY; CULTURE; CUSTOMER ORIENTATION; DECISION MAKING; DESIGN; DEVELOPING COUNTRIES; DEVELOPMENT; DIFFUSION; DISRUPTIVE INNOVATION; DIVERSITY; DYNAMIC CAPABILITIES; E-BUSINESS; CONOMIC DEVELOPMENT; ECONOMIC GROWTH; EDUCATION; EFFICIENCY; ELECTRONICS INDUSTRY; EMBEDDEDNESS; EMPIRICAL RESEARCH; ENDOGENOUS GROWTH; ENTREPRENEURIAL ORIENTATION; ENTREPRENEURSHIP; ENVIRONMENT; ENVIRONMENTAL MANAGEMENT; ENVIRONMENTAL POLICY; ETHICS; EVOLUTION; EVOLUTIONARY ECONOMICS; EXPLOITATION; EXPLORATION; FINANCIAL INNOVATION; FIRM PERFORMANCE; FIRM SIZE; FLEXIBILITY; FORECASTING; FORESIGHT; GAME THEORY; GERMANY; GOVERNANCE; GROWTH; HUMAN CAPITAL; IMITATION; IMPLEMENTATION; INCENTIVES; INDIA; INDUCED INNOVATION; INDUSTRIAL POLICY; INDUSTRY EVOLUTION; INFORMATION TECHNOLOGY; INNOVATION ADOPTION; INNOVATION MANAGEMENT; INNOVATION NETWORKS; INNOVATION PERFORMANCE; INNOVATION POLICY; INNOVATION PROCESS; INNOVATION STRATEGY; INNOVATIVENESS; INSTITUTIONAL THEORY; INTEGRATION; INTELLECTUAL CAPITAL; INTERNATIONAL TRADE; INTERNATIONALIZATION; INTERNET; IRELAND; ITALY; JAPAN; KNOWLEDGE; KNOWLEDGE CREATION; KNOWLEDGE ECONOMY; KNOWLEDGE SHARING; KNOWLEDGE TRANSFER; KOREA; LEADERSHIP; LEARNING; LICENSING; MANAGEMENT; MANUFACTURING; MARKET ORIENTATION; MARKET STRUCTURE; MARKETING; MARKETING TRATEGY; MODULARITY; MULTINATIONAL CORPORATIONS; NANOTECHNOLOGY; NETWORKING; NEW PRODUCTS; OPEN INNOVATION; OPEN SOURCE SOFTWARE; ORGANIZATIONAL CHANGE; ORGANIZATIONAL INNOVATION; ORGANIZATIONAL PERFORMANCE; OUTSOURCING; PERFORMANCE; POLICY; POWER; PROCESS INNOVATION; PRODUCT DEVELOPMENT; PRODUCT INNOVATION; PRODUCTIVITY; PRODUCTIVITY GROWTH; PROJECT MANAGEMENT; PROXIMITY; PUBLIC POLICY; QUALITY; R&D COOPERATION; R&D MANAGEMENT; RADICAL INNOVATION; REAL OPTIONS; REGIONAL DEVELOPMENT; REGIONAL INNOVATION SYSTEMS; REGULATION; RELATIONSHIP MARKETING; RESEARCH; RESOURCES; SCIENCE PARKS; SERVICE INDUSTRIES; SERVICE INNOVATION; SERVICES; SOCIAL CAPITAL; SOFTWARE; SPAIN; STANDARDS; STRATEGIC MANAGEMENT; STRATEGY; STRUCTURAL EQUATION MODELING; SUPPLIER RELATIONS; SUPPLY CHAIN MANAGEMENT; SUSTAINABILITY; SUSTAINABLE DEVELOPMENT; TACIT KNOWLEDGE; TAIWAN; TECHNOLOGICAL CHANGE; TECHNOLOGICAL INNOVATION; TECHNOLOGY; TECHNOLOGY ADOPTION; TECHNOLOGY DIFFUSION; TECHNOLOGY INNOVATION; TECHNOLOGY MANAGEMENT; TECHNOLOGY POLICY; TECHNOLOGY STRATEGY; TECHNOLOGY TRANSFER; TELECOMMUNICATIONS; TRANSACTION COSTS; TRANSFORMATIONAL LEADERSHIP; TRUST; UNCERTAINTY; VENTURE CAPITAL; VERTICAL INTEGRATION</p>
<p>"CONCEPT KEY WORDS": AGGLOMERATION/AGGLOMERATIONS; CLUSTER/CLUSTERS; COLLABORATIONS/COLLABORATION; COMMUNICATION/COMMUNICATIONS; DIFFUSION OF INNOVATION/DIFFUSION OF INNOVATIONS/INNOVATION DIFFUSION/INNOVATION DIFFUSION THEORY; E-COMMERCE/ELECTRONIC COMMERCE; EXPORTS/EXPORT;EXTERNALITIES/EXTERNALITY; FDI/FOREIGN DIRECT INVESTMENT (FDI)/FOREIGN DIRECT</p>

