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INNOVATION AND ENTREPRENEURSHIP IN ORGANIZATION STUDIES

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Contents

1. Introduction

This thesis consists of three essays at the intersection of entrepreneurship, innovation and creativity theories. Unifying the essays are two themes: firstly, a focus on what can we learn by combining the creativity, innovation and entrepreneurial management litteratures and secondly, the existence of specific collective cognitions shared by researchers, schools of thought, but even by firms within a sector, that can influence how innovation arise and how quickly and completely they diffuse, and can give us another key to better understand the knowledge progress.

Turning to specifics, the first study, following the conceptual recombination theory, by which ideas and concepts are merged to mentally transform and extend knowledge, explores and summarizes the current sources of academic literature, simultaneously engaging research in the fields of entrepreneurship and creativity. It is evident how the concept of creativity, understood as the production and development of new and useful ideas over the short or long term and at the individual (Amabile, 1996) or the organizational level (Woodman, Sawyer and Griffin, 1996; George, 2008; Shalley, Zhou and Odham, 2004), not only has many conceptual similarities with entrepreneurship, but also underscores the role of change drivers by promoting the generation of entrepreneurial opportunities (creation theory) or facilitating innovative developments in the business exploitation phases (discovery theory). The goal of this study is to detect and visualize the intellectual structure of the shared ground among both sets of literature and identify the connected schools of thought, methods, constructs, and theories to problematize or

literature gaps to be filled. Co-citation analysis and Pathfinder methods reveal the network structure—the central, bridge, and peripheral articles—and enable to hypothesize trailblazing trends, sidings, or forgotten contributions.

The second study, contributes to the ongoing debate to better understand the relationship between innovation and individual and organizational cognitive structures and processes. This work, focus on those contributions to the cognition and innovation in the management literature and business domains recognized as being the most influential, highlights different natures of organizational knowledge, culture, interfirm alliances and strategy.

In the third study, based on the patent bibliometrics and longitudinal patent co-citation method and through a strategic lens, I integrate and extend the cognition and technology strategy literatures by proposing an invention behavior map of leading companies and groups in the automotive industry. In fact, while collective cognition has received broader increasing attention in the field of organization, academic research has largely overlooked its potential role on shaping innovation trajectories and technological change adaptation at a firm and industrial levels (Johnson and Hoopes, 2003; Nadkarni and Narayanan, 2007). Research on innovation and patent strategies has been largely silent about the cognition's role (Kaplan and Tripsas, 2008) and empirical studies thus far have not questioned how industry beliefs truly define technological trajectories and patent strategies.

Part I.

"Drawing the Commingling Map between Entrepreneurship and Creativity: a Co-Citation Analysis"

2. Abstract

This work, following the conceptual recombination theory, by which ideas and concepts are mentally merged to transform and extend knowledge, explores and summarizes the current sources of academic literature, simultaneously engaging research in the fields of entrepreneurship and creativity. A bibliometric co-citation analysis was applied to identify the "invisible colleges" and the latent relationships among the most significant papers. Multivariate analyses including cluster, latent class, multidimensional scaling, and Pathfinder were combined to map the "nodes" positioning the literature. The goal of this study is (1) to increase the awareness of scholars by detecting and visualizing the intellectual structure of the shared ground among both sets of literature; (2) to identify the connected schools of thought, methods, constructs, and theories to problematize or literature gaps to be filled; (3) to reveal the network structure—the central, bridge, and peripheral nodes—and to hypothesize trailblazing trends, sidings, or forgotten contributions; and (4) to generate, thanks to a creativity "grant," new insights to enable entrepreneurs to explore new frontiers. Using creativity techniques and a panel of experts in support, 26 keywords were generated, extracted, assessed and exploited to identify the research unit of 1533 articles. Following a further evaluation process, 73 major co-cited items were finally selected. Given the transverse nature of the creativity domain and of the search for academic interdisciplinary comminglings, data were collected from Science (SCI), Social Sciences (SSCI) and Arts and Humanities (A&HCI) citation indices for the 1991-2013 period.

3. Introduction

Two schools of thought struggle with the determinants and definition of entrepreneurship: the "discovery theory" and the "creation theory." The discovery theory focus on the entrepreneurial ability to detect, recognize, evaluate, and exploit new business opportunities that, being exogenous in nature, exist in the environment independently of their owners (Kirzner, 1973; Venkataraman, 1997, 2012; Shane et al., 2000; 2013). The creation theory assigns a builder role to entrepreneurs, who are asked to generate and implement new business opportunities after creatively destroying previous market equilibria (Schumpeter, 1934; Weick, 1979; Aldrich and Kenworthy, 1999; Sarasvathy, 2001; Aldrich and Ruef, 2006).

Although both theories are internally consistent, it is clear that the beliefs about what generates the market imbalance inherent in the two approaches have strong implications for entrepreneurial and policymaker actions. If we think that the entrepreneur is primarily an adventurous "discoverer," it will be useful to refine the characteristics related to perception and reasoning, while if we consider the entrepreneur to be primarily a creative being who can generate endogenous shocks, then it will be essential to focus and enhance skills of generation and ingenuity.

It is evident how the concept of creativity, understood as the production and development of new and useful ideas over the short or long term and at the individual (Amabile, 1996) or the organizational level (Woodman, Sawyer, and Griffin, n.d.; George, 2008; Shalley, Zhou, and Oldham, 2004), not only has many conceptual similarities with

entrepreneurship, but also underscores the role of change driver by promoting the generation of opportunities (creation theory) or facilitating innovative developments in the entrepreneurial exploitation phases (discovery theory).

Previous studies shuffle the two concepts by theoretically building "entrepreneurial creativity" and "creative entrepreneurship" constructs. The first is defined as the generation and implementation of novel, appropriate ideas to establish a new venture (Amabile, 1996; Perry-Smith and Coff, 2011; Dayan, Zacca, and Di Benedetto, 2013), while the second implicitly highlights a creative entrepreneurship process by opposing an uncreative one, which is understood as an entrepreneurial process that is not able to generate high levels of novelty and utility (Plant, 2008; Arroyo, 2009).

Though creativity and entrepreneurship clearly present certain relevant elements of similarity, there is a gap in the literature of studies that simultaneously address these two fields. Considering the bounded rationality (Simon, 1991) that characterizes all researchers, I have chosen to balance the analysis of a great deal of quantitative data with a complemantary perspective gained through qualitative research (Fillis, 2010) by exploring the gaps in the literature with a quantitative bibliometric approach. A co-citation analysis was applied to identify the "invisible colleges" and the latent relationships among the most significant papers.

The goal of this study is to (1) increase the awareness of researchers by detecting and visualizing the intellectual structure of what is common to both sets of literature; (2) to identify the connected schools of thought, methods, constructs, and theories to problematize or the literature gaps to be filled; (3) to reveal the network structure—the central, bridge, and peripheral nodes—and to hypothesize trailblazing trends, sidings, or forgotten contributions; and (4) to generate, thanks to a creativity "grant," new insights to enable entrepreneurs to explore new frontiers.

Four multivariate analyses including cluster, latent class, multidimensional scaling and Pathfinder were combined to map the "nodes" positioning the literature. Using creativity

techniques, content analysis, co-word analysis, and a panel of experts in support, 26 keywords were generated, extracted, assessed, and finally filtered to identify the research unit of 1533 articles, subsequently reduced to 73 major co-cited items.

Given the transverse nature of the creativity domain and of looking for interdisciplinary academic contaminations, data were collected from Science (SCI), Social Sciences (SSCI), and Arts and Humanities (A&HCI) citation indices for the 1991-2013 period.

The analysis highlights thriving creativity influences able to enrich the agenda of entrepreneurship, innovation and strategy studies, and is structured as follows.

First, I describe the co-citation methodology employed.

Second, I show the bibliometric results and provide a graphical representation of publication proximities and intellectual structure descriptions created by multidimensional scaling (MDS), cluster analysis, and Pathfinder analysis.

Finally, I offer my conclusions, discuss the limitations of the study, identify implications for research and practice, and recommend avenues for future research.

4. Literature background

4.1. Co-citation analysis

> ..."Remember that the past is not the bay where to look for a landing, but it's just the point from which sail away"...

Co-citation analysis aims to reconstruct the history of scientific fields.

It adopts statistical techniques and considers the number of simultaneous citations as an acceptable surrogate to measure the influence of various information sources on a research product or author (Garfield, 1979). Co-citation analysis is a form of document coupling that measures the number of documents that have cited any given pair of documents (Small, 1973). It is a bibliometric technique or a quantitative bibliography (Pritchard, 1969) that is considered attractive because it is unobtrusive and understood as sparsely subjective and hardly conditionable (Garfield, 1979). A co-citation occurs between two papers, say paper A and paper B, when a paper citing paper A (which could have been published in any journal) also cites paper B. The number of co-citations (the co-citation index) equals the number of times both A and B are cited together in a third articles.

The basic premise behind this approach is that the scholarly contributions that are frequently co-cited are likely to embody similar or related concepts. That they are cited

together in the same paper establishes a quantifiable link between the earlier papers, a link that becomes stronger with the number of times a pair of documents are cited together. Therefore, the frequency of co-citation is a measure of the connection between papers. The structure, and consequently the meaning, of a co-citation graph is strongly influenced by the operational uncertainties associated with two fundamental assumptions. First, it is assumed that highly cited papers represent important concepts and methods in science. Second, it is assumed that frequently co-cited papers are related in content.

A graphic representation of which published works tend to be cited together by researchers helps identify research streams and other clusters of scholarly work. Studies focusing on cited works try to establish the general structure of the discipline (what types of works are dominant), as well as the discipline's boundaries and the relations between disciplines and fields (Nerur, 2008). Furthermore, co-citation studies can show us what topics, authors, journals, and research methods are central and peripheral to the field and how they may have changed over time.

Small argues that the co-citation method can be used to observe and assess the state of the art of literature and the state of the development of a paradigm. In fact, when a paradigm emerges, the consensus generated can be identified through an increase in the number of citations of articles dealing with this new paradigm (Small 1980). Moreover, changes in co-citation patterns over time can be analyzed in order to document the scientific turnover preceding the emergence of a new paradigm (Keen, 1978).

In sum, co-citation is metaphorically similar to a bucket that is able to bring up the water (the most influential articles) that has irrigated academic fields and generated the flowers and plants (the cited articles) of a particular topic. From the mere observation of the latter, it would be impossible to grasp the flavor and the real organoleptic qualities that emerge from the depths of a well and can be observed thanks to bibliometric analysis (Morgan, 1986).

