Structure and evolution of adoption of innovations research from 1950 up to 2012. A co-word analysis

Abstract

Thepaper presents a bibliometric study of the adoption of innovations research (A.I.R.),from its inception in the scientific literature in 1950 up to 2012. This approach, based on co-word analysis, permits detecting and visualising the division of conceptual subdomains of the adoption of innovations research (A.I.R.). The analysis reveals the A.I.R. literature to be characterized as very fragmented and evolving. In particular, five strongly-linked research areas are extracted with a clustering algorithm: 1) studies on perception or attitudes of technologies, 2) studies on decision making in the context of technology adoption, e-commerce or consumer behaviour, 3) studies on strategic orientations in SMEs, 4) studies on management and technological innovation and 5) studies on stages established by the IDT theory, and the Internet.This methodology allows us to quantify and visualize the thematic evolution, to understand the current state-of-art ofA.I.R. and suggesting future research directions.

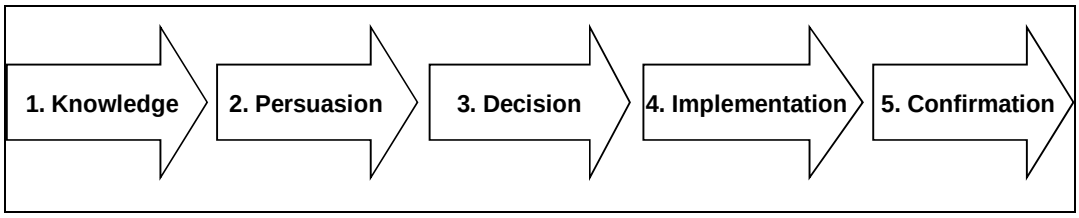
Keywords: Co-Word Analysis, BibliometricStudy, Conceptual Subdomains, Emerging Trends, Adoption of Innovations Research, Longitudinal Approach

1. The study of the adoption of innovations research (A.I.R.). Review of the state-of-art

Innovation is important on different levels (for nations and regions) and for different reasons. On the one hand, innovation is an important driver of economic growth and improvement and, on the other hand, there are several reasons for the firms including survival, growth and shareholder return (Mobbs, 2010).

The complexity of the study of innovation and its adoption increases when we find that the process of adoption and diffusion happens in different phases. In particular, innovation Diffusion Theory(IDT) establishes three main states: evaluation, adoption and implementation of the innovation (Prescott and Conger, 1995). Our study focuses in the phase of adoption that occurs with the initial decision to use an innovation (Surry &Elly, 2006). One of the most important theories discussed by Rogers (1983: 165) is the Innovation-Decision Process Model. As shown in Figure 1, the model suggests that the adoption of an innovation is not a single act, but a process that occurs over time. Potential adopters go usually through five stages when interacting with an innovation. The first stage named "knowledge" happens when potential adopters find out about an innovation and gain a basic understanding of what it is and how it works. The second stage is "persuasion" in which potential adopters form a positive or negative perception of the innovation. It is in the third stage, "decision", when the innovation could be adopted or rejected. The fourth stage, "implementation", happens when the innovation is actually used. In the fifth stage, "confirmation", the adopter search for information about the innovation and either continues or discontinues use of the innovation. The confirmation stage might also describe the final adoption of an innovation previously rejected.

Figure 1.Five stages of Rogers' (1983) Innovation-Decision Process Model.



In this context, many studies have focused on the adoption state of a technological innovation from the users' viewpoint, obtaining models of intention or theories of behavioural decision,

traditionally applied in social psychology (e.g. Swanson, 1982 [among small businesses]; Davis et al., 1989; Harrison et al., 1997; Pavlou, 2002, Liébana-Cabanillas et al., 2013 [among end users]).

Researchers therefore seem to have decided thattheories of behavioural decision or intention provide a basis for the study of adoption of Information Technologies (IT) (e.g. Davis et al. 1989; Taylor & Todd, 1995; Harrison et al., 1997; Karahanna et al., 1999; Moon & Kim, 2001; Venkatesh, et al., 2003) and electronic commerce (Chen et al., 2002; Pavlou, 2002; 2003; Featherman & Pavlou, 2003; Gefen et al., 2003; Sánchez & Rondán, 2005; Liébana-Cabanillas et al., 2013), among other applications.

Among the models most frequently usedto examine adoption of technological innovation are the Theory of Reasoned Action, TRA (Fishbein & Ajzen, 1975), the Theory of Planned Behaviour, TPB (Ajzen, 1991), the Technology Acceptance Model, TAM (Davis et al., 1989), the Motivation Model (Davis et al., 1992), and the UTAUT's model (Venkatesh et al., 2003). Although the first models of Fishbein and Ajzen were designed to explain any human behaviour, they also contained theoretical principles valid in a wide variety of contexts. The predictive value of TAM and TRA to explain behaviour towards adoption of IT has been consistently significant (e.g., Lucas, 1975; Davis et al., 1989; Bernadette, 1996; Harrison et al., 1997). However, several modifications and extensions have been applied to these original models.

As the above show, perceptions about the use of an innovation are key to its diffusion, rather than traditional definitions of perceptions about the innovation in itself (Moore & Benbasat, 1991). The usefulness of the TAMkind of model lies in describing the factors conducive to the acceptance of online adoptions, which help both academics and users to better understand online behaviour in emerging exchange relations such as Business-to-Business or B2B (e.g. Quaddusand Hofmeyer, 2007; Mishra and Agarwal, 2010), Business-to-Consumer orB2C (e.g. Pavlou, 2003; Chan and Lu, 2004; Zviran et al., 2005) or Administration-to-Consumer or A2C, concretely e-learning (e.g. Selim, 2003; Li et al., 2004; Ong et al., 2004). In this sense we can see a more recent trend toward the adoption of, and the study of adoption of, innovations related

with Internet. For example, Web 2.0, e-banking, social networks, or e-learning;and related tools as general Web-based content management systems – such as Moodle, Wordpress and wikis).

There are theoretical studies based purely on assumed business innovativeness processes and technology management that attempt to model 'how things ought to be' (e.g. Linton, 2002 [a successful implementation process of the innovation], Pilkington and Teichert, 2006 [study of technology management]) while other studies are firmly grounded in an empirical analysis of 'how is' (e.g. Pittaway et al., 2004 [business networking for innovativeness]). All studies have made more or lesser contributions to the knowledge base and the current and future direction of research in these fields (e.g. Linton, 2002 [implementation process of innovations]; Cornelius and Persson, 2006 [venture capital]).