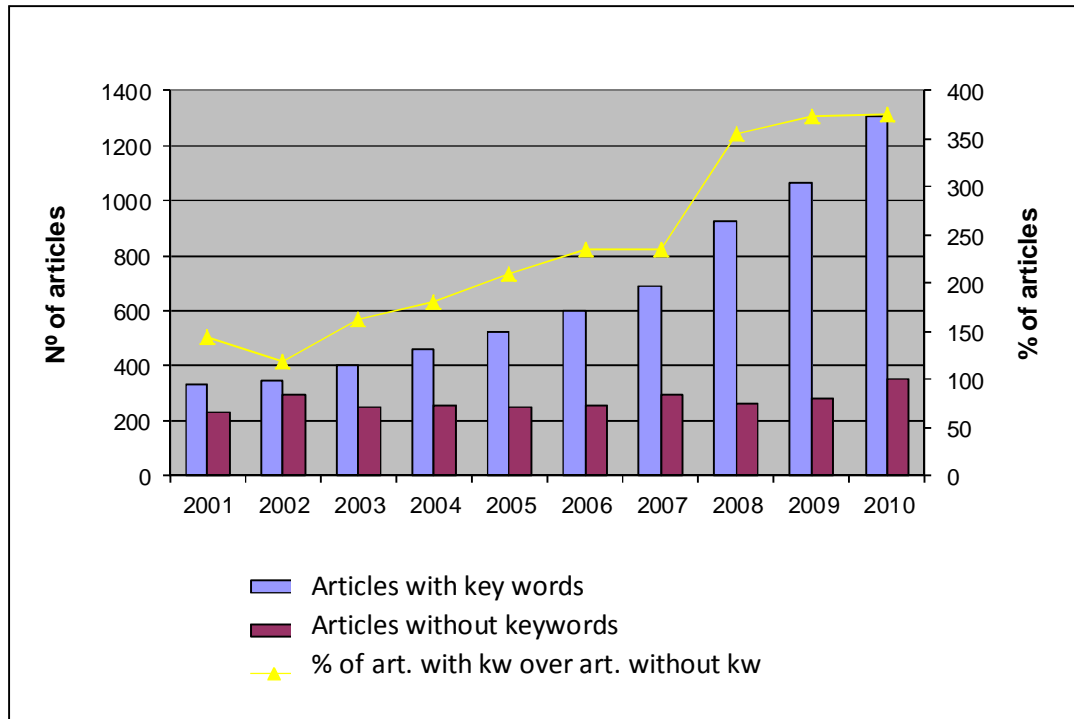
INVESTMENT;GLOBALISATION/GLOBALIZATION; HUMAN RESOURCE MANAGEMENT/HUMAN RESOURCES; ICT/ICTS;INNOVATION SYSTEM/INNOVATION SYSTEMS; INTELLECTUAL PROPERTY/INTELLECTUAL PROPERTY RIGHTS;NETWORK/NETWORKS; ORGANISATIONAL LEARNING/ORGANIZATIONAL LEARNING; PATENT/PATENTS; PHARMACEUTICAL INDUSTRY/PHARMACEUTICALS; SPILLOVERS/SPILLOVER; UNIVERSITIES/UNIVERSITY; TRANSITION/TRANSITIONS; TQM/TOTAL QUALITY MANAGEMENT (TQM)/TOTAL QUALITY MANAGEMENT; TEAMS/TEAM; STRATEGIC ALLIANCES/STRATEGIC ALLIANCE; START-UPS/START-UP/STARTUPS; SOCIAL NETWORKS/SOCIAL NETWORK; SME/SMES/SMALL AND MEDIUM ENTERPRISES (SME)/SMALL- AND MEDIUM-SIZED ENTERPRISE (SME)/SMALL AND MEDIUM-SIZED ENTERPRISES (SMES)/SMALL FIRMS; RESOURCE-BASED VIEW/RESOURCE-BASED THEORY; R&D INVESTMENT/R&D INVESTMENTS; R&D/RESEARCH AND DEVELOPMENT (R&D)/RESEARCH AND DEVELOPMENT; PATENT CITATIONS/PATENT CITATION; ORGANIZATIONAL CULTURE/ORGANISATIONAL CULTURE; NEW PRODUCT DEVELOPMENT/NEW PRODUCT DEVELOPMENT (NPD); NETWORK EXTERNALITIES/NETWORK EXTERNALITY; NETWORK EFFECTS/NETWORK EFFECT; KNOWLEDGE SPILLOVERS/KNOWLEDGE SPILLOVER; KNOWLEDGE MANAGEMENT/KNOWLEDGE MANAGEMENT (KM); KNOWLEDGE FLOWS/KNOWLEDGE FLOW; INVESTMENT/INVESTMENTS; INVENTION/INVENTIONS; INSTITUTIONS/INSTITUTION; ENVIRONMENTAL REGULATION/ENVIRONMENTAL REGULATIONS; ENDOGENOUS GROWTH/ENDOGENOUS GROWTH THEORY; HIGH TECHNOLOGY/HIGH-TECHNOLOGY/HIGH TECH/HIGH-TECH; INDUSTRIAL CLUSTER/INDUSTRIAL CLUSTERS; MANUFACTURING INDUSTRIES/MANUFACTURING INDUSTRY; NATIONAL CULTURE/NATIONAL CULTURES; PERFORMANCE MEASUREMENT/PERFORMANCE MEASURES; TOTAL FACTOR PRODUCTIVITY/TOTAL FACTOR PRODUCTIVITY (TFP)