5. Data and research method

Our analysis, following the prescriptions of the co-citation method (McCain, 1990; Nerur, Rasheed, and Natarajan, 2008; Di Guardo and Harrigan, 2010), comprises six steps:

1. Selecting the unit of analysis;
2. Retrieving co-citation frequencies;
3. Compiling the raw co-citation matrix;
4. Converting the raw co-citation matrix into a correlation matrix;
5. Multivariate analysis;
6. Interpreting the findings.

5.1. Unit of analysis

The unit of analysis can be defined in terms of articles or authors, depending on whether the analysis aims to identify the structure of specific or broad fields of inquiry (White and Griffith, 1986; Culnan, 1986). In particular, for the studies targeted at specific research areas (as in our case), it is preferable to analyze articles, so that the results

will not be biased by the fact that the same author may have published in different fields (Acedo, Barroso, and Galan, 2006). In our case, this method made it possible to identify the connections among the most influential contributions regarding the relationship between entrepreneurship and creativity literature in order to draw a commingling map of research streams and provide indications for future research.

Given the transverse nature of the creativity domain and of looking for interdisciplinary academic comminglings, data were collected both from Science (SCI), Social Sciences (SSCI) and Arts and Humanities (A&HCI) citation indices for the 1991-2013 period. I used Thomson-ISI for the consistency of its database in terms of quantity and quality of scientific contributions. This database, which covers over 2,700 of the world's leading scholarly journals in more than 90 disciplines, provides access to bibliographic information, author abstracts, and cited references. I used the time period 1991-2013. The 22-year period represents a significant slice of time that witnessed the growth and maturity phases of research in entrepreneurship and creativity. Adopting brainstorming techniques and a panel of experts in support, 26 keywords were generated, extracted, assessed, and exploited to identify the research unit of 1533 articles.

The criteria adopted crossed two subsets of keyword: this ensured that the retrieved articles would refer to at least one of the keywords for each subset (Culnan, 1987) (Fig.5.1.1).

TS=(("entrepreneur*" OR "founder*" OR "new business*" OR "new compan*" OR "new firm*" OR "new organization" OR "new organizations" OR "new venture*" OR "startup*" OR "start up*")
AND
("analogical thinking" OR "artistic*" OR "brain storm*" OR "brainstorm*" OR "creativ*" OR "divergent thinking" OR "eureka moment*" OR "fantasy" OR "idea* generation*" OR "ideation" OR "imagination" OR "improvisation" OR "intuition" OR "invention*" OR "lateral thinking" OR "originality"))

Figure 5.1.1.: Entrepreneurship and creativity search query and keyword

The process of the generation of keywords progressed through five stages:

1. The individual generation phase;
2. Brainstorming with the first group of researchers, which generated 64 terms for the topic of entrepreneurship and 106 for creativity;
3. Consultation of WordNet, a large lexical database where nouns, verbs, adjectives, and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept, along with other traditional lexical resources for finding synonyms;
4. A content analysis of the 30 most cited papers, looking for the most frequent terms and keywords adopted by the most influential entrepreneurship and creativity-focused contributions; and
5. A filter phase run by a panel of eight experts, from which emerged the 26 keywords with 70% uniformity.

5.2. Retrieval of co-citation data

The search was performed by selecting the publications whose title, abstract, and keywords matched our criteria, and that were present in both the subsets. By screening the Thomson-ISI database according to the above search criteria, I selected all manner of publications in all fields to analyze cross-citations and interdisciplinary commingling, obtaining a set of 1533 contributions.

Given our interest in defining the hard core of the discipline, I selected only the most-cited papers (Acedo, Barroso, and Galan, 2006).

Equivalent with other bibliometric studies (Culnan, 1986; Rowlands, 1999), the selection was set at 45 citations for papers issued between 1991 and 2009, and 35 citations for articles published after 2010. This filter highlighted the 73 most co-cited articles, with a total of 7363 single citations (100 on average) and an h-index of 54.

In order to standardize the data and avoid possible scale effects, as well as to reduce the number of zeros in the matrix, prior to the analysis I converted the raw co-citation matrix into a correlation matrix, using SPSS Version 20 to calculate the Pearson's correlation coefficient for each cell of the matrix (Rowlands, 1999).

Correlation coefficients represent a measure of similarity between two papers: the higher the positive correlation, the higher the perceived similarity between the two works. Once the correlation matrix was obtained, drawing on similar studies (Culnan, 1986; Brown and Gardner, 1985), I proceeded to apply four multivariate statistical techniques to the correlation matrix.

5.3. Multivariate analysis

First, non-metric multidimensional scaling (MDS), a data reduction procedure that allows the generation of a map using similarities between objects (Wilkinson, 2002), was employed, allowing us to map the relationships between papers. This map represents the position and perception of the community of scholars who cite the article's selected nodes or search keys (White and McCain, 1998). It is a method of displaying the intellectual distances between scientific contributions, and showing any areas where there are no studies yet in order to spot gaps in the literature. Furthermore, the evolution of the field may be discerned by examining changes in the structure of such maps over time.

Secondly, I applied a hierarchical cluster analysis, which groups the papers in terms of similarity, thus providing an indication of the most relevant research subfields. Third, a Bayesian latent class analysis was performed in order to triangulate the goodness of the number of clusters previously identified (McCutcheon, 1987, 2002).

Finally, I ran a Pathfinder analysis (Schvaneveldt, Dearholt, and Durso, 1988; Schvaneveldt, Durso, and Dearholt, 1989; Nerur, 2008; Bullmore and Sporns, 2009; Di Stefano, Verona, and Gambardella, 2012; Shapique, 2013) with the aim of recognizing and map-

ping paper links and measuring the degree and betweenness centralities of articles/nodes. Pathfinder analysis fundamentally draws on concepts from graph theory to generate a network structure called a PFNet, in which the strongest relationships between concepts of interest in the domain are emphasized (Schvaneveldt, 1990). Pathfinder is a data reduction technique that is able to detect only the significant links within a too-complex high-degree social network analysis. As mentioned earlier, the co-citation frequency between authors is a measure of their conceptual similarity.

6. Discussion of results

6.1. Bibliometrics

From preliminary bibliometric research, I extracted 1533 scientific contributions containing at least a couple of the 26 previously-identified keywords (at least one per topic). The number of published articles from 1991 to the present has been steadily growing, as has the number of total citations received. Below is a list of the main publishing Journals (Table 6.1).

N.	Publishing Journals	N.
1	Management Decision	67
2	Journal of Business Venturing	51
3	Harvard Business Review	36
4	Journal of Organizational Change Management	35
5	International Journal Of Manpower	34
6	Research Policy	28
7	International Marketing Review	24
8	Small Business Economics	24
9	Technovation	23
10	Industrial Management Data Systems	21
11	British Food Journal	17
12	European Journal Of Marketing	17
13	Entrepreneurship Theory And Practice	16
14	Strategic Entrepreneurship Journal	16
15	Management Science	15

Table 6.1.: Top 15 publishing journals of 1533 total keyword generated papers from 1991 and 2013

The vast majority of articles were published in business economics, engineering, public administration, computer science, geography, psychology, and sociology. The Universities of Harvard, Illinois, Toronto, and Valencia were the top four sites for the production of entrepreneurship and creativity publications, and Shane, Nijkamp, Mitchell, Zahra, and Acs the most-cited authors.

In order to detect the most influential articles of the 1533 previously selected, I carried out a further filter procedure, in which I measured the number of co-citations between articles with at least 35 single citations. Within a raw co-citation matrix, I inserted simultaneous citation values. At this stage, 138 articles satisfied the methodological conditions. At the end of the co-citation count, all items with more than 90% of zero co-citations were eliminated (Acedo, Barroso and Galan 2006). The filter phase highlighted the 73 most co-cited articles (Table 6.2), which had received a total of 7363 single citations. The authors of these articles with more than one contribution include Shane, Zahra, and Kor.

A deeper examination of the 73 papers and their journals of publication revealed various interesting points (Table 6.3):

1. The Journal of Business Venturing and Entrepreneurship Theory and Practice are the most influential journals in the combined field, as two out of every five most important articles were published in one or the other;
2. Theoretical and empirical papers were equal;
3. Regression methods were prevalent;
4. Only two articles were published in a practitioner-oriented journal (the Harvard Business Review);
5. Articles mainly focused on the topics of entrepreneurship, cognition, organization studies, strategy, and innovation management; and

P1:Teece, David J.,Smj,2007	P26:Witt, U,Jebo,1998	P51:Audretsch, Db,Rp,2005
P2:Ahuja, G,Smj,2001	P27:Shepherd, Da,Etp,2005	P52:Bhide, A,Hbr,1994
P3:Shane, S,Ms,2002	P28:Ward, Tb,Jbv,2004	P53:Jones, Gr,Jm,1992
P4:Hitt, Ma,Smj,2001	P29:Markman, Gd,Jbv,2005	P54:Nijkamp, P,Rs,2003
P5:Thursby, Jg,Ms,2002	P30:Bercovitz, Janet,Os,2008	P55:Shah, Sonali K.,Sej,2007
P6:Zahra, Sa,Jms,2006	P31:Knight, Ga,Jbv,1997	P56:Mosakowski, E,Os,1998
P7:Garud, R,Rp,2003	P32:Corbett, Ac,Etp,2005	P57:Lowe, Ra,Ms,2006
P8:Rothaermel, Ft,Smj,2001	P33:Dushnitsky, G,Smj,2005	P58:Davis, Jason P.,Asq,2009
P9:Ireland, Rd,Jm,2003	P34:Autio, E,Jibs,2005	P59:Siegel, Donald S.,Orep,2007
P10:Gans, Js,Rp,2003	P35:Mueller, Sl,Jbv,2001	P60:Gaglio, Cm,Etp,2004
P11:Etzkowitz, H,Rp,2003	P36:Acs, Zoltan J.,Sme,2009	P61:Hellmann, Thomas,Ms,2007
P12:Carter, Nm,Jbv,1996	P37:Shane, S,Icc,2003	P62:Nerkar, A,Ijio,2003
P13:Miner, As,Asq,2001	P38:Ruef, M,Icc,2002	P63:Agarwal, Rajshree,Sej,2007
P14:Magretta, J,Hbr,2002	P39:Tiessen, Jh,Jm,1997	P64:Sarasvathy, Sd,Jm,2004
P15:Shane, S,Ms,2001	P40:Lipparini, A,Jm,1994	P65:Loane, Sharon,Imr,2006
P16:Fleming, L,Smj,2004	P41:Anton, Jj,Jleo,1995	P66:Gibb, A,Ijmr,2002
P17:Gans, Js,Rje,2002	P42:Lumpkin, Gt,Etp,2005	P67:Harmon, B,Jbv,1997
P18:Antoncic, B,Jbv,2001	P43:Steyaert, Chris,Erd,2007	P68:Radosevich, R,Ijtm,1995
P19:Stewart, Wh,Jbv,1999	P44:Shane, S,Jm,2004	P69:Dimov, Dimo,Etp,2007
P20:Lee, Sy,Rs,2004	P45:Kor, Yy,Jms,2000	P70:Chiles, Todd H.,Ost,2007
P21:Baker, T,Rp,2003	P46:Zahra, Shaker A.,Jm,2007	P71:Baron, Ra,Etp,2004
P22:Zahra, Sa,Jbv,1996	P47:Cardon, Melissa S.,Amr,2009	P72:Smilor, Rw,Jm,1997
P23:Kim, Dj,Os,1996	P48:Van Looy, B,Rp,2006	P73:Samsom, Kj,Tech,1993
P24:Feldman, Mp,Rs,2005	P49:Katila, R,Amj,2005	
P25:Shane, S,Ms,2002	P50:Kor, Yasemin Y.,Jms,2007	