While these attempts described above to compile what has happened in the past are interesting and necessary to understand how A.I.R. will evolve in the coming years, we believe that their qualitative, and mostly subjective, nature means they should be complemented by more quantitative, and arguably more objective, research. We propose to use as input data drawn from the literature on innovation in major scientific publications over an extended time period (from 1950, when the first paper was published, up to 2012) and subject them to arigorous andsystematic approach. By doing so, we are able to highlight not only those aspects of innovation that have been the focus of interest of researchers over the years, but also these aspects have been related.

The paper is organized as follows. Section 2 introduces the focus of the paper and analysis methodology. Section 3 describes the main outcomes, including the most frequently-occurring journals, keywords and themes, and the relationships between the identified themes. This section also provides maps and diagrams used to assess the development and future trends of A.I.R. Finally, we draw some conclusions, identify limitations and comment on future research.

2. Focus of the paper and methodology

2.1. Focus of the paper and objectives

Bibliometrics uses statistical models and/or representations to assess discipline-specific research based on keywords analysis, co-occurrences of keywords, citations, year, affiliations and other

information available in library databases. As a consequence, the technique is accompanied by informed interpretation (He and Hui, 2002).

In particular, in-depth studies of academic disciplines are becoming increasingly frequent and can be carried out in various manners such as reviews of comprehensive scientific literature (e.g. Rust and Chung, 2006; Chase and Apte, 2007), doctoral theses –based on original research and through which doctoral students can demonstrate their research capabilities– (e.g. Silverman and Manson 2003; Gázquez and Jiménez 2009); conferences or meetings at universities (e.g. Barreiro et al. 2004); the analysis of citations (e.g. Rousseau and Zuccala 2004; Chang and Huang 2011; Shilbury 2011; Samee and Chabowski 2012; Vogel and Güttel, 2013); the analysis of keywords in published databases based on frequency (e.g. Samee and Chabowski 2012; Kunz and Hogreve 2011 [initial identification of keywords]); or science mapping with co-words analysis based on keywords (e.g. Bailón-Moreno et al. 2006; Leydesdorff and Zhou 2008; Lopez-Herrera et al. 2009, 2010, 2012; Muñoz-Leiva et al. 2012a, 2012b, 2013; Cobo et al. 2011a).

To summarize scientific knowledge, different bibliometric analyses have been applied across a broad range of business disciplines in the past. These disciplines include: venture capital (Cornelius and Persson, 2006), technologies management (Pilkington and Teichert, 2006), management information systems (Culnan, 1986) andstrategic management (Ramos-Rodríguez and Ruíz-Navarro, 2004, Vogel and Güttel, 2013 [through dynamic capability view (DCV)]). Different techniques have been applied including representation of the co-citation matrix through multi-dimensional scaling, MDS (Cornelius and Persson, 2006; Vogel and Güttel, 2013 [graph layout algorithm similar to MDS]) or factor analysis (e.g. Pilkington and Teichert, 2006).

This paper presents a bibliometric and visual study of the literature on the adoption of innovations, during the period 1950-2012. Theapproach, based on co-word analysis, permits the detection and visualisation of the conceptual subdomains of the literature on the adoption of innovations research (A.I.R.). Qualitative and quantitative methodsare used to identify the most prominent themes that connect together the keywords used within the AIR literature. Quantitative indicators (such as those based on citations and number of documents published)

are used to measure the quality and/or impact of the detected themes.The study also uses bibliometric maps to show in a visual way the associations between the main concepts treated by the A.I.R. community. The maps provide insight into the structure of the A.I.R., visualize the division of the field into several subfields, and indicate the relationships between these subfields. Thequalitative observations(thickness of the edges, evolutions along the time,…) are used to connect together related keywords in to themes or clusters of topics.

All this allows us to quantify and visualize the thematic evolution of the A.I.R. It also helps both experts and novices to understand the current state-of-art of the A.I.R. and to predict where future research could lead.

2.2. Methodology applied

A bibliometric approach applyingco-word analysis to the literature in A.I.R. provides information on the interests and aspirations of academic researchers in this or any field (Cornelius and Persson, 2006).Themethod applied combines both performance tools and science mapping techniques to analyse a research field (Cobo et al., 2011a; 2011b; López Herrera et al., 2012), and detect and visualise its conceptual subdomains (particular topics/themes or general thematic areas) and thematic evolution.

Specifically, co-word analysis is aneffective technique in mapping the strength of association between information units in textual data (Whittaker, 1989; Callon et al., 1991; Coulter et al., 1998).In any academic discipline, papers published in their respective journals represent “production units” of scientific knowledge (Talukdar and Arihanan, 2011).In particular, co-word analysis is a powerfulbibliometric technique for identifying, describing and visualising the interactions between keywords/terms/topics, applicable in any field in scientific research (e.g. Callon et al., 1991; Bailón-Moreno et al., 2006; Leydesdorff & Zhou, 2008; López-Herrera et al., 2009; López-Herrera et al., 2010; Meng, et al., 2011; Park & Lee, 2011; Viedma-del-Jesus et al., 2011; Muñoz-Leiva et al., 2012a, 2012b; Wang & Ohsawa, 2012; Muñoz-Leiva et al., 2013).

In our case, themethod applied reduces a space of keywords to a set of network graphs that effectively illustrate the strongest associations between those keywords. Additionally, it

develops a (more quantitative)performance analysis of specific themes using a series of basic bibliometric indicators.The software used to extract the networks graphs was NodeXL version 1.0.1 under the Fruchtermann-Reingold force-directed layout algorithm (see Socialmedia Research Foundation, 2012).Our graph layout algorithm, similarly to multidimensional scaling approaches, optimizes distances between every pair of nodes.

In order to deepen the structure of the conceptual subdomains of the A.I.R several groups of keywordsor thematic networkswere extracted with the Wakita and Toshiyuki's clustering algorithm[1].The interpretation of the groups rested on a basic assumption: the clusterization had grouped the keywords based on their modularity[2]. In our study we have ignored the directed nature of the network (as is common in community structure calculations), assuming any link between two items, regardless of direction, to be an indication of their similarity. We supposed that the keywords in the network being linked if they are frequently used by the same document. Each group of closely related keywords should have a research problem or set of studies dealing with in common, and the name of that set or scientific specialty should be the identification of each group.