“KEY WORDS OTHERS”: ADOPTION others; AGGLOMERATION others; ALLIANCES others; ASIA others; BIOTECHNOLOGY others; CAPABILITIES others; CHANGE others; CLUSTER/CLUSTERS others; COLLABORATION others; COMMERCIALIZATION others; COMMUNICATION others; COMPETITION others; COMPETITIVENESS others; COMPLEXITY others; COOPERATION others; COORDINATION others; CREATIVITY others; CULTURE others; DESIGN others; DEVELOPMENT others; DIFFUSION others; DIVERSITY others; EDUCATION others; EFFICIENCY others; ENTREPRENEURSHIP others; ENVIROMENT others; EVOLUTION others; EXPLOITATION others; EXPLORATION others; EXPORTS others; FORECASTING others; FORESIGHT others; GOVERNANCE others; GROWTH others; IMPLEMENTATION others; INCENTIVES others; INSTITUTIONS others; INTEGRATION others; INTERNATIONAL others; INTERNATIONALIZATION others; INTERNET others; INVESTMENT others; KNOWLEDGE others; LEADERSHIP others; LEARNING others; LICENSING others; MANAGEMENT others; MANUFACTURING others; MARKETING others; NETWORK others; OUTSOURCING others; PATENT others; PERFORMANCE others; POLICY others; POWER others; PRODUCTIVITY others; PROXIMITY others; QUALITY others; R&D others; REGULATION others; RESEARCH others; RESOURCES others; SERVICES others; SME/SMES/SMALL TO MEDIUM-SIZED ENTERPRISES/SMALL FIRMS others; SOFTWARE others; SPILLOVER/SPILLOVERS others; STANDARDS others; STRATEGY others; TEAMS others; TECHNOLOGICAL others; TECHNOLOGY others; TELECOMMUNICATIONS others; TRANSITION others; TRUST others; UNCERTAINTY others; UNIVERSITIES others; UNIVERSITY-INDUSTRY others

It can be observed within the sample that each year more papers include “Key Words”, to such an extent that in 2001, 40% of the papers were excluded from the sample, whilst in 2010 only 21% were excluded for the lack of their defining “Key Words” (graph 1).

Topics consist in three different kinds of “Key Words”. “Pure Key Words” are those “Key Words” within the paper and there are no others similar “Key Words” with the same meaning (for instance: “absorptive capacity”, “agglomeration”). “Concept Key Words” are several “Key Words” grouped because of their same meaning (for instance: “start-ups/start-up/startups”, “SME/SMES/small and medium enterprises (SME)/small- and medium-sized enterprise (SME)/small and medium-sized enterprises (SMES)/small firms”). “Key Words others” are those clusters of “Key Words” containing at least one pure “key word” or a concept “key word” (for instance: “agglomeration others” include: Agglomeration economies, agglomeration and dispersed equilibria, agglomeration economics, agglomeration externalities, etc.) (table 4).