Table 6.2.: The set of 73 most co-cited articles from 1991 and 2013

6. Creativity source journals are underrepresented, which probably means that while entrepreneurship researchers gleaned information from creativity constructs, the opposite did not typically happen.

The shape of the journals' structure varied considerably between that of the 1533 articles with the keywords extracted and that of the 73 articles selected by the co-citation method. An analysis of these differences highlights significant considerations about the scientific contributions that simply exist and those that have had the significant impact simultaneously in entrepreneurship and creativity fields. It should be noted here

N.	PUBLISHING JOURNALS	
1	Journal of Business Venturing	15
2	Entrepreneurship Theory and Practice	6
3	Management Science	6
4	Research Policy	6
5	Strategic Management Journal	6
6	Journal of Management Studies	3
7	Organization Science	3
8	Regional Studies	3
9	Administrative Science Quarterly	2
10	Harvard Business Review	2
11	Industrial and Corporate Change	2
12	Journal of Management	2
13	Strategic Entrepreneurship Journal	2
14	Academy of Management Journal	1
15	Academy of Management Review	1

Table 6.3.: Top 15 publishing journals of 73 most co-cited articles

that Management Decision lost its leadership among journals, and the Harvard Business Review lost its third-place standing, while entrepreneurship- and strategy-focused sources increased their presence. In both classifications, however, the striking absence of journals from the social and psychological fields should be highlighted.

6.2. Multidimensional scaling

The multidimensional scaling analysis consisted of projecting the papers on a two-dimensional map, using the data from the correlation matrix as input data. The values obtained in the statistical analyses that exhibit goodness of fit (STRESS=0.17) and the estimated variance percentage (RSQ=0,85) permit us to state that this representation is a good approximation of reality.

Papers within group boundaries share similar co-citation profiles. Thus, this "relationship" only means that papers address the same broad questions, without necessarily

agreeing with each other in their findings. The proximity of the items within the groups implies a conceptual proximity, as well; however, a joint analysis of the concentration and positioning of groups in the axes was needed and consequently performed.

Results of the analysis are depicted in Fig. 6.2.1, showing the multidimensional scaling map and the groups of papers revealed by the cluster analysis and confirmed by the latent class analysis.

The map shows:

1. The positions of papers with respect to the map's axes;
2. Identifiable paper groups, which represent research topics/lines of research;
3. The location of these groups with respect to each other; and
4. Proximities of papers within groups and across group boundaries ("border papers").

Commentary on each point follows.

The left end of the abscissa axis identifies the theoretical, pre-paradigmatic contributions; moving to the right, the papers acquire a more structured, theoretical focus. In the lower part of the axis of ordinates, contributions focus on the nature and predictors of the entrepreneurship and creativity individually; moving up, the focus shifts to an organizational level, and to the literature more closely addressing the innovation, implementation, and commercialization of the most technologically advanced inventions.

The central part of the map and the lower and upper left are empty, and therefore potentially relevant to the identification and filling of research gaps. In particular, the vacuum in the central area highlights the lack of a series of contributions considered dominant by the citing authors.

The map also shows how some areas are more dense and extended than others. It

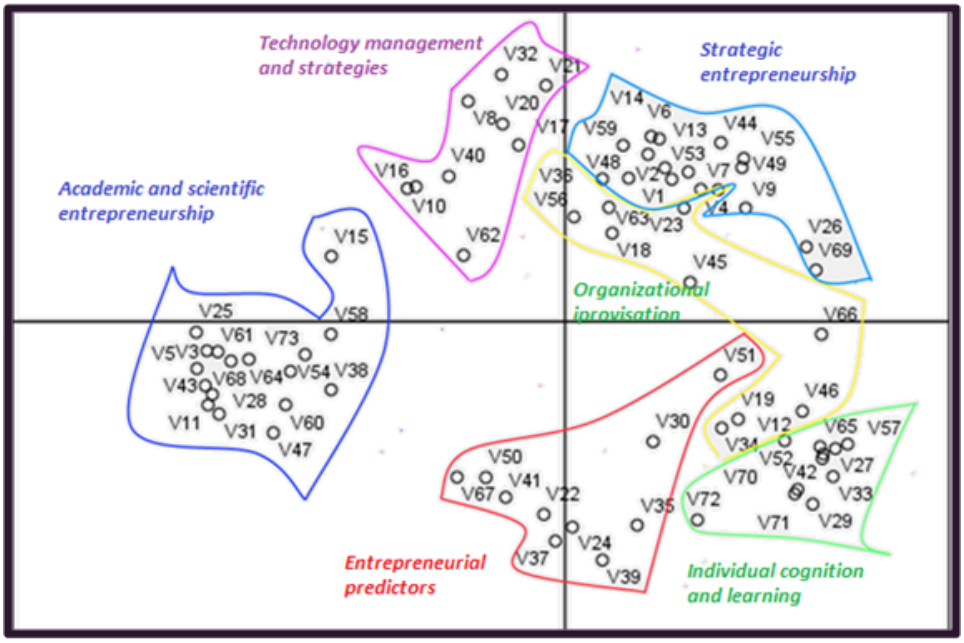


Figure 6.2.1.: Map obtained through multidimensional scaling and cluster analysis

identifies the level of conceptual proximity between and within paper groups. These considerations will be discussed in the following cluster analysis.

6.3. Cluster analysis and Latent class analysis

Six major groups emerged from the analysis.

I describe the groups below, starting from the bottom and moving towards the right (counterclockwise) on the map.

6.3.1. Entrepreneurial predictors group

This cluster is composed of eleven items and is located at the bottom of the map, with two contributions that extend to the center right. The average number of paper citations is 74, with a range of variation of 72 (112 to 40) while the 17-year range of variation

(1992-2009) is the highest among the clusters. The number of theoretical and empirical papers is almost equivalent. The heterogeneity of the sources is mid-level. Five of eleven different journals involved are traditional top entrepreneurship journals, like the Journal of Business Venturing, Regional Studies and Small Business Economics.

The group conceptually analyzes the joint domains of entrepreneurship and creativity through the observation of individual, contextual, and cultural potential predictors and drivers of startup success. From this point of view, authors mainly focus on the entrepreneurial activities required to generate small and medium-sized new ventures, incorporating private actors from across a broad technological spectrum. The entrepreneur is seen as a change agent who is able to disrupt established balances in the name of "creative destruction" (Schumpeter, 1934).

From the individual point of view, entrepreneurs must be innovative, proactive, motivated to enter new businesses, and capable of self-renewal—namely, open to and able to change (Antoncic, 2001). From the perceptual point of view, the entrepreneur must be able to efficiently manage the creative process of generating new ideas, and must identify the entrepreneurial opportunities better than others (Shane and Venkarataman, 2001). Most of the articles in this cluster analyze in-depth the role of culture and context in the generation of new ventures (Mueller, 2001; Nijkamp, 2003; Lee, 2004; Feldman, 2005). How can the culture of individualism or collectivism determine the quantity and quality of innovation produced (Tiessen, 1997)? How do new ventures act as learning and creativity (Zoltan et al., 2009)? Along with a vision of the individual as solely responsible for the entrepreneurial process, hence the careful analysis of individual characteristics, the group also considers exogenous factors, such as social diversity, crucial for success in business. From the organizational point of view, some contributions focus on the phenomenon of "intrapreneurs" (Schöllhammer, 1981, 1982; Burgelman, 1983; 1985; Kanter, 1984; Pinchot, 1985; Irvin and Rule, 1988; McKinney and McKinney, 1989; Guth and Ginsberg, 1990; Zahra, 1991), as opposed to that of the "renegades." Employees of a

company are facing a crossroads, where they can develop their own ideas within the organization or generate a new organization, breaking away from their former comrades.

Shane and Venkataraman (1993) show more championing strategies for "renegades" over "rationals"intrapreneurs in individualistic cultures. The contributions that arise from creativity studies are concentrated primarily on the analysis of the role of entrepreneurs in change and the emergence of innovative clusters, as well as the cultural aspects behind entrepreneurs' success (individualism vs. collectivism). Hamel and Prahalad (1993) argue that the entrepreneur is the one who has an incongruence between ambition and resources possessed, and that this imbalance is the mainspring of his action. However, creativity is once again seen from the point of view of the individual and not as a strategy or as a characteristic of an organization (Howe, 2006; Chesbrough, 2003).

This item is completely sidelined, and it will be faced by contributions in clusters 4 and 6. Specifically, Feldmann (2005) focuses on the processes of generating innovative clusters and on the relationships between individual entrepreneurs, government policies, and local contexts. The author supports that the central role of the entrepreneur is to be a "change agent" through active learning and experimentation in generating dynamics that encourage the process of innovation from the bottom, as opposed to a top-down approach, as in the case of Silicon Valley and Route 28, and thanks to huge investments for the creation of research institutes of excellence (Kargon, 1992; Kenney and Von Burg, 1999). In the third stage of horizontal development, Feldmann states that all components, firms, incubators, and universities are efficient and fully performing. Feldmann's work fits with Markusen's context analysis, tagging sites as "sticky" or "slippery" in their ability to encourage the process of generating technology clusters.