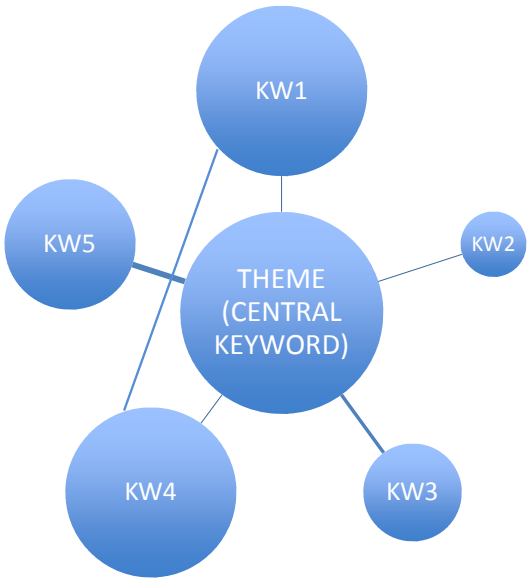
Finally, other specific software (IBM SPSS v.20) was used to extract different tables of frequencies and to plot the keywords in a space of mean year, the number of documents, times cited and the combination of these two indicators.

The keywords and their interconnections can be drawn in one or more network graphs called 'thematic networks' where each thematic network links together a group of keywords based upon their close association. Eachparticular thematic networkis labelled using the name of the most significant keyword in the associated theme (usually identified by the most central keywordof the theme; "adoption of innovations" in this case). The volume ofthe spheres(see Figure 2) is proportional to the number of documents correspondingto each keyword, and the

[1]Wakita and Tsurumi's hierarchical agglomeration algorithm is useful for detecting the community structure in network topologies which works by greedily optimizing the modularity metric. Modularity is a property of a network and a specific proposed division of that network into 'communities' (Newman and Girvan, 2004). This algorithm is described in the article written by Ken Wakita and Toshiyuki Tsurumi (2007) and implemented in NodeXL. Under this algorithm, we can get a visualization of the communities or groups' conceptual structure at maximum modularity.

thickness of the link betweentwo spheres *i* and *j* is proportional to the co-occurrence of both. A document is linked to a themeif it contains at least two keywords that are present in the thematicnetwork. An example of a thematic network is drawn in Figure 2.

Figure 2. Example of thematic network.



Source: The authors

3. Data sets/Data analysis

Following standard bibliometric protocol, the data for this research were extracted from the ISI Web of Science[2] (ISIWoS) data base, and added to by data from the SCOPUS[3]base. In particular, the initial download of records consists of a corpus containing 1,903 documents(journal articles, reviews, proceeding and conference papers and chapter in books) published in the academic literature onA.I.R. until and including 2012. These documents weredrawn from query #1 on 1st June, 2013.

> **query** #1: TS= ("adoption of innovations") OR TS= ("adoption of innovation"), TS= ("innovations adoption") ORTS= ("innovation adoption") ORTS= ("acceptance of innovations")

[2] The WoS's Citation Databases are: Science Citation Index Expanded (SCI-EXPANDED) –1900 to present; Social Sciences Citation Index (SSCI) –1900 to present; Arts & Humanities Citation Index (A&HCI) –1975 to present; Conference Proceedings Citation Index– Science (CPCI-S) –1990 to present; Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) –1990 to present; Book Citation Index– Science (BKCI-S) –2005 to present; and Book Citation Index– Social Sciences & Humanities (BKCI-SSH) –2005 to present.

[3] The SCOPUS-areas are: Life Sciences (> 4,300 titles), Health Sciences (> 6,800 titles; 100% Medline coverage), Physical Sciences (> 7,200 titles), Social Sciences & Humanities (> 5,300 titles).

ORTS= ("acceptance of innovation") ORTS= ("innovations acceptance") ORTS= ("innovation acceptance")

where TS field is a search based on the "Topic" (title, abstract and keywords).

But after eliminating the duplicate records the final number of manuscripts was 1,382 (712 from ISIWoS, and 670 from SCOPUS).

In this study the citations of the documents are also used. We have considered for each paper or chapterthe citations received until June1st, 2013. The citations that we take into account proceed from the both ISIWoS and SCOPUS databases, respectively. When the records are duplicates the number of citations is obtained from the ISIWoS database.

Before analyzing the data, the researchers carried out a normalization process on the keywords while maintaining their original meaning, wherea) the plural and singular forms of the keywords are joined, b) the acronyms (for two words as Information Technology –IT–) are also joined with the respective keywords or c) well-known words are joined with their respective acronyms (as CRM–Customer Relationship Management–). In this process we have conserved the initial forms of INNOVATION and INNOVATIONS, since usually the first form (the singular) is considered as referring to a process in general and the second one (the plural) refers mainly to particular products and/or services. In this way, we can maintain the inherent meaning of the terms and still compare the relationship with other keywords.

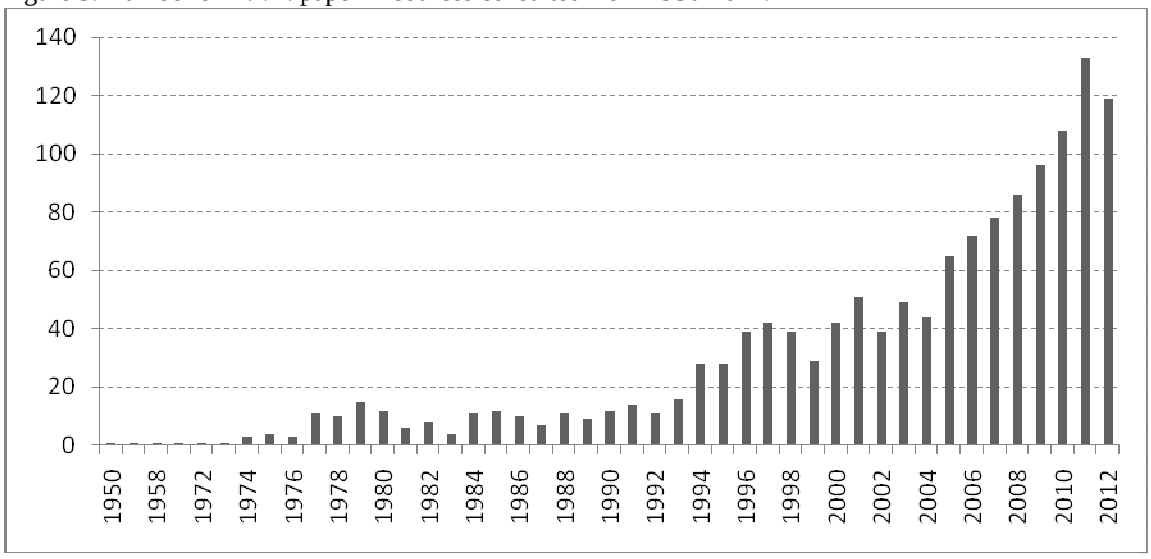
Furthermore, in the dataset a good number of papersdo not have keywords specified (mainly in chapters and proceedingsorconferences papers). To improve the quality of the database and avoid the introduction of potential bias or error in the analysis and the process of identifying trends,we have imputed manually the missing keywords for those articles more highly cited. Regarding the number of keywords to impute, we have chosen five keywords since the average number of keywords used in the dataset was 4.80.