Graph 1. Articles characterized by “Key Words” and articles removed of the sample



We believe that the topics sufficiently describe the innovation construct if the "Key Words" selected sufficiently describe the scientific output regarding innovation. This way, 93% of the sample of papers is properly characterised using between 2 and 7 of the selected “Key Words”. Consequently, a total of 6,156 papers form the body of the innovation construct.

Methodology

To situate the topics within the innovation construct two variables are used: Relative importance and current interest.

The relative importance of the dimension (RI_j) is defined as,

$$RI_{jt} = \frac{\sum_{i=A}^N a_{ij}}{\left(\sum_{i=A}^N a_i \right) / D},$$

where a_{ij} are the papers published in year i containing, at least, one keyword of the j dimension; D is the total number of dimensions of the innovation construct; A is the first year of each five year period and N is the last year of each five-year period; t equals 1 for the first five-year period (2001-2005), and equals 2 for the second one (2006-2010).

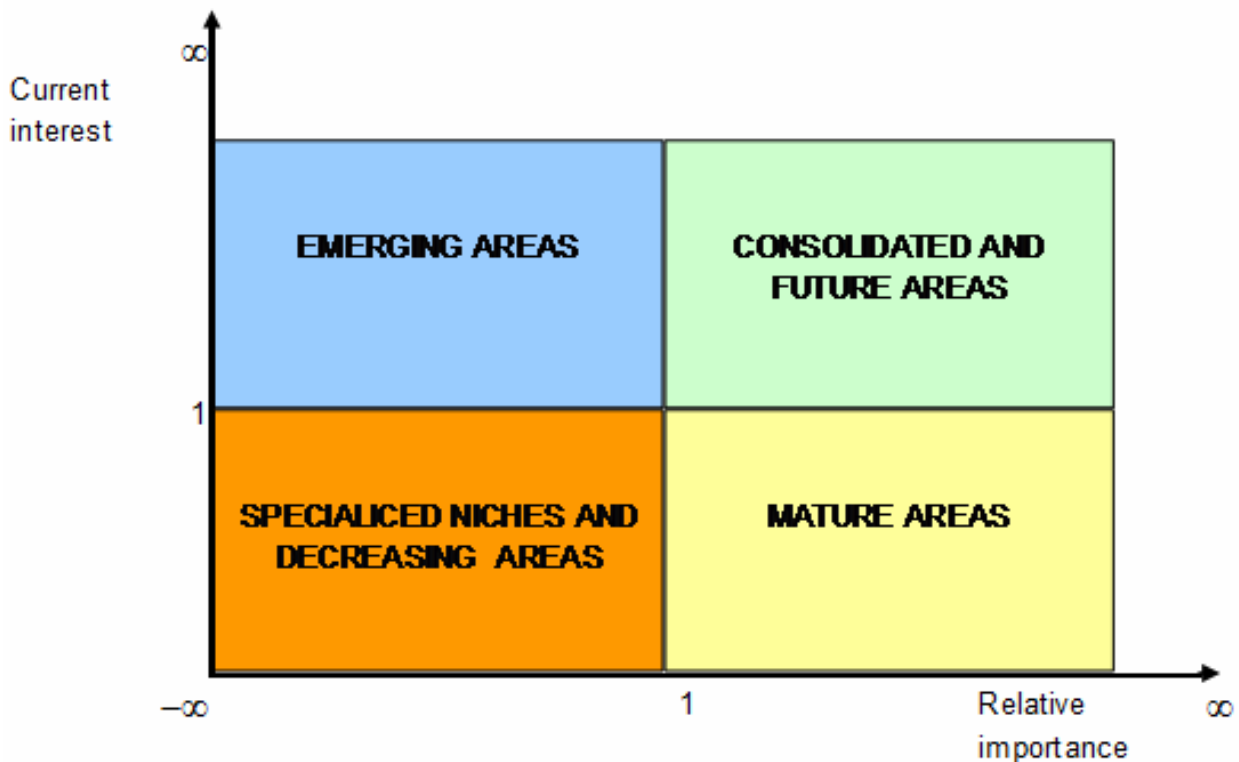
The contribution of each dimension to the innovation constructor is characterised by RI_{j2} given that the number of papers published over the last decade has rapidly increased.

The current interest of the dimension (CI_j) is defined as,

$$CI_j = \frac{\left(\frac{RI_{j2} - RI_{j1}}{IR_{j1}} \right)}{\left(\sum_{j=1}^D \frac{RI_{j2} - RI_{j1}}{RI_{j1}} \right) / D}$$

A dimension j would be more current (CIj) when its relative growth is larger. The relation between relative importance (RIj2) and current interest (CIj) allows text clustering to be carried out which classifies dimensions in four clusters (graph 2).