6.3.2. Individual cognition and learning group

Ten papers belong to this cluster, positioned in the lower right corner of the map, very close and related to clusters 1 and 3. The median date of the cluster is 2005, the latest

on the map, with a variation range of 12 years (1997-2009). The number of average citations is the lowest, amounting to 57.3, with a maximum of 88 and a minimum of 38. Theoretical papers make up 90% of the contributions.

This cluster represents the most modern thinking to emerge. It is the most concentrated and high-density cluster, with little extension. These factors imply a strong conceptual proximity between the contributions, also highlighted by the low diversity of sources. In fact, the contributions come mainly from only three journals with a high impact factor: the Journal of Business Venturing, Entrepreneurship Theory and Practice, and the Academy of Management Review. This group focuses on the individual sphere of cognition, mental processes, and learning styles to approach opportunity creation/recognition as a key factor of entrepreneurship (Shane and Venkarataman, 2000). Antecedents and drivers that encourage the generation and identification of successful ideas are described and analyzed in depth. The main studies in this group are strongly linked to the field of psychology, and address the mental mechanisms that underlie creative behaviors related to the nature and dynamics of entrepreneurial learning, mainly in the new venture creation or startup phases. A significant number of authors investigated the relationship between prior knowledge, the generation of new ideas, and opportunities recognition processes from a cognitive point of view.

According Smilor (1997), the entrepreneur is able to generate new ideas, not only thanks to his or her know-how or the social capital of the context in which he or she operates, but also thanks to the creative process of bisociation, defined as the ability to relate two seemingly unrelated things to produce that "ah-ha" sensation in the marketplace (Koestler, 1990). Ward (2004) argues that sometimes prior knowledge facilitate the generation of new ideas, while at other times it has a blocking effect. The author lists and describes three main techniques of thought—recombination, analogy, and initial problem reformulation—showing that the qualitative result of the creative process depends on how one deals with a problem. In short, it is the cognitive approach to creativity, understood

as a series of mental operations, that make the difference between familiar or novel ideas in a continuous rating scale (Sheperd, 2004). Sheperd also accurately describes the relationship between prior knowledge, monetary rewards, and performance in opportunity identification in terms of quantity and innovativeness of outputs. Usually, the greater the prior knowledge is in terms of education, employment, and other means, the greater the opportunities identified. The reason for this is that greater the prior knowledge, the greater the ability to make associations and the greater the absorption capacity (Cohen and Levinthal, 1990). Those with these abilities can process and analyze information better, and seem to think in a more intuitive and focused way, becoming more efficient. Finally, rewards moderate the result. No mention is made of the innovative capabilities of non-experts, understood as people with little prior knowledge in a specific domain (Lackani, 2008).

Another group of researchers in the cluster focuses on the differences in thinking between entrepreneurs and non-entrepreneurs. Baron (2004) describes and aims to investigate entrepreneurial decision-making patterns as heuristic or planned, and the relationship of these patterns with their knowledge structures. Entrepreneurs appear to focus on different information and to reason differently, showing heterogeneous abilities to manage complex processes and link patterns, connecting the dots in order to identify the best opportunities. A number of cognitive measures have been suggested and tested in support of future discoveries, in particular conceptual structures (Mitchell, 2002), priming, and neuropsychological generative tasks and behavioral measures. Gaglio (2004) identifies the processes of mental simulation heuristics and counterfactual thinking as capable and responsible methods for opportunity identification and as responsible for generating the different ways in which entrepreneurs shape and pursue higher market opportunities.

In sum, entrepreneurs have a greater capacity for alertness and opportunity identification because of their way of thinking when they are faced with the unusual. In this case, the activation of their sensemaking occurs thanks to heuristics.

Corbett introduces the element of learning. He focuses on the impact of different learning styles on the idea generation, opportunity identification, and business exploitation phases. Cognitive learning improves the generation of new ideas, while behavioral style improves evaluation phase. Finally, Cardon (2009) analyzes in-depth the role of passion in entrepreneurial dynamics, examining its enhancing effects in a model related to identity construct. The author identifies three types of identities: inventor, founder, and developer. Within the model, he analyzed the roles of these identities and the elements of dysfunction that arise when an entrepreneur with a particular identity (e.g. inventor) takes care of business for another identity (e.g. developer). The relationships between passion and features affected by that passion such as motivation, persistence, creative problem solving, and the ability to learn were also explored within the model.

6.3.3. Organizational improvisation and innovative networks group

This group, positioned like a bridge between groups 2 and 4, occupies a large portion of the second and third quadrants of the map. It contains 11 articles with, on average, 97 individual citations within a variation range of 157 (197-40). The median publication year is 2003, with an interval of 11 years (1996-2007). The papers are divided equally between theoretical and empirical. Seven different academic journals from different areas highlight the high heterogeneity of sources. The density is low while the heterogeneity of sources is high; in fact, seven different academic journals come from different scientific areas.

This group focuses on organizational improvisation, bricolage learning, new venture creation processes, and user entrepreneurship, addressing the common ground between entrepreneurship and creativity from an organizational point of view in an attempt to summarize strategic issues of individuals and firms.

Miner (2001), located in the middle of the strategy articles at the top right of the map, extends prior research by theorizing a relationship between the different types

of improvisation and organizational learning. Essentially, he compares the strategies of unplanned change with those of planned change, focusing on the impacts of creativity and innovation. Baker (2003) analyzes in detail the dynamics of improvisation and bricolage in the processes of the creation of new businesses. His study confirms the existence of improvisation dynamics during firm gestation phases as well as in aspects related to tactics and strategy formulation. Throughout the cluster, the relationship and links between planned and unplanned internal processes of creativity and innovation are very present. Baker (2003) stresses the key role of the network in learning the organizational skills of improvisation. The unplanned organizational behaviors associated with social and cultural ties, both strong and weak, are drivers for organizational innovations (Ruef, 2002). Only by increasing these reports and, especially, such diversities, as well as the heterogeneity of the team (fighting loneliness at work), can the business group fight the urge to conform and improve its creative abilities. The implicit theory here is that weak ties encourage both the opportunity for and the availability of new ideas, and the implementation of these ideas into work routines. Garud (2003) argues that bricolage, improvisation, and adaptation processes contrast with breakthroughs, and shows through a cross case analysis that the first result in better performance.

Sarasvathy (2004) and Zarha (2007) also make a relevant contribution to future research in the field of entrepreneurship. The first adopts the creative method (Getzels and Csikzentmihalyi, 1976) of reformulation of problems for generating new research insights. In particular, Sarasvathy (2004) considers the outdated and useless dichotomy between entrepreneurs and non-entrepreneurs, deeming more important an understanding of the barriers to entry of this phenomenon. In addition, from an organizational perspective, the author reformulates questions about the importance of design firms as a means to express the potential of entrepreneurs. From this perspective, entrepreneurship is regarded as the interface between internal characteristics (psychology and enterprise resources) and external (the life cycle of industrial and technology trajectories). This article is the

natural bridge between clusters 2 and 4.

Zarha (2007) proposes a matrix in which new and established theories can be combined and correlated with known or unknown phenomena resulting in trailblazing. The author generates four dimensions whose highest level of innovation and scientific contribution is represented by the implementation of new theories to unknown empirical cases.

Carter (1996), located near cluster 2, contributes to bridging the role of the entrepreneur and the organizational activities that take place in a new organization. In summary, he is responsible for analyzing in detail the list of activities that are carried out by a large number of "nascent entrepreneurs" in the process of business creation. Such activities mainly include the organization of the team, planning, fundraising, hiring employees, etc. Carter divides new entrepreneurs into three types: startuppers, give up, and still trying.

6.3.4. Dynamic capabilities and strategic entrepreneurship group

The fourth group includes 15 items in the upper right corner of the map in the second quadrant, on the border between the two clusters of organizational improvisation and technology entrepreneurship. The median publication date of the articles is 2003, with a variation range of 15 years (1993-2008), and on average 137 individual citations, with the widest range of variation among all groups at 454. This cluster contains the highest percentage of theoretical contributions (13 out of 15). The heterogeneity of sources is high. There are 10 journals with high-impact factors that contribute to the grouping, mainly on the topic of organization and management. Strategic (the Strategic Management Journal) and organizational (the Journal of Management Studies and Organization Science) journals prevail.

The main contributors to this group analyze strategic entrepreneurship in terms of dynamic capabilities and organizational structures for innovation within Shumpeterian and social cognitive perspectives. They focus on aspects related to the internal firm skills

and creative destruction that promote strategic behavior adaptation and the emergence of radical innovations (Hitt, Ireland, Camp, and Sexton, 2001; Rothaermel, 2001). Most contributions refer to large and multinational companies instead of individual companies or SMEs. Some authors analyze in detail the strategic entrepreneurship construct, primarily theorizing differences and similarities between the strategic management and entrepreneurship fields.

Ireland (2003) observes that the disciplines of entrepreneurship and strategic management are inseparable. Barney and Arikan (2001) suggest that there is a close, though not fully specified, relationship between theories of competitive advantage and theories of creativity and entrepreneurship. Entrepreneurship is defined as the identification and exploitation of previously unexploited opportunities. Entrepreneurial actions entail creating new resources or combining existing ones in new ways to develop and commercialize new products and services for new customers and move into new markets (Ireland et al., 2001; Ireland and Kuratko, 2001; Kuratko, Ireland, and Hornsby, 2001; Sexton and Smilor, 1997; Smith and DeGregorio, 2001). On the other hand, strategic management entails the set of commitments, decisions, and actions designed and executed to produce a competitive advantage and earn above-average returns (Hitt, Ireland, and Hoskisson, 2001). Strategic management calls for choices to be made among competing alternatives (Stopford, 2001). Entrepreneurship is about creation, while strategic management is about how advantage is established and maintained from what is created (Venkataraman and Sarasvathy, 2001). In short, strategic entrepreneurship is the integration of entrepreneurial opportunity-seeking behavior and strategic advantage-seeking perspectives in developing and taking actions designed to create wealth.