In particular, the imputation consisted ofan exhaustive process. First, those documentswithout keywords and more than 10 times cited were selected. For these articles an *adhoc* script in Visual Basic for M. Excel extracted the abstract's words appearing more than five times in the preliminary analysis (within full documents). In this step, more than five keywords(average

number of keywords in full documents -4.8-)could be replaced checking simultaneously the existing Keywords Plus (in ISIWoS) and Index Keywords (in SCOPUS) classification systems of the documents. Other studies have found an average number of 5 keywords in the published papers (Ding et al., 2000).

Figure 3 shows the evolution of the number of documents per year from 1950 for both databases consulted.

Figure 3. Number of A.I.R. paper in sources consulted from 1950-2012.



Source: The authors

The proliferation of publications on A.I.R. from 1994 shows an exponential growth since the appearance of the Internet (see Figure 3). Half of the total papers werepublished within the last 7 years (i.e. from 2006 to 2012), displaying a continued increase from 2005.

4. Results of the application

This section shows the main keywords associated with A.I.R., the most important themes and the thematic networks associated to them, and their thematic evolution.

4.1. Main keywords associated with A.I.R.

First, the terms or keywords most frequently associated with the A.I.R. (query #1), with more than 15 repeats are given in Table 1.The level of centrality of each keywordin the database, as the number of edges to other keywords, is located in the last column.

Table 1. The top 25 most frequently-occurring keywords associated to A.I.R.

KEYWORD	**No. of documents[a]**	**Mean year[b]**	**Mean times cited**	**No. of edges to other keywords**
ADOPTION OF INNOVATIONS	312	2004	19.9	24
INNOVATION	160	2005	14.6	23
ADOPTION	111	2005	29.2	23
DIFFUSION OF INNOVATIONS	73	2005	31.3	18
DIFFUSION	61	2004	25.5	19
INTERNET	39	2004	15.5	20
TECHNOLOGY	39	2001	37.4	20
INFORMATION TECHNOLOGY	38	1992	39.0	21
ICT	37	2003	19.8	20
TECHNOLOGY ADOPTION	34	2006	27.2	20
SMEs	33	2007	6.3	15
INNOVATIONS	32	2003	38.1	20
E-COMMERCE	31	2008	9.3	10
MANAGEMENT	26	2003	41.2	17
IMPLEMENTATION	24	2005	57.4	14
ACCEPTANCE	21	2004	20.1	18
ATTITUDE	20	2004	38.7	17
INNOVATIVENESS	20	2002	66.1	15
CONSUMER BEHAVIOUR	19	2009	12.3	10
DECISION MAKING	19	2001	26.4	14
PERCEPTION	19	2002	28.6	16
TECHNOLOGICAL INNOVATION	19	2005	16.5	14
ERP	17	2006	12.8	12
LEARNING	16	2006	34.6	12
TAM	16	2008	27.3	14
REST	**3,761**	**2007**	--	--
TOTAL	**4,997**	**2005**	**18.6**	--

a: The calculation does not take into account the number of times that the terms appear in the title, the abstract or Keyword Plus.
Only terms with a frequency greater than 15 were selected.
b: Meanyear of the papers using this term.
Source: The authors

A more detailed analysis shows that the more emerging keywords appearing in the scientific literature for average year 2009 was CONSUMER BEHAVIOUR; in 2008, E-COMMERCE and the TAM model; in 2007, research applied to SMEs (as rest of keywords); in 2006, TECHNOLOGY ADOPTION, the ERP systems and LEARNING process; and finally, in 2005, INNOVATION and ADOPTION in general, DIFFUSION OF INNOVATIONS, the IMPLEMENTATION of innovations and TECHNOLOGICAL INNOVATION.

In Table 1, the documents most cited have been those that refer to INNOVATIVENESS (cited a mean of 66.1 times) or IMPLEMENTATION (57.4 times) processes, MANAGEMENT (41.2 times), INFORMATION TECHNOLOGY (39.0 times), the ATTITUDE construct (38.7 times),

INNOVATIONS (38.1 times), TECHNOLOGY (37.4 times), LEARNING (34.6 times) or DIFFUSION OF INNOVATIONS (31.3 times).

But in the set of all documents, the most cited document (874 times – see Table A and B of the appendix) was one that included these keywords: Information Systems (IS) USE, Management Information Systems (MIS) IMPLEMENTATION and USER BEHAVIOR; these keywords appear in Karahanna et al.'s (1999) paper. Then, the keywords attached to the next most cited papers in the scientific literature on A.I.R. were TRA model (441.5; in several papers), ORGANIZATION LEARNING AND DIFFUSION TECHNOLOGY (345; in Attewell, 1992), INNOVATION EVOLUTION (260, in Swanson, 1994), COERCIVE PRESSURES, FINANCIAL ELECTRONIC DATA INTERCHANGE, INSTITUTIONAL INFLUENCES, MIMETIC PRESSUERES and NORMATIVE PRESSURES (224; in Teo and Benbasat, 2003), GUIDELINES and IMPLEMENTATION STRATEGIES (215; in Wensing et al., 1998), NETWORK (209.5), as well as CENTRALIZATION, NATURAL RESOURCE MANAGEMENT, PSYCHOLOGY, SOCIAL ISSUES and SOCIOLOGY TRIALS (173; in Pannell et al., 2006).