Graph 2. Clusters of the innovation construct



Cluster 1. Specialised niches and decreasing areas. Current interest (CIj) and relative importance (RIj2) are below average. These are areas of research that have been extensively explored in the scientific literature in previous decades and thus are not so appealing to researchers or they are dimensions related to specialised papers with moderate outcome.

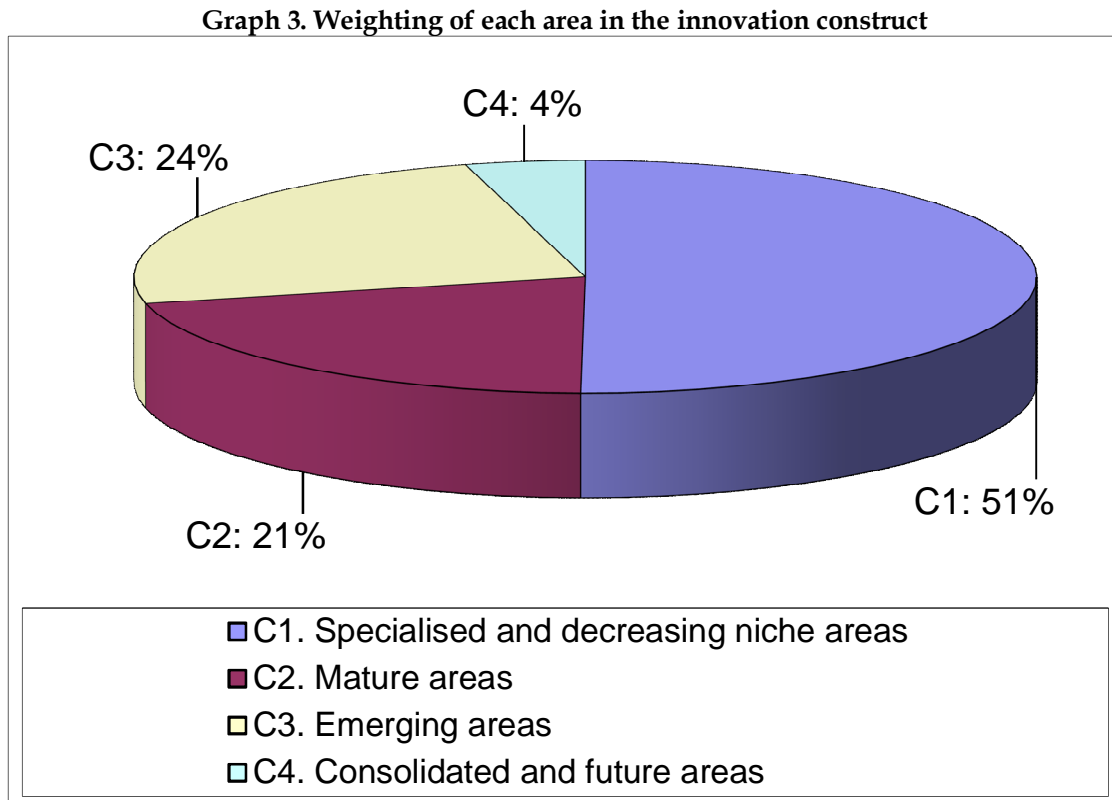
Cluster 2. Mature areas. Their current interest (CIj) does not reach the average although their relative importance (RIj2) is larger than average. They are primary areas that continue in scientific works over the decade.

Cluster 3. Emerging areas. They have a current interest (CIj) above average, albeit its relative importance (RIj2) is below average. They are “emerging” because they have been more widely utilised by researchers over the second five-year period but still do not have a relevant output, they are not yet consolidated.

Cluster 4. Consolidated and future areas. They have a current interest (CI_j) and a relative importance (RI_{j2}) above average. They have had strong relevance in the scientific literature concerning innovation and also points to continue to do so in the future.

Results

The dispersion of topics indicates that clusters are not homogeneous (graph 3). Thus, the cluster Specialised niches and decreasing areas embraces around the 51% of topics. Moreover, the clusters Matures areas and Emerging areas include 21% and 24% of topics respectively. The cluster Consolidated and future areas covers only 4% of total topics of the innovation construct.



We analyse in detail each of the clusters (graph 4). Different scales are used in each cluster because the dispersion of the values is large and heterogeneous.