As part of the analysis of internal resources, contributions that focus on dynamic capabilities emerge. Zahra (2006) analyzes the difference between dynamic capabilities and substantive capabilities. How do dynamic capabilities come into existence? What is the role of the firm's entrepreneurial and learning processes in creating and sustaining

these capabilities? How do new ventures and established companies vary in their dynamic capabilities and what are the important consequences of these differences? Authors, after describing the dynamic capabilities such as skills, processes, procedures, structures, and rules that improve sensing, seizing, and reconfiguring, focus on the need to orchestrate these skills, and especially on their uniqueness as a source of competitive advantage. In addition, the focus on multinational companies justifies this group's placement in the top right sector of the map. This group lacks the cognitive aspect of group knowledge and analysis (mental maps of companies). Finally, the opportunity recognition construct is transposed to a firm level.

6.3.5. Scientific entrepreneurship and technology transfer group

The fifth group, meanly extended in the space but extremely detached from the others and situated on the left part of the map, includes 17 items. The average number of citations is 91, with a maximum of 268 and a minimum of 38. The median variation is 15 years. There are only three theoretical contributions. The group is characterized by the high number of empirical contributions that use mainly quantitative regression models (11) and case studies (3). Prevalent academic sources come from management journals (the Journal of Management and Management Science), innovation journals (Research Policy and Technovation) and entrepreneurship (the Journal of Business Venturing). No creativity-focused journals appeared within this group.

This group analyzes innovation actors such as inventors, researchers, and universities, and their roles. The articles show up at a high density, but present an evident tendency toward insulation on the left part of the map. This represents a high level of conceptual distance from all other clusters with the exception of the sixth. This positioning, and the consequent low commingling with other group contributions, opens interesting scenarios for future research.

Bercovitz (2008) represents a theoretical point of departure for analyzing the relevant

academic entrepreneurship in terms of organizational change, understood as the pursuit of new strategic initiatives and essential to organizational survival (Van de Ven, 1986). In fact, the author does not opt for the university context at random; the choice depends precisely on the institutionalization and, consequently, its resistance to change (Meyer and Rowan, 1977; Di Maggio and Powell, 1983). The transition from mertorian norms to marketing opportunities is critical. It is not enough to create formal structures for technology transfer without a change on the individual level and intraorganizational acceptance of new standards of academic entrepreneurship. The study analyzes the behavior of individuals to understand the links between intraorganizational dynamics and organizational change, and concludes that the work environment plays a key role. Harmon (1997) highlights two different technology transfer processes. The first is formally linear from idea generation to patenting, and the other mainly horizontal and characterized by informal networked arrangements. Radosevich (1995) categorizes "inventor-entrepreneurs," those who are directly involved in the development and commercialization of new technologies, and "surrogate-entrepreneurs," those who take over the marketing stage. Samson (1993) focuses on potential conflicts between inventors (who often lack managerial skills), universities, and private companies.

Two other contributions relate the nature of the invention (radicality, importance, and patent scope) to the importance of actors such as venture capitalists (Shane and Stuart, 2002), or to determining which type of new business is more efficient, startups or established businesses (Shane, 2001). Finally, many contributions highlight the exponential growth of the contributions of academia in the development of its third entrepreneurial mission in terms of quantity as well as disclosures of patenting and licensing (Thursby, 2002), and correlate these with the academic performance of firms that grow to grow of appropriability (intellectual property rights).

6.3.6. Technology strategies and innovation management group

The sixth group, situated in the highest part of the map between the first and second quadrant, on the border between the two clusters of academic entrepreneurship and strategic management, includes nine items. The median publication date of the articles is 2002, with a variation range of 12 years (1995-2007) and 148 single citations (192-44). The cluster also contains the highest percentage of contributions that adopt quantitative methods (66%), mainly linear regression. It has a medium density and the articles in the cluster are characterized by a high degree of homogeneity. This implies a high level of maturity and the potential to reach a "dead end" in the medium to long term. The Strategic Management Journal and commercialization- and technology entrepreneurship-related journals are the most relevant sources.

This group focuses on innovation and technology management with constant attention paid to the competitive dynamics of new entrants and incumbents. Seven articles analyze the strategic issues between new entrants and incumbent firms. Zahra (1996) addresses the issue by defining two actors in the innovation process—independent new ventures and new corporate ventures (spinoffs)—and identifies seven technological choices that determine the strategies of firms. In some cases, there is a strong focus on issues related to appropriability (Gans, 2002, 2003), understood as a driver of business decisions and marketing employees (Anton, 1996; Helmann, 2007) and independent contractors (Rothaermel, 2001; Gans, 2003), or on the importance of complementary assets (Gans, 2003).

6.4. Pathfinder analysis

A Pathfinder algorithm, following a social network approach, was run for measuring and analyzing degree and betweenness centralities (Schvaneveldt et al., 1988, 1989), and, consequently, relationship and ties between 73 nodes or articles exploited from the web

of a science database. This method added useful information to the multidimensional scaling and clustering techniques traditionally adopted for co-citation analysis (Nerur, 2008; Di Stefano et al. 2012; Acedo et al., 2006; Gregoire et al., 2006; Ramos and Rodriguez, 2004).

First, a deep understanding about group structure emerged.

Second, the node links and positioning analysis provided a better understanding about bridge concepts not immediately evident upon previous application of multivariate statistics.

Third, it enabled the analysis of papers in term of hubs, bridges, and peripheral nature. Regarding the latter, each node could be evaluated as a trailblazing, forgotten, or dead-end node. Furthermore, Pathfinder analysis showed two kinds of thought evolutions in the literature: consequential and branched. The ramification level highlighted cognitive field maps useful for understanding future research directions and potential impacts. The method made it possible to conduct in-depth evaluation of group and subgroups relations.

Finally, a triangulation of methods highlighted significant differences, but also allowed us to reinforce beliefs about substantive analogies made with previous multivariate results.

The Pathfinder analysis showed 73 nodes split up on five scientific macro areas, one displaced in the central position, another extending on the lower right side, two positioned upwards, and the last one positioned on the left and bottom left side of the network map (Fig.6.4.1). The right and left groups present the highest levels of ramification. There are 17 hub or crossroads nodes, 4 "bridge" nodes (nodes that link two hubs), 15 "middle" nodes represented by articles of passage between one node and another, and, finally, 37 peripheral nodes (Tab. 6.4). Counter-intuitively, the central papers and hubs are not theoretical, and not necessarily older than the peripheral ones—and the latter are not, as expected, mainly empirical. Theoretical and empirical nodes are, in fact, equally distributed on the map.

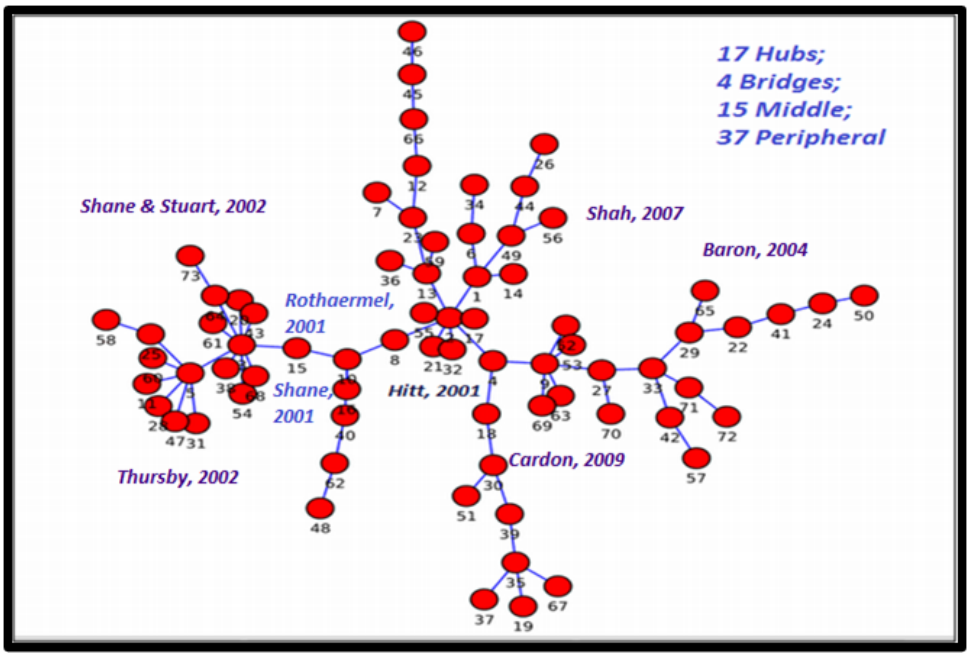


Figure 6.4.1.: Map obtained through Pathfinder analysis

Pathfinder	N.	Median age	SD	Theoretical	Median age	Empirical	Median age
Nodes	73	2003	4,2	36	2004	37	2003
Hubs	17	2003	2,7	11	2003	6	2001
Bridge	4	2001	2	2	1999	2	2001
Middle	15	2004	4,9	7	2004	8	2003
Peripheral	37	2004	4,8	17	2004	20	2003

Table 6.4.: Pathfinder descriptive statistics

The date of publication of the articles and its variance are, however, discriminating. The standard deviation of peripheral papers is significantly higher than that of the central and hub contributions.

The structural difference with the previous statistical analyses emerges in terms of numerosity and group positioning. The items that belonged to the strategic cluster decreased in numerosity, while those that were part of the entrepreneurial cognition and entrepreneurial drivers groups are joined in a novel group named "entrepreneurial behavior."

Previous organizational improvisation contributions show inconspicuous variations. Fi-

nally, the new group of "scientific entrepreneurship" unifies the previous groups of academic and technology entrepreneurship (Tab. 6.5). Some significant "fish out of water" emerged.

The entrepreneurial behavior group, that stemmed from Hitt (2001) node, and in which seven hubs opened new potential frontiers through 13 peripheral papers, is the most ramified.

The scientific entrepreneurship group's numerosity is similar, while its structure is concentrated on three main hubs with 14 peripheral nodes. The upward groups count only four hubs and eight peripheral nodes together. Four are main bridges; two are fundamental bridges that link large numbers of papers and "bridge" key knowledge—Rothaermel (2001) linking the center to the left technological part and Shane (2001) crossing that knowledge towards the academic entrepreneurship domain. The other two bridges are minor, and link entrepreneurial antecedents articles on the lower part of the map. Middle and peripheral articles are prevalent in entrepreneurial behavior and scientific entrepreneurship groups.

N.	Denomination	Branch level	Previous cluster	Nodes	Hubs	Bridge	Middle	Peripheral	Med.
1	Centre	Low	4 e 6	5	3	0	0	2	2001
2	Entrepreneurial behaviour	High	1 e 2	27	7	2	5	13	2004
3	Capabilities microfoundations	Low	4	8	2	0	2	4	2005
4	Organizational improvisation	Low	3	9	2	0	3	4	2003
5	Scientific entrepreneurship	High	5 e 6	24	3	2	5	14	2003
				73	17	4	15	37	2003

Table 6.5.: Pathfinder macro-groups statistics

Finally, the median date of publication for groups highlights that the center position averages earlier dates than the peripheral, with dates up to 2004 for groups two and

three.