4.2.Structure of the conceptual subdomains of the A.I.R.

Figure4 shows the global thematic networkwith the most frequentkeywords (with a co-occurrence between two keywords equal to, or greater than 5 and a frequency of appearing individually in the set of papers greater than 15) and five themes or thematic subnetworks. In the diagram, the arcs connecting keywords represent the amount of co-occurrence – the closer they are then the higher they co-occur. The volume of the spheres is proportionalto the number of published documents which contain the keyword.

First, the keywordsADOPTION and INNOVATION (of product or as a process) appear to be closely located (35 times co-occur), and strongly related with the keyword DIFFUSION (19 times with the first and second one). This type of relationship occurs also among ADOPTION OF INNOVATIONS with the process of DIFFUSION OF INNOVATIONS (27) or DIFFUSION (17), with INNOVATION (20 times) or INNOVATIONS (17). DIFFUSION is linked to ACCEPTANCE (6).

Focusing on ADOPTION OF INNOVATIONS, this keywordappears to be closely related to different themes as Technologies in general (TECHNOLOGY ADOPTION -14 times, ICT -13-, INFORMATION TECHNOLOGY -8- and TECHNOLOGY -6-),INTERNET (13 times) and keywords as DECISION MAKING (13), INNOVATIVENESS (12), E-COMMERCE (10), IMPLEMENTATION (10), MANAGEMENT (9), Small and Medium-Sized Enterprises, SMEs (9), ATTITUDE (8), Enterprise Resource Planning, ERP (8) systems, LEARNING process (8), PERCEPTION (7), TECHNOLOGICAL INNOVATION (6), ACCEPTANCE (5) and TAM (5).

The presence of ADOPTION is also related to Technologies (ICT -10-, TECHNOLOGY -8- and INFORMATION TECHNOLOGY -5-), PERCEPTION (8), INNOVATIONS (7), ATTITUDE (6), DIFFUSION OF INNOVATIONS (6), IMPLEMENTATION (6), SMEs (6), ACCEPTANCE (5), E-COMMERCE and ERP systems (5). The keyword ACCEPTANCE to ATTITUDE (5), and ATTITUDE to PERCEPTION (5) and IMPLEMENTATION (5).

The keyword INNOVATION is linked to E-COMMERCE (11), SEMs (10), CONSUMER BEHAVIOUR (8), ATTITUDE (7), INNOVATIONS in general (7), MANAGEMENT (7), ACCEPTANCE (6), ERP systems (5), IMPLEMENTATION (5) and INFORMATION TECHNOLOGY (5). INNOVATIONS are also related with ACCEPTANCE (6), and in this case, with DIFFUSION (5) and ICT (5).

Over the last four years the TAM model has been associated (5 times) with the DIFFUSION OF INNOVATIONS process, and ADOPTION OF INNOVATIONS.

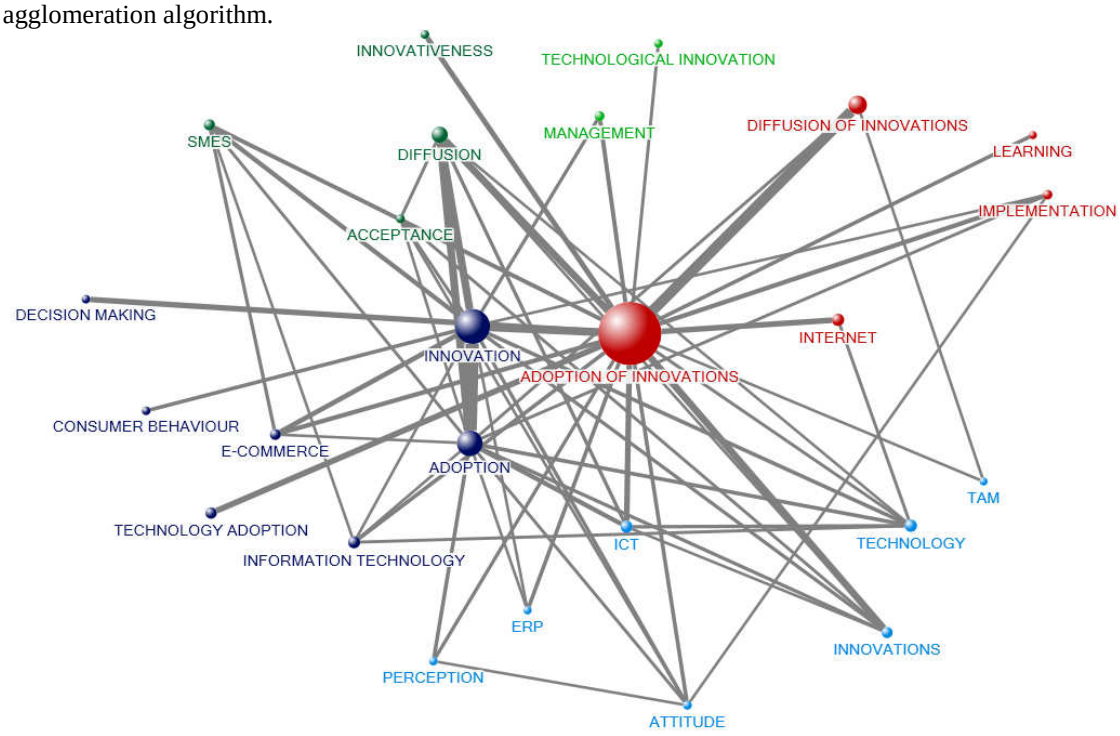
Regarding TECHNOLOGY, this topicis connected with INNOVATION (8); obviously with the ICTs (7) and INFORMATION TECHNOLOGY (6) and the DIFFUSION process (5). ICT is also connected with DIFFUSION (7) or INFORMATION TECHNOLOGY with SMEs (5).

Finally, only 6 papers deal with the INTERNET and TECHNOLOGY in a more superficial manner by providing a general association between both themes.

Although normally the semantic meaning of E-COMMERCE is included in the mediumINTERNET, these topics do not appear together a lot of time (only on 3 occasions). E-

COMMERCE has surprisingly appeared in a relatively lowcentral position with only four connections to other keywords(as SMEs).