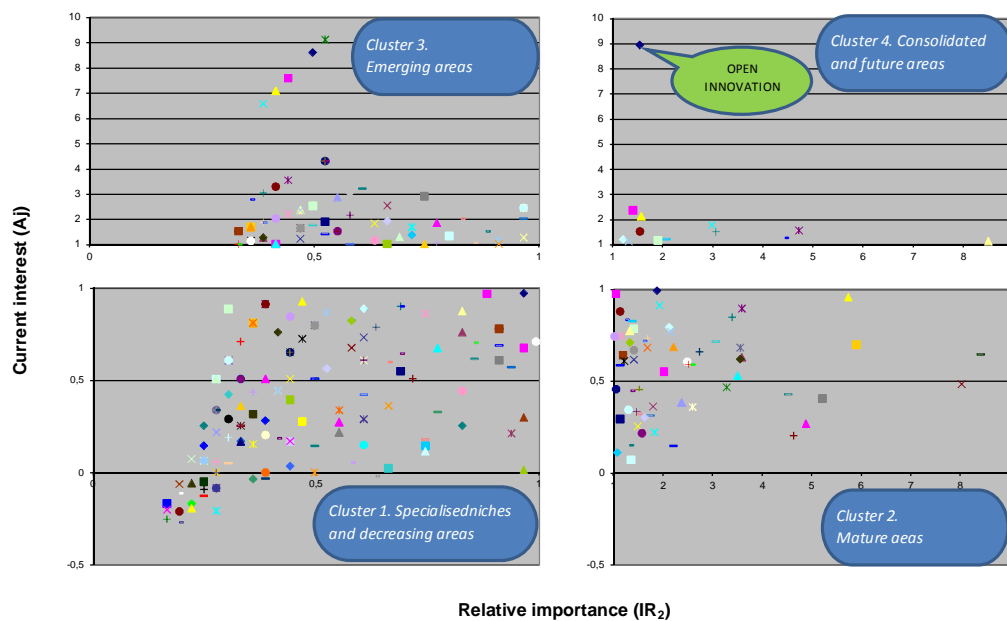
Within the cluster *Specialised niches and decreasing areas* there are 19 dimensions that have a negative current interest, which means that they are out of use within the innovation construct (for instance: “transaction costs”, “productivity growth” or “evolution”).

Other dimensions are less interesting for research than dimensions in other clusters, despite having undergone a moderate growth. This is the case of topics like “incentives” or “organisational performance” that have relative importance (RI_{j2}) and current interest (CI_j) next to 0.5.

The cluster *“Mature areas”* is characterised by the high presence of “Key Words others”, such as “R&D others”, “capabilities others”, “investment others”. Moreover “technology others” and “management others” stand out from all the topics of the construct due to their high relative importance. “Technology others” and “Management others” include lots of “Key Words”. They are broad topics that register more than 860 papers. *Technology others* collect “Key Words” such as “disruptive technology”, “technology intelligence”, “technology life cycle”, etc.. Meanwhile “Management others” includes “Key Words” such as

“total quality management”, “intellectual property management”, “management consulting”, etc. Thus we can say that this cluster is composed of generic “Key Words” in innovation research.

Graph 4. Structure of the innovation construct



Within the cluster “Emerging areas” we can find a number of topics that stand out for their high current interest: “service industries”, “disruptive innovation”, “transformational leadership”, “R&D investment/ R&D investments” and “exploitation”. Their relative growth has been between 6 and 9 times higher than the average of the areas within the innovation construct.

Finally, within the cluster “Consolidated and future areas”, “innovation policy”, “social networks/social network” and “open innovation” are those with major current interest. “Open innovation” is the dimension where a greater importance in the future is foreseen, given that it is current and moreover its relative importance places it beyond the introductory stages of a new area.

“Open innovation” has special features that make it the most unique item in the evolutionary dynamics of the innovation construct. The reason lies in a favourable position of its relative importance, because 53 articles published in the last three years have been identified, 32 of them in 2010. This circumstance makes its relative importance 1.5 times the average and its current interest is placed in nine times the average, reaching maximum values of the topics better placed in “Emerging areas”.

Open innovation

Open innovation is a paradigm introduced by Henry Chesbrough in 2003, thus it is a new-born area which makes its relative importance even more relevant.

Chesbrough (2003) defined open innovation as “a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology.”

A relationships map has been drawn up for open innovation, it being a singular topic within the innovation construct. The topics that relate to open innovation arising from the association of all the “Key Words” that appear together with open innovation characterising articles.

Topics related to "open innovation" are many and varied, so to delve into the roots of "open innovation", we will proceed to analyse in depth all the topics that are associated at least twice with the "key word" open innovation.