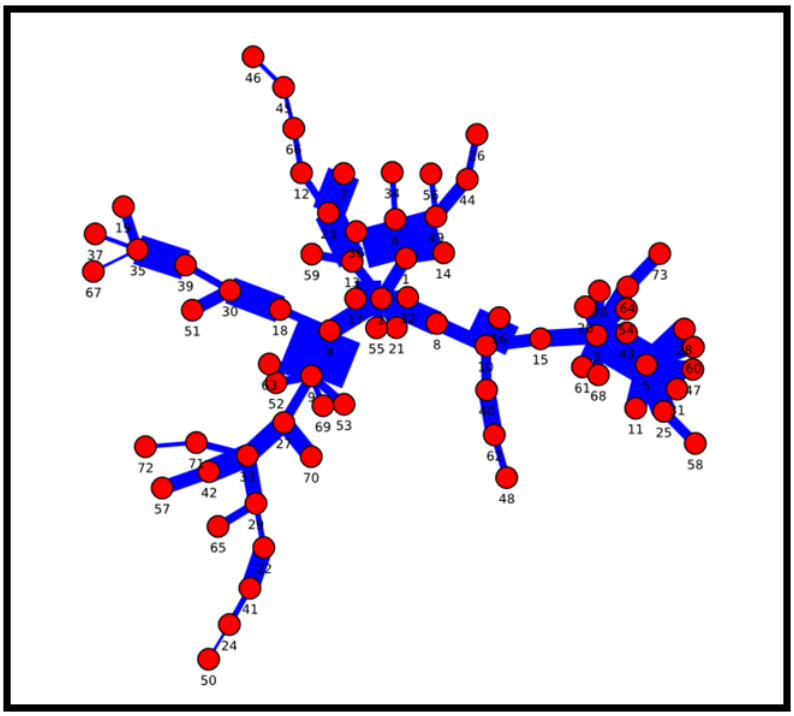


Figure 6.4.2.: Map obtained through weighted Pathfinder analysis

Analyzing the weighted map (Fig. 6.4.2) reveals that some groups are characterized by greater density or more degree linkages, like the heart of the map, as well as the Ireland "island," the cognition group, and the bunching around Ravasi and Gaglio. Regional studies papers are characterized with a relatively low-weight linkage. The very strong relating nodes dealing with dynamic capabilities are evident on the upper right, while on the left two subgroups emerge: improvisation and theoretical entrepreneurship.

6.4.1. The central structure

The central group is composed of five nodes, three of which are hubs and two of which are peripheral, with a 2001 median publication date. Ahuja, Morris, and Lampert (2001),

the most central node on the map, analyze breakthrough innovations from the strategic point of view of large, established firms. Mosakowski (1998) is the bridge between individual and team entrepreneurial resources and the knowledge management domain, and finally Fleming (2004) focuses on the relationship between science, innovation, and research, intended as a recombinational process. As expected, three contributions at the heart of the Pathfinder map possess seminal key concepts as noted with cluster and MDS analysis, such as technology entrepreneurship, strategy, scientific entrepreneurship, and individual and team resources. Kim (1996) and Dushnitzky (2005) stem from Ahuja, and are very central, representing an endeavor within scientific entrepreneurship to evaluate and consider intellectual property and patent nature the responsibility of innovation strategies. They have not yet been followed by other contributions, and for this reason represent a potential for future research highlighted by a Pathfinder algorithm.

6.4.2. The right structure

The groups on the right are divided into five subgroups and composed of 27 nodes, 7 hubs, 2 bridges, and 13 peripheral nodes. The median publication date is 2004 (Tab 6.6). Pathfinder analysis clearly shows that Hitt's (2001) guest editor special issue presenting contributions on the strategic entrepreneurship construct is a crucial hub between two main developments of ramified knowledge. It seems that this article represents the source both of entrepreneurial cognition and of antecedents dealing with aspects of creativity.

Sub-group	Branch level	Nodes	Hubs	Bridge	Middle	Peripheral	Med.
2.1	Low	9	3	2	0	4	1998
2.2	Medium	5	1	0	0	4	2007
2.3	Low	2	1	0	0	1	2006
2.4	Low	5	1	0	2	2	2004
2.5	Low	6	1	0	3	2	2004
Subtotal		27	7	2	5	13	2004

Table 6.6.: Pathfinder sub-group 2 statistics

Subgroup 2.1

On the right side of the group (downwards on the map), an "ancient" group emerges, with a median publication date of 1998, composed of eight nodes (two hubs, two bridges, and four peripheral) with a low ramification level. Authors in this subgroup focus mainly on intrapreneurship, entrepreneurial context, education, and innovation culture constructs. Antoncic (2001) is a bridge node and engages intrapreneurship to create a model within four dimensions: new business venturing, innovativeness, self-renewal (strategy reformulation, reorganization, and organizational change), and proactiveness. Intrapreneurship is evaluated within firm context and performances. Knight (1997) focuses on an entrepreneurial scale validation called "entrescale" for cross-cultural studies, preceded by Jones (1992), the oldest map node, dealing again with intrapreneurship, but from a deeper creativity- and innovation-based point of view. Tiessen (1997) acts as the bridge linking individual entrepreneurial drivers to cultural influences. Mueller (2001) is a hub for three peripheral nodes that follow, and deep entrepreneurial culture-drivers. The author focuses on individualist and collectivist cultures, with an entrepreneurial orientation and innovativeness constructs. He correlates certain characteristics or individual traits, such as locus of control and innovativeness of entrepreneurs, with cultural aspects such as individualism and collectivism, entrepreneurial orientation, and uncertainty avoidance. At first glance, Stewart (1999) looks like a "fish out of water" in this group, as he analyzes the relationships and differences between entrepreneurs, small business owners, and managers based on three main variables: achievement motivation, risk-taking propensity, and preference for innovation. The latter in particular represents the contribution of creativity studies to the topic of entrepreneurship and justifies the presence of the node in this group. In essence, it is the high level of creativity and, within this, the different styles of creativity and innovation that discriminate against entrepreneurs from other subjects. Lipparini (2003) offers an analysis of the entrepreneurial

capability to link external ties to improve creativity and innovation in SMEs, focusing on the consequential competitive advantage. An entrepreneur is an "orchestrator" of inter-firm linkages, relying on personal networks and prior relationships, and is able to identify possible sources of knowledge and reduce uncertainty. Finally, Gibb (2002) presents a trailblazing contribution focusing on the importance of entrepreneurship education for European and global development. The distinctive feature of this work is its proposal of an entrepreneurial formation for all sectors of social life, not necessarily focused on business. Moving from Hitt (2001) to the left instead of sequentially leads to the other 4 subgroups.

Subgroup 2.2

The Ireland hub group is composed of five nodes, four of which are peripheral and hold a very recent 2007 median publication date. Ireland (2003) blazes the trail towards individual cognition and technology entrepreneurship contributions. Four recent papers departing from this one are, respectively, Cardon (2009), previously assigned to the individual cognition group; and three "strategic" and, in this case, "fish out of water" papers such as Katila (2005), Chiles (2007), and Agarwal (2007). In all cases I can hazard the hypothesis that these contributions represent trailblazing articles. Cardon, in fact, published very recently and analyzes the role of a very innovative factor in entrepreneurship research, that of "passion" from a creative point of view. Furthermore, Chiles, following Burt (1992), who in a discussion of structural holes within the network says, "People who stand near the holes in social structure are at risk of having good ideas," tries to overtake Shumpeterian and Kirznerian approaches to entrepreneurship in order to better understand the potentialities of the creation and exploitation of opportunities through human imagination and resource combination and recombination. Agarwal focused on the dynamic of new entrants and incumbents forging constructs of "creative construction," overtaking the classical Shumpeterian vision analyzing the role

of knowledge spillover as a key mechanism that affects new venture formation.

Subgroup 2.3

Moving again to the deep part of the entrepreneurial behavior macrogroup, I encounter the Sheperd subgroup, formed by two only nodes. Opportunity identification is the central topic of these nodes. In fact, Sheperd and Dimov, previously part of cluster two, deal with the effects of prior knowledge on the identification of opportunities in terms of innovativeness and quantitative impact, but also in terms of highlighting the process nature of opportunity identification instead of the single insight perspective. Along the right on the Pathfinder map, Corbett (2005) represents the hub from which three branches depart, two veering to the right and the third opening new frontiers on the left. The first group, composed of four papers, influences creativity and entrepreneurship literature in terms of the impact of organizational learning processes on strategic renewal and opportunity recognition (Lumpkin, 2005), cognitive and mental processes (Gaglio, 2004), and the path from idea generation to the commercialization process (Ravasi and Turati, 2005). A probable dead end is represented by Smilor (1997), an article too ancient and too little cited to be evaluated differently.

Subgroup 2.4 - 2.5

The right side, derived from Corbett, contains six papers. Ward and Baron correspond to the expected cognition perspective of creativity and entrepreneurship. A conceptual line seems to exist from Sheperd to Baron, who constitute the cognitivist and psychological points of view. Baron, examining the mental processes that foster or inhibit idea generation, represents the key conjunction with regional studies articles, on the right side, which deal with entrepreneurial-specific issues of focused territories.