Figure 4. Thematic network with 25 most frequently occurring keywords.Wakita and Tsurumi's agglomeration algorithm.



In summary, the connections stronger among them appear in this way:

- Group 1. **Studies on perception of technologies**. This group includes papers more related with PERCEPTIONS, ATTITUDES, TAM model, INNOVATIONS, TECHNOLOGY, ICT and ERP systems.
- Group 2. **Studies on decision making in the context of e-commerce or consumer behaviour**. This set is comprised by the keywordsINNOVATION, ADOPTION INFORMATION TECHNOLOGY, and TECHNOLOGY ADOPTION and the keywords CONSUMER BEHAVIOUR, E-COMMERCE and DECISION MAKING.
- Group 3. **Studies on strategic orientations in SMEs**. This group include more general concepts as INNOVATIVENESS, ACCEPTANCE or DIFFUSION applied to SMEs.
- Group 4. **Studies on management and technological innovation**. This small group only integrates these two keywords.
- Group 5. **Studies on stages established by the IDT theory and the Internet.** Concretely, evaluation (included or linked to LEARNING activities), ADOPTION and

IMPLEMENTATION are the stages established by the IDT (Prescott and Conger, 1995). This set is also compound by DIFFUSSION OF INNOVATIONS and INTERNET.

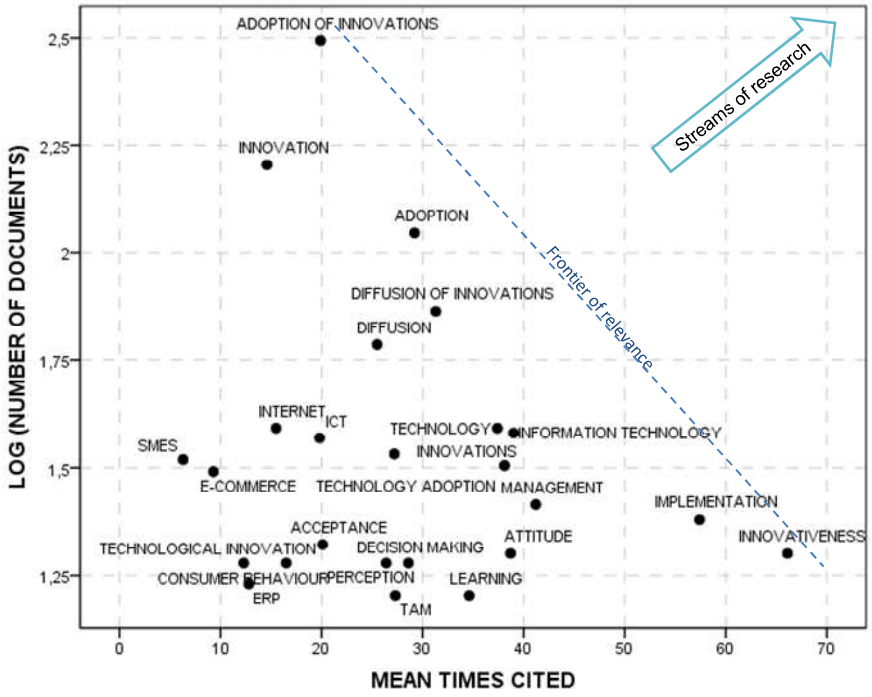
The globalthematic network shows that some major groups have a higher number of keywords (e.g. Group 1 or 2) but are connected to other sets of smaller groupsthat act as “bridges" between them (e.g. group 3 or group 4 –by the keyword MANAGEMENT–).

We can be sure about the fragmented and evolving nature of this network, becausea large number of previous studies have been devoted to a descriptive examination of different themessuch as ICTs or inter-organizational systems (e.g. Reich and Benbasat, 1990; Teo et al., 2003), and/or under explanatory perspective as CONSUMER BEHAVIOUR (e.g. Feathermanand Pavlou, 2003; Zviran et al., 2005), among others.

Next, we have proposed two plots combining, firstly, the number of documents (applying a logarithm-base 10) and the mean times cited; and secondly, the ratio of these two indicators and the mean year. Some previous studies have carried out analyses of citations from different disciplines (total citations and numbers of papers) as a function oftime identifying profiles (e.g. Kostoff et al., 2001, 2003), but no paper has combined these indicators in a two-dimensional space. This proposal allows identification of the “stream of research” and “future impact” of the themes analysed.

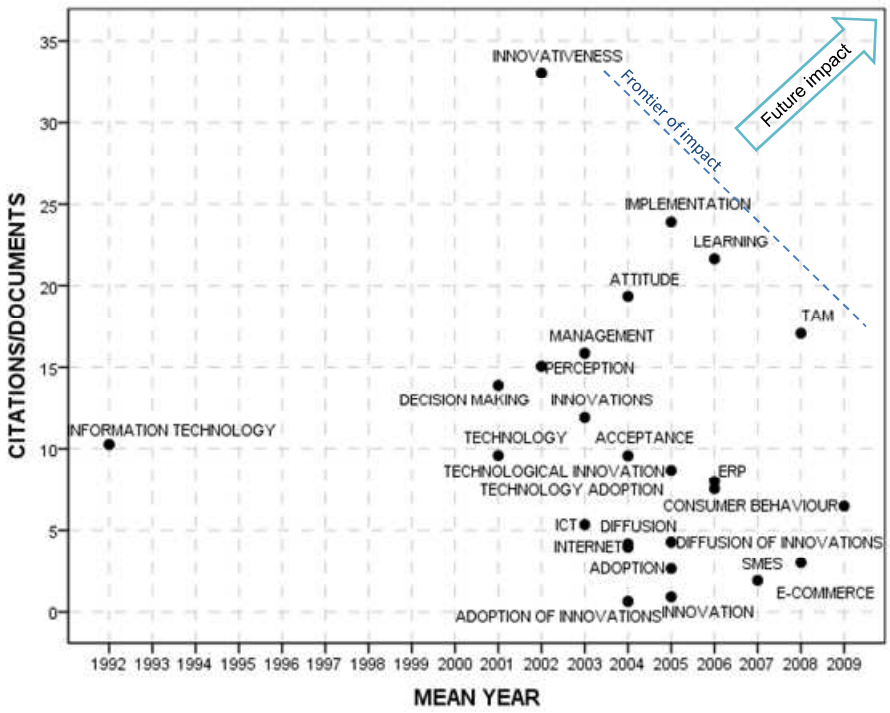
In this case, INNOVATION DIFFUSIONor DIFFUSION has won‘fashion status’ or peaking, with 2005 and 2004 as the average year, respectively (see Figure 5 and Table 2). Other streams of recent research have been themes related with INTERNET (and E-COMMERCE), ICTs, ITs or TECHNOLOGIES ADOPTION and their MANAGEMENT. Regarding Management of Technology, over the last three decades technology management (TM) has gradually established itself as an academic discipline (Pilkington and Teichert, 2006). For example, Drejer (1997) identifies four schools of thought as the discipline evolved from R&D Management, through Innovation Management and Technology Planning before developing as Strategic Management of Technology (MOT). Finally, the studies of IMPLEMENTATION of innovations have also been an area of interest on A.I.R.