The relationships map (graph 5) places the topics associated with "open innovation" in each of the defined clusters (*Specialised niches and decreasing areas*, *mature areas*, *emerging areas* and *Consolidated and future areas*); thus we can analyse its scientific interest according to its current interest and its relative importance. So we will study the roots of the uniqueness that characterises open innovation, in addition to analysing the scientific interest of each of these relationships.

Interestingly, there is no topic related to "open innovation" that is in a situation of decline, so that all the issues associated with "open innovation" have increased their production over the first part of the decade.

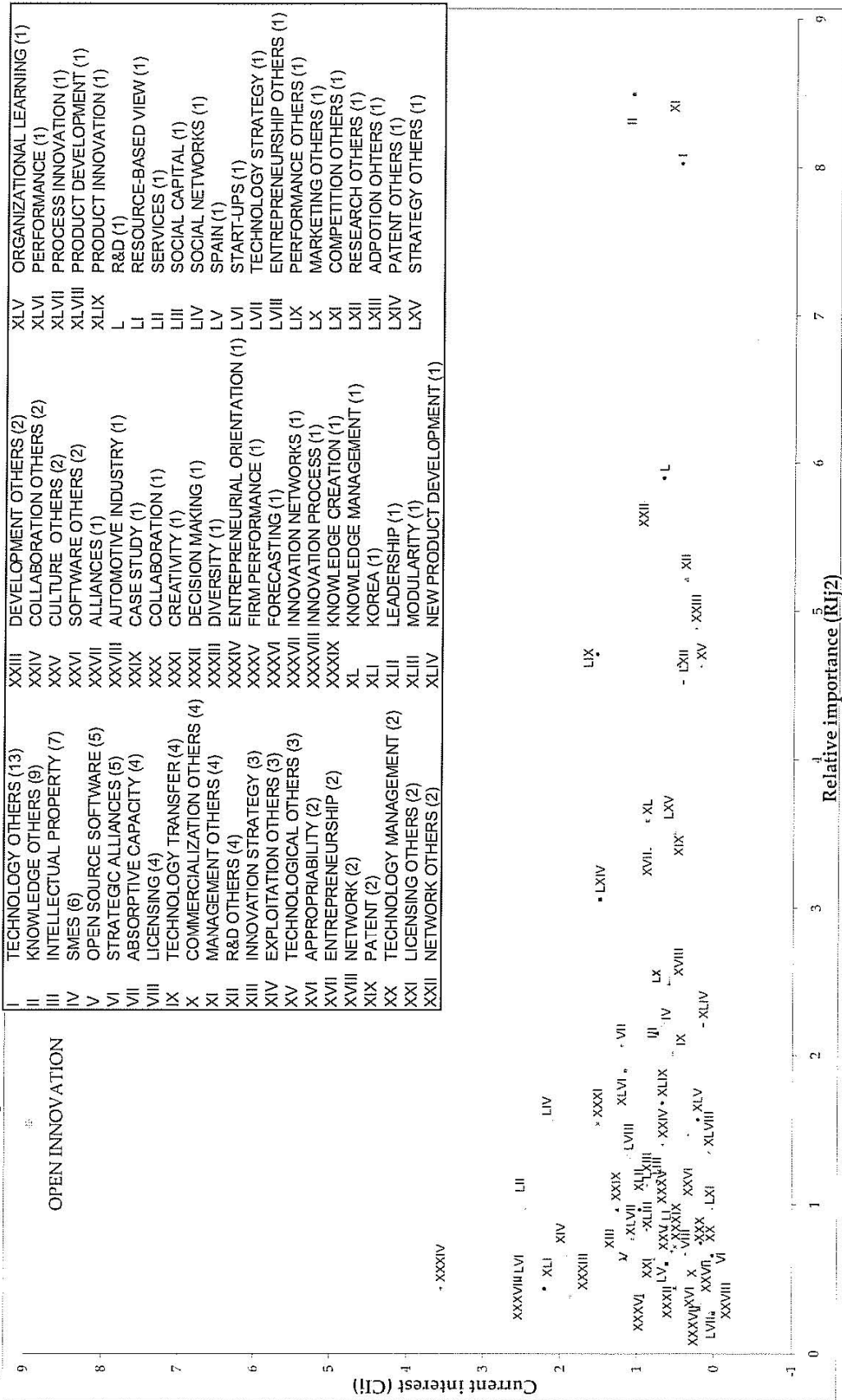
Among the topics highlighted by relating two or more occasions to open innovation, there are three topics which current interest and relative importance place in the middle of the cluster *Specialised niches and decreasing areas*: "Licensing (VIII)", "Licensing others (XXI)" and "Culture others (XXV)". "Licensing others" shows a current interest greater than "licensing" despite having a similar level of relative importance. This indicates that in recent years the topic "licensing" is specialising. Authors like Lichtentaler (2008a, 2010a) show that technology licensing, within a context of open innovation, offers significant strategic benefits beyond own revenues from licenses.