6.4.3. The upward structure: capabilities microfoundations group

In the upper part of the map, there are two groups: on the right side, strategic papers, and on the left, the organizational improvisation "cluster." In both cases, the level of ramification is very low. The capabilities microfoundations group consists of eight nodes, of which two are hubs, two are middle, and four peripheral. Organizational improvisation, on the other hand, is composed of nine nodes: two hubs, three middle, and four peripheral. Despite the similarity of structure, the median publication date of the strategic group is later, and dates reach 2005, while the left group stops at 2003. This group is mainly composed of articles dealing with dynamic capabilities and knowledge as antecedents of firm strategic success. In this group, all contributions are theoretical. The main bunch is composed of four nodes from Teece (2007), to Kor (2007; 2000), and finally to Witt (1998). In these articles, it is possible to observe a significant link between entrepreneurship and strategic theories in order to translate opportunity identification processes and capabilities from the individual level to the firm level. Teece (2007) accurately describes what kinds of creative skills, processes, procedures, structures, and rules improve enterprise (not individual) sensing, seizing, and reconfiguring. He also focuses on the relevance of "orchestrating" these skills, processes, etc. in order to become unique—not copable—and obtain a competitive advantage. In this group, the conception of the subjectivity of entrepreneurial creation is very strong. Building on Penrose (1959), Kor (2007) focuses on the links between entrepreneurial creativity, intuition, and entrepreneurial knowledge. Within a subjective, resource-based approach, it is clear that entrepreneurial intuition and imagination must precede the firm or product-development decisions (Penrose, 1959, p. 34). Individual and firm creativity is the key point, and this perspective differs from a neo-Schumpeterian evolutionary approach in which companies focus on business procedures and routines. Entrepreneurial heuristics are also influenced by experience and knowledge, explicated and tacit (Spender, 1989;

Tsoukas, 1996; Nonaka, 2005; Zander, 2007), and depend on inter-divisional spillovers (Audretsch and Keilbach, 2007) as well as interactions with customers, technologies, and other stakeholders. In short, the firm is seen as a repository of specific knowledge and unique capabilities and competencies responsible for the creation and recognition of very different opportunities (as happened in the context of individual entrepreneurs). In this group has not yet considered a cognitive approach to firm mental processes, but this consideration will probably come. Finally, this group tries to integrate entrepreneurship and strategic management research literature in a subjective and competencies-centric point of view. There are four peripheral branches. The first, right one is Magretta (2002), one of two managerial papers appearing on the map, and representing the only one paper contributing to business model literature. The author tries, in a very managerial manner, to establishe the theoretical difference between business model and strategy. Another very interesting peripheral is Shah (2007), who describes a trailblazing concept of user entrepreneurship, building on Enos (1962), Knight (1963), Freeman (1968), von Hippel (1988), Kline and Pinch (1996), Franz (2005), and Luthje, Herstatt, and von Hippel (2005). Vice versa on the left side: departing from Teece, Zarha tries to better explicate the nature of dynamic capabilities, showing the differences between them and the substantives ones. The latter are simply more pragmatic and related to the operative abilities of the firm, while dynamic capabilities are more general and strongly tied to learning and organizational knowledge.

6.4.4. The upward structure: organizational improvisation group

This group has a quite linear structure, and therefore is conceptually subdivided into two main groups. The first one is composed of the first five ramified nodes, and the other, more linear, one, growing upward, has four elements. The Pathfinder analysis distinguishes improvisation-focused papers, entrepreneurial predictors groups, and a theoretical contributions group. In fact, the articles in this group do not fit perfectly as

an "organizational improvisation and innovative networks cluster," and node links give relevant new insights. Davis (2009) appears from cluster 4, while the other three moved respectively to the lower left group, Stewart, or to the top right, Autio and Shah. Miner (2001) and Baker (2003), focused on organizational improvisation and learning, are the central articles in this neighborhood. Both authors underline the crucial role of unplanned change and behavior in the new firm creation process and organizational learning. Miner gives an explanation about the differences between improvisation, creativity, and innovation, while Baker examines improvisation and strategic links through social network ties. The three peripheral nodes analyze, each from a different point of view, the relevance of the organizational structure (Davis, 2009), the context or network ties, diversity, and innovation performance (Garud, 2003; Ruef, 2002). Davis analyzes the relationships between the organizational structure, performance, and the moderated role of the environment within organizational studies, in which loose coupling, ambidexterity, and improvisation are key, along with creativity (Amabile, 1996), innovation (Davis, 2009), group problem solving (Bigley and Roberts, 2001; Okhuysen and Eisenhardt, 2002), organizational change (Tushman and O'Reilly, 1996; Gilbert, 2005), and organizational learning (Tripsas, 1997; Hansen, 1999). Ruef and Garud's contribution highlights the relevance of cultural and social ties for organizational innovation, often against breakthrough management behavior. Carter (1996) constitutes a starting point of improvisation vs. planned activities. The author tries to establish a series of activities for a startup firm, mixing individual and organizational tasks. The last three articles offer theoretical contributions to the entrepreneurship domain by reformulating the usual problems (Sarasvathy), exploring new scenarios (Zahra), and offering the unique entrepreneurship literature review. This last group is important for understanding new methods for facing long-standing problems.

6.4.5. The lower left structure

In the left-hand part of the map, it is possible to observe two macro-groups. The first one, in the lower part, is composed of five nodes, of which one is a hub, three middle, and one peripheral. It has a very linear development, and a median publication date lower than other two subgroups. On the left, passing through Gans and Stern (2003), it is possible to highlight two other, very ramified, subgroups. The first one, departing from Shane, is composed of 10 nodes, of which only one is hub, one bridge, one middle, and seven peripheral. The other subgroup, stemming from Thursby (2002), has eight nodes: one hub, one middle, and six peripheral, with a median publication date of 2004, more recent than the others. Two contributions are bridges from the center towards the scientific and technology entrepreneurship papers: Rothaermel (2001) and Gans (2003). The former is the stargate of the left-hand groups. The author is evidently considering the crossroads between technology and academic entrepreneurship, and works within a strategic perspective of exploitation and exploration strategies, opening the way to new entrants vs. incumbents studies, interfirm cooperation, innovation strategies, new product development and commercialization, and exploitation vs. exploration concepts and strategies (Tab. 6.7).

Sub-group	Branch level	Nodes	Hubs	Bridge	Middle	Peripheral	Med.
5.1	Low	6	1	1	3	1	2002
5.2	High	10	1	1	1	7	2003
5.3	High	8	1	0	1	6	2004
Subtotal		24	3	2	5	14	2003

Table 6.7.: Pathfinder sub-group 5 statistics

Sub group 5.1

This subgroup analyzes the dynamics between new entrants and incumbents from a strategic point of view, and above all in cases where the new "inventor" is a dependent.

Gans creates a framework to manage and choose strategies that fit depending of the kind of innovation, the complementary assets, and the appropriability of the idea, considering also in which cases it is better to contract or not. Gans (2002) also offers the first considerations of innovation sources, alliances, acquisition, and internal generation. Bhide and Anton develop a strategic plan for employees who are among the 71% of entrepreneurs. Finally, Helmann, in a similar vein, proposes four types of equilibriums in which employees could decide to develop their inventions internally or external. Shane (2001) is the natural bridge between the subgroups. Previous research has focused on new venture formation in the context of startups vs. incumbents, focusing on inventors and academic researchers, and usually dealing with high technology startups. Past literature proposed three categories of factors that influence the decision to exploit an invention through firm creation: the nature of the individual making the decision (Roberts, 1991), the nature of the industry in which the opportunity would be exploited (Audretsch, 1995), and the nature of the opportunity itself (Henderson, 1993). To date, however, researchers have not directly examined the effects of the attributes of new technologies themselves on firm formation.

Sub group 5.2 - 5.3

This subgroup circles around Shane and Stuart's 2002 work, and it is absolutely not linear or consequential. Using inventions and patent data, these authors highlight social capital ties, venture capitalist support, and founder experience as drivers of technological companies' success, while Thursby (2002) focuses on academic entrepreneurship and, primarily, on disclosures, patents, and licensing. Based on the consequent productivity analysis of faculties, commercial use of university research has historically been viewed in terms of spillovers. The Pathfinder analysis helped to identify these two contributions as crucial nodes and all other as peripheral. In this vein, it would be redundant to explicate any further papers.

7. Conclusion and limitations

This study increases scholarly awareness by detecting and visualizing the intellectual structure of the common ground shared by literature on entrepreneurship and creativity, and by identifying the connected schools of thought, methods, constructs, and theories to problematize, or literature gaps to be filled. It also reveals the network structure—the central, bridge and peripheral nodes—and hypothesizes latent trailblazing trends, sidings, or forgotten contributions. The study tries to contribute a joint glance towards an unexplored scientific territory in which, it seems, there are vast spaces to discover. The research highlighted how creativity contributed significantly to the development of entrepreneurship studies, while the opposite has not happened. The arts and humanities seem the be, at present, an island, which could probably offer relevant contributions in the future of the field of entrepreneurship. Various subfields of entrepreneurship receive contributions both at the individual and organizational level. Moreover, the main contributions of creativity have been observed through cognition, knowledge, and learning studies, which open the way to interesting future research on entrepreneurial creativity constructs. Furthermore, the keyword generation process offered a methodological contribution that in future research will be improved with a more extensive co-word analysis able to identify latent semantic factors and probably able to better isolate idea generation phases from implementation contributions. The multivariate analysis showed three gaps in the center and on the left upper and lower parts of the MDS map. There is not yet a unified group of creativity-centered contributions to entrepreneurship studies, and cog-

nitive and individual studies have not yet been considered by academic and technology entrepreneurship researchers.

Finally, I discuss some limitations. Although quite rigorous, a co-citation analysis is subject to some limitations that can bias the results of the research if not properly addressed, namely homogeneity, immediacy, and stability (Brown and Gardner, 1985; Pierce, 1990; Amabile et al., 1994) Homogeneity refers to the fact that each research field has its own peculiarities, so that the criteria for the selection of papers for co-citation analysis have to be targeted to the field. Immediacy regards the conservative nature of the analysis, which is based on the accumulation of a sufficient number of citations for a paper to be included in the study. Instability regards the unavoidable fluctuations in research analysis over time.

Part II.

"The Cognitive Lens on Innovation Studies: a Bibliometric Approach"

8. Abstract

This study contributes to the ongoing debate to better understand the relationship between innovation and organizational cognitive structures and processes. Using bibliometric co-citation techniques and explorative multivariate analysis—such as cluster analysis, multidimensional scaling, and factor analysis—I map the joint intellectual structure through the most relevant articles that simultaneously deal with two topics. The study highlights three types of findings: The first shows the different nature of individual, organizational, and strategic cognition contributions to innovation; the second visually reports the literature gaps, the potential blind alleys or forgotten trailblazers and the future trends; and the third reveals the latent relationships among groups and subgroups in terms of theories, constructs, methods, and schools of thought. Data from 834 of the most influential articles and then afterwards filtered to 55 major co-cited items were collected from Social Science Citation Index (SSCI) for the 1991-2013 period. Contribution is positioned on innovation, organization, and strategy studies.