Figure 5. Analysis of streams of research of the 25 most frequently occurring keywords (number of documents vs. times cited)



A more complete picture of how the different keywords impact on A.I.R., measured as number of citations/documentsand its evolution is provided in Figure6. This analysis contributes to a longitudinal perspective of A.I.R. during the period analysed.The keywords located close to the upper right cornerhave developed more recently and have a higher impact on this scientific community. Concretely, several topicssuch as INNOVATIONS, MANAGEMENT, DECISION MAKING, PERCEPTIONS, ATTITUDES, LEARNING processes,IMPLEMENTATION, INNOVATIVENESS or other more recent developments, as the extensions of TAM model, have had, and will continue to have a strong impact on A.I.R.. INTERNET and E-COMMERCE have losttheir peakstatus in terms of numbers of studies on topics as WEB 2.0 and 3.0 applications, social networks, e-banking and other tools used through the Net become more dominant.This is due to the disaggregation of Internet applicationsand / or their study.

Figure 6. Longitudinal analysis of the 25 most frequently occurring keywords (citations/documents vs. mean year)



5. Conclusions and contributions

The aim of the present study has been to offer asnapshot of the thematic evolution of the Adoption of Innovations Research (A.I.R.) during the period 1950-2012 by identifying the structure of the previous and current themes, and predicting emerging trends. Tothis purpose, the study uncovers the underlying relationships among themes.The approach is complemented with a cluster analysis of issuesmore related among them. In the thematic networks, the volume of the spheres is proportional to the number of published documents and the thickness of the link between two keywords is proportional to the co-occurrence of both. The analysis has also extracted the journals and the top authors most frequently associated to the A.I.R community.

The paper shows that the proliferation of publications on the A.I.R. from 1994has an exponential growth since the appearance of the Internet among other interesting topics; and more than half of the relevant papers have beenpublished within the last eight years with a continued increase (from 2005).

The thematic network finds that the keywordsADOPTION and INNOVATION, closely located, are strongly related with DIFFUSION. This type of relationship occurs also among ADOPTION

OF INNOVATIONS with the stage of DIFFUSION OF INNOVATIONS or DIFFUSION in general, with INNOVATION or INNOVATIONS.Focusing the attention in ADOPTION OF INNOVATIONS, this topic appears to be closely related to different themes such as Technologies in general (and with ADOPTION in general),INTERNET, and the keywords DECISION MAKING, INNOVATIVENESS, E-COMMERCE or IMPLEMENTATION.The keywordINNOVATION (of product or process) is linked to keywords E-COMMERCE or SMEs. Only a few papers deal with the INTERNET and TECHNOLOGY in a more superficial manner by providing a general association between both themes.Although normally the semantic meaning of E-COMMERCE is included in the mediumINTERNET, these topics do not appear together a lot of times.

In order to deepen the structure of the conceptual subdomains of the A.I.R five groups of keywords were extracted with the Wakita and Toshiyuki's clustering algorithm. These groups with stronger associations are:

- Group 1. Studies on perception or attitudes of technologies (including ERP systems).
- Group 2. Studies on decision making in the context of technology adoption, e-commerce or consumer behaviour.
- Group 3. Studies on strategic orientations (innovativeness, acceptance or diffusion) in SMEs.
- Group 4. Studies on management and technological innovation.
- Group 5. Studies on stages established by the IDT theory, and the Internet.

The analysis reveals the A.I.R. literature to be characterized as very fragmented and evolving. For example, a large number of recent studies have been devoted to a descriptive examination of different topics: ICTs (includingthe Internet), systems (such as ERP), or modelling of CONSUMER BEHAVIOUR (with analysis of ATTITUDES and PERCEPTIONS), amongst others. The perceptions of the use of an innovation are key to its diffusion, rather than a traditional definition of perceptions about the innovation itself (Moore & Benbasat, 1991). However, significant progress has been made, and the field shows more and more publications

on A.I.R. Thus, in-depth bibliometric studies of this academic discipline should be developed as reviews of comprehensive scientific literature.

The analysis of stream of research in A.I.R. shows two areas clearly delimited:on one hand, research on ADOPTION, IMPLEMENTATION and DIFFUSION OF INNOVATIONS, and on the other hand, research on ICTs (including the Internet and e-commerce applications) and its management.

Specially, several topicshave had and will have a strong impact on A.I.R.. These issuesare INNOVATIONS, DECISION MAKING, PERCEPTION, MANAGEMENT, ATTITUDE and LEARNING process, TAM, IMPLEMENTATION and INNOVATIVENESS, as well as, WEB 2.0 and 3.0 applications, social networks, users' communities,e-banking servicesor e-learningand related tools as general Web-based content management systems.The predictive value of TAM (and its modifications and extensions) to explain behaviours towards adoption of IT will be consistently significant on the A.I.R.

Referring to Figures 4 and 5, it appears that Groups 1 and 2 (on perceptions of technologies and decision making) have a lower popularity, but low-moderate proportion of citations. Group 4 (management and technological innovation) appears to be of low popularity and moderate citation. In essence, Groups 1, 2 and 4 fit more towards the bottom left portion of Figure 5. Groups 3 and 5 (on strategic orientations and IDT theory respectively) are arguably more diverse, containing individual keywords either very popular with the greatest number of publications, or the highest proportion of citations.