In the cluster of *"mature areas"*, "Technology others (I)" and "Management others (XI)" are highlighted, being two of the three topics that have the greatest relative importance of the entire relationships map. "Intellectual property (III)", "SMES (IV)", "Entrepreneurship (XVII)" and "Network others (XXII)" stand out within the quadrant for having relative importance between two and six times the average and current interest 65% higher than the average.

"Technology others (I)" and "Management others (XI)" are complex topics that include numerous "Key Words" related to technology and management respectively, so it is not a direct relationship between these issues and open innovation.

The relationship between open innovation and "Intellectual property (III)" can be seen in works such as Mehlman et al (2010) where the equilibrium is analysed in terms of time for the exchange of intellectual property is optimal. The firm size is an issue that has been important only from the perspective of small and medium enterprises. So, Lee et al (2010) find that open innovation has great potential for small and medium enterprises and the importance of relationships as an effective means to facilitate such open innovation.

Graph 5. Relationships map of open innovation.



"Network others (XXII)" consists of many "Key Words" such as "collaborative networks", "technology networks", "social network theory", etc.. That is why their relative importance is so high; however, their relationship with open innovation is limited to two papers. Kim and Park (2010) use a Bayesian network, the method used to show that not all open innovation activities have a positive effect on innovation output. Within the cluster "*Emerging areas*" three themes are highlighted for their relationship with open innovation: "Open source software (V)", "Innovation strategy (XIII)" and "Exploitation others (XIV)". "Exploitation others (XIV)" is characterised as the topic with major current interest among all those who make up the relationships map of open innovation. Lichtentaler (2008b) studied the ability to manage the different stages of external technology exploitation to influence the outcome of licensing, which explains the discrepancies between the success of some companies and the problems that others may encounter.

Regarding "Open source software (V)", Stam (2009) examines how participation in open innovation communities influences the results of companies that commercialise open source software. Stam establishes that a broad technical participation in open source software projects is related to the result of the companies that are also involved in community activities, for larger firms and for firms with high R&D intensity. Muller-Seitz and Reger (2010) analyse the effect of the "open source software" projects on open innovation.

Finally the "Innovation strategy (XIII)" has been addressed by authors such as Herzog and Leker (2007), who study the human side of open innovation (underlying innovation culture) focusing on the differences between open innovation and closed innovation through the syndrome of "not invented here" (NIH), risk taking and management support.

In the last cluster, "*Consolidated and future areas*", "Knowledge others (II)" is a topic that comprises a large number of "Key Words" and is also the topic of greatest relative importance within the innovation construct. This fact makes it repeatedly related to open innovation, but there is not a pattern between the two.

Regarding the topic "Absorptive capacity (VII)", as Tether and Chopping (2008) state, beyond investing in absorptive capacity, firms with greater ability to relate and greater social capital are more likely to benefit from relationships with suppliers who are specialists in knowledge. Spithoven et al (2010) study small and medium enterprises in traditional sectors, which generally have low absorption capacity. Spithoven et al (2010) focus on the importance of research centres when it comes to supporting these companies to overcome the gap of lacking a good absorption capacity that allows them to incorporate innovations from outside.

Conclusions

The study of the "Key Words" of the innovation articles of the last decade reveals 303 significant topics. The current interest and relative importance of each topic classifies innovation into four different clusters. The largest number of topics is within the cluster "*Specialised niches and decreasing areas*", highlighting, among others, "transaction costs" "productivity growth" or "evolution" as being obsolete topics. The cluster "*Mature areas*" is characterised by the high presence of "key other words" where topics are grouped generically. The cluster "*Emerging areas*" compiles 24% of the topics, but only "service industries", "disruptive innovation", "transformational leadership", "R&D investment/R&D investments" and "exploitation" are characterised by high current interest. Within the latter cluster "*Consolidated and future areas*" open innovation stands out above all.

Open innovation is a nuclear topic on the latest scientific literature and is the connection between diverse topics. The relationships map of open innovation shows that up to 21% of the topics are related to open innovation. The strongest links are given with open source software or absorptive capacity, both characterised by a current interest above average. We can predict that in the coming years research on absorptive capacity in the field of open innovation will star in the pages of major journals.

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