9. Introduction

In times when technology constantly unfolds new business opportunities, firms need to keep up with the pace by defining the most fruitful strategies to gain competitive advantages over their competitors. More and more often, in order to avoid the time-consuming, path-dependent, and uncertain processes of internally accumulating capabilities for producing streams of innovation, many companies have adopted heterogeneous cognitive frames and strategies (Abrahamson and Hambrick, 1997; Eggers and Kaplan, 2009). Inter-firm team and individual cognition and cooperation specifically aimed at technological learning and new knowledge creation, which represent one category of such strategic choices, have proven to be particularly successful and have therefore grown rapidly since the mid 1980s (Hagedoorn, 1993; Duysters & De Man, 2003). Likewise, the interest of scholars from the management and business fields also increased, leading to the extraordinary growth in the number of research publications on cognition-related innovation processes seen in the last two decades.

This impressive body of knowledge spanning the many facets of each contributing discipline has seldom been analyzed, while often, only the dominant field-related perspectives are considered to build on further knowledge. While research depends on the flow of information through the publications of people working in a specific field, knowledge can be substantially enriched by the scattered, inter-disciplinary, and sometimes contradictory contributions that have explicitly or implicitly studied related issues.

Thus, there is a need to rationalize the literature in the effort to unveil hidden patterns

and possible disregarded points of view. By studying the intellectual structure of the innovation-related cognition field, insights should be available concerning the status of cognition and innovation theory, the cross-disciplinary nature of the area of study, the identification of emerging trends, and the effects of cognition on firms' technological performance.

In order to assess the state of development of cognition theory, many qualitative attempts have been made (Narayanan et al., 2010). Another approach is to quantitatively examine the large body of academic literature available, searching for the most relevant publications and citations in the fields and evaluating their evolving research utility by identifying and illustrating the major knowledge groups in the field and the general relationships between them.

In this paper, I focus on those contributions to the cognition and innovation literature that have been recognized as being the most influential in the management and business domains. I use co-citation analysis to trace the linkages among them; search for broad research fronts or subfields; and determine the relationships, if any, among the subfields. By reviewing these contributions, I propose a state of the art that might guide future research in the broader field of cognition and innovation.

The paper starts with a brief review of the bibliometric methodology employed here. I then describe and justify our data source for the study. Next, I present the results of the analysis and describe the intellectual structure of the field. Last, I offer our conclusions, discuss the limitations of the study, identify implications for research and practice, and recommend avenues for future research.

10. Methodology

10.1. Bibliometrics

This work explores the structure of the cognition and innovation research field to better understand its origins, current state of development, and future trends. In order to meet these goals, I based our literature review on co-citation analysis, which is based on a count of the number of times two documents or authors are cited jointly in the same work (Small, 1974). This is a bibliometric technique used to analyze publication patterns in a field or body of literature. By using statistical techniques, co-citation analysis makes it possible to map research on a topic and to identify the dominant approaches in the field, thus shedding light on social structures and uncovering the "vast interpersonal network that screens new ideas in terms of central theme or paradigm, permitting some a wide audience and consigning many to oblivion" (Crane, 1972). Leydesdorff and Vaughan (2006) discuss the information I can obtain through co-citation analysis, where they speak of publications as texts: "Co-citation data can be considered as such linkage data among texts, while cited references are variables attributed to texts. [...] one should realize that network data are different from attributes as data. From a network perspective, for example, one may wish to focus on how the network develops structurally over time." Identifying co-citations can tell us, through factor analysis for example, what the major factors and groups are within the field and how they vary across journals and over time.

I can also graphically illustrate what the most influential citations are for each of the

factors, how they are related, how strong their relationships are, and how far removed from or central to the factor groups they are—in other words, the relationships inherent in the intellectual structure of the field. Co-citation studies can show us what topics, authors, journals, and research methods were central and peripheral to the field and how they may have changed over time.

In co-citation analysis, the data compiled are counts of the number of times two documents are jointly cited in later publications. Thus, cited references for a paper A would include any scholarly publication appearing in any journal that cites the paper A. Each cited reference has a unique identifier that forms the basis for getting the co-citations between a pair of papers. A co-citation occurs between two papers, say A and B, when a cited reference to paper A (which could have been published in any journal) also cites paper B. That is, the number of cited references of A that match the cited references of B gives the frequency of co-citations between A and B. The basic premise behind this approach is that the scholarly contributions that are frequently co-cited are likely to embody similar or related concepts. The fact of having been cited together in the same paper establishes a quantifiable link between the earlier papers, the strength of the link depending upon the number of times that a pair of documents are cited together. Therefore, the frequency of co-citation is a measure of the proximity between papers. The structure, and consequently the meaning, of a co-citation graph is strongly influenced by operational uncertainties associated with two fundamental assumptions. First, it is assumed that "highly" cited papers represent "important" concepts and methods in science. Second, it is assumed that "frequently" co-cited papers are related by content. A graphic representation of which published works tend to be cited together by researchers helps identify research streams and other clusters of scholarly work. Studies focusing on cited works try to establish the general structure of the discipline (what types of works are dominant), as well as the discipline's boundaries and relations to other disciplines. Our analysis, following the method prescriptions (McCain, 1990), comprises six steps:

(1) selecting the unit of analysis, (2) retrieving co-citation frequencies, (3) compiling the raw co-citation matrix, (4) converting the raw co-citation matrix into a correlation matrix, (5) multivariate analysis, and (6) interpreting the findings. The unit of analysis can be defined in terms of articles or authors, depending on whether the analysis aims to identify the structure of specific or broad fields of inquiry (White and Griffith, 1981; Culnan, 1986). In particular, for the studies targeted at specific research areas (as in our case), it is preferable to analyze articles so that the results will not be biased by the fact that the same author may have published in different fields (Acedo, Barroso, and Galan, 2006). In our case, this method makes it possible to identify the connections between the most influential contributions regarding the relationship between cognition and cooperation literature and innovation theory in order to systematize them in a model, thus overcoming the fragmentation and specialization of the different research streams and providing indications for future research. I based the analysis on the Social Science Citation Index (SSCI) of Thomson-ISI, available on the on-line database and consistent with the aim of our analysis. This database, which covers over 1,700 of the world's leading scholarly social sciences journals in more than 50 disciplines, provides access to bibliographic information, author abstracts, and cited references. Given the aim of our analysis, I defined a criterion to search for papers. I used the time period 1991–2013. The 23-year period represents a significant slice of time that witnessed the growth and maturity phases of research in cognition and innovation. The criterion adopted crossed two subsets of key words; this ensured that the retrieved articles would refer to at least one of the key words for each subset.

The first subset limited the search to the field of cognition with the words "cognition/cognitions." The second subset limited the search to the innovation field, with the words "innovation," "R&D," and "high technology." The search was performed by selecting the papers whose title, abstract, and keywords matched our criteria and that were present in both the subsets. By screening the Thomson-ISI SSCI database according

to the above search criteria, I selected only journal articles (excluding proceedings or working papers) in the fields of business and management, and I obtained a set of 249 contributions. Given our interest in defining the hard core of the discipline, I selected only the most cited papers. (Acedo, Barroso, and Galan, 2006). Coherent with other bibliometric studies(Culnan, 1986; Rowlands, 1999), the selection was set at 50 citations for papers issued between 1980 and 2004, 40 citations for articles published in 2005, 30 citations for articles published in 2006, 20 for articles published in 2007, and 10 citations after 2007. This resulted in a total of 61 papers. This procedure's main drawback is the use of a relevance criterion that favors older documents to the detriment of more recent ones that might have had a greater impact on the theory. This entails a static view of the theory and does not capture the new trends being shaped in the most recent years. Next to selecting the unit of analysis, each of the 61 papers was paired with every other paper, and the co-citation frequency of each pair was computed from the total references in the Social Sciences Citation Index (SSCI) online. The result of this procedure was a 61 by 61 matrix of co-citation counts; the rows and columns represent the articles included in the set, and the cells represent the number of times each pair of documents has been cited. Consequently, cells on the main diagonal report missing values (McCain, 1990) since they should represent the times a document has been cited together with the document itself. In order to obtain more interpretable and robust results, two criteria were established to screen the initial list of candidate documents: (i) the number of total co-citations received, and (ii) the number of zeros and ones in its line of the matrix (Rowlands, 1999; Acedo, Barroso, and Galan, 2006). I eliminated papers with more than 2/3 of zeros and a very low number of total co-citations received (<2) (Jarneving, 2005). By reducing the initial set of papers with this procedure, I obtained the set of 55 contributions used throughout our analysis and shown in Table 10.1.

Table 10.2 shows the publishing journals for the 55 most co-cited works in the field of cognition and innovation. The inspection of the papers journal-wise reveals various

P1:Tripsas M, Gavetti G; SMJ 2000	P29: Cardon MS; AMR 2009
P2: Tsai WP; OS 2002	P30: Danneels E; SMJ 2003
P3: Madhavan R, Grover R; JM1998	P31: Davidson EJ; MQ 2002
P4: Chen CC, Greene PG, Crick A; JMV 1998	P32: Gilbert CG; OS 2006
P5: Chatman JA, Polzer JT, Barsade SG; ASQ 1998	P33: Kaplan S, Tripsas M; RP 2008
P6: Uzzi B, Lancaster R; MS 2003	P34: Leiponen A, Helfat CE; SMJ 2010
P7: Pouder R, StJohn; AMR 1996	P35: Tsoukas H; OS 2009
P8: Smith WK, Tushman ML; OS 2005	P36: Kaplan S, Murray F, Henderson, R; ICC
P9: Garud R, Rappa MA; OS 1994	P37: Kaplan S, Henderson R; OS 2005
P10: Fiol CM; OS 1994	P38: Pearce CL, Ensley MD; JOB 2004
P11: Miner AS, Bassoff P, Moorman C; ASQ 2001	P39: Wuyts S; JEBO 2005
P12: Moran P; SMJ 2005	P40: West MA; AIS 2000
P13: Ibarra H, Kilduff M, Tsai W; OS 2005	P41: Vandenbosch, B; Higgins, C; ISR 1996
P14: Cross R; Sproull L; OS 2004	P42: Agarwal R, Helfat CE.; OS 2009
P15: Hargadon AB, Bechky B; OS 2006	P43: Akgun AE, Lynn GS, Byrne JC; HR 2003
P16: Geletkanycz MA; SMJ 1997	P44: Dimov D; ETP 2007
P17: Greve HR; SMJ 1998	P45: Snyder WM, Cummings; HR 1998
P18: Cannon MD, Edmondson AC; JOB 2001	P46: Baron RA, Ward TB; ETP 2004
P19: Postrel S; OS