As an observation and notwithstanding the diversity of publication frequency versus citation within the Groups 3 and 5, keywords such as ADOPTION OF INNOVATIONS, INNOVATION and ADOPTION are clearly popular topics with by far the greatest number of articles, however, their citation is proportionately low. By contrast, keywords such as INNOVATIVENESS and IMPLEMENTATION (which locate across Groups 3 and 5) are apparently less popular topics but extremely well cited. This could reflect the more diffuse and human element to the topics (i.e. keywords) inasmuch as the focus includes a social element,

whilst ADOPTION OF INNOVATIONS and INNOVATION are more focused on the innovation itself.

One could also postulate, somewhat cynically, that the currency for both the individual researcher and the journal is greater for INNOVATIVENESS and IMPLEMENTATION given the impact factor status attributed to citations. This clearly has implications for both authors and journal editors, from both an individual perspective and the scholarly advancement of the A.I.R. field.

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ANNEX

Table A. The top 20 keywords in most cited documents

KEYWORD	**Mean times cited[a]**	**No. of documents[b]**
IS USE	874.0	1
MIS IMPLEMENTATION	874.0	1
USER BEHAVIOR	874.0	1
TRA	441.5	2
ORGANIZATION LEARNING AND DIFFUSION TECHNOLOGY	345.0	1
INNOVATION EVOLUTION	260.0	1
COERCIVE PRESSURES	224.0	1
FINANCIAL ELECTRONIC DATA INTERCHANGE	224.0	1
INSTITUTIONAL INFLUENCES	224.0	1
MIMETIC PRESSURES	224.0	1
NORMATIVE PRESSURES	224.0	1
GUIDELINES	215.0	1
IMPLEMENTATION STRATEGIES	215.0	1
NETWORK	209.5	2
CENTRALIZATION	173.0	1
NATURAL RESOURCE MANAGEMENT	173.0	1
PSYCHOLOGY	173.0	1
SOCIAL ISSUES	173.0	1
SOCIOLOGY TRIALS	173.0	1

a:Only keywords with a number of times cited greater than 150 were selected.
b: The calculation does not take into account the number of times that the terms appear in the title, the abstract or Keyword Plus. For this calculation, none constraint was put.
Source: The authors

Table B. The top 20 papers most cited

Paper	**Times Cited**	**Authors' keywords (a) or Keywords imputed (b)**
Karahanna et al. (1999)	874	(a) IS USE, MIS IMPLEMENTATION, USER ATTITUDES, USER BEHAVIOR
Tornatzky and Klein(1982)	541	(b) INNOVATION CHARACTERISTICS; ADOPTION OF INNOVATIONS; INNOVATION IMPLEMENTATION; META-ANALYSIS
Moon (2002)	428	(b) INFORMATION TECHNOLOGY; IMPLEMENTATION; TECHNOLOGY; MANAGEMENT E-GOVERNMENT; GOVERNANCE
Westphal et al. (1997)	372	(b) ADOPTION OF INNOVATIONS; TQM; IMPLEMENTATION; INNOVATIONS; NETWORK; FACTORS OF ADOPTION
Attewell (1992)	345	(a) ORGANIZATION LEARNING AND DIFFUSION TECHNOLOGY
Swanson (1994)	260	(a) INFORMATION SYSTEMS, INNOVATION TYPES, DIFFUSION, INNOVATION EVOLUTION
Teo et al. (2003)	224	(a) FINANCIAL ELECTRONIC DATA INTERCHANGE, INTERORGANIZATIONAL SYSTEMS, INSTITUTIONAL INFLUENCES, MIMETIC PRESSURES, COERCIVE PRESSURES, NORMATIVE PRESSURES
Wensing et al. (1998)	215	(a) GUIDELINES, IMPLEMENTATION STRATEGIES
Gallivan (2001)	201	(a) TECHNOLOGY ADOPTION, TECHNOLOGY DIFFUSION
Pannell et al. (2006)	173	(a) AGRICULTURE, ECONOMICS, EXTENSION, INNOVATION, LEARNING, NATURAL RESOURCE MANAGEMENT, PERSONALITY, POLICY, PSYCHOLOGY, SOCIAL ISSUES, SOCIOLOGY TRIALS
Moch and Morse (1977)	173	(b)ORGANIZATIONAL SIZE; CENTRALIZATION; ORGANIZATIONAL INNOVATION; ORGANIZATIONAL ADOPTION; ADOPTION OF INNOVATIONS
Wejnert (2002)	171	(a) DIFFUSION MODELS, ADOPTION OF INNOVATIONSS, ADOPTERS, DECISION MAKING

Paper	Times Cited	Authors' keywords (a) or Keywords imputed (b)
Damanpour (1996)	171	(a) ORGANIZATIONAL INNOVATION, STRUCTURAL COMPLEXITY, ORGANIZATIONAL SIZE, CONTINGENCY MODEL, META-ANALYSIS
Frambach and Schillewaert (2002)	149	(a) INNOVATION, ADOPTION, DIFFUSION, ORGANIZATIONS, TECHNOLOGY ACCEPTANCE
Premkumar and Roberts (1999)	137	(a) SMALL BUSINESS, IT ADOPTION, COMMUNICATION TECHNOLOGIES, IS IMPLEMENTATION, IT
Plouffe et al. (2001)	125	(a) TECHNOLOGY ACCEPTANCE MODEL, PCI, ADOPTION, MANAGERS, PERCEPTIONS, ATTITUDES, INTENTIONS, FIELD STUDY, HIGH TECHNOLOGY, SMART CARDS
Backer et al. (1986)	115	(b) ADOPTION OF INNOVATIONS; BEHAVIOUR; SEM; POTENTIAL ADOPTERS
Roman and Johnson (2002)	112	(a) NALTREXONE, ORGANIZATIONAL CHANGE, SUBSTANCE ABUSE TREATMENT, TECHNOLOGY TRANSFER
Henrich (2001)	105	(a) INNOVATION DIFFUSION, CULTURAL TRANSMISSION, LEARNING, CULTURAL EVOLUTION
Reich andBenbasat (1990)	105	(a) INFORMATION FOR COMPETITIVE ADVANTAGE, IT ADOPTION, IT IMPLEMENTATION, INTER-ORGANIZATIONAL SYSTEMS (IOS), STRATEGIC INFORMATION SYSTEMS (SIS)

a. Original author's keywords
b. Keywords imputed from the title, abstract and content of the paper

Source: The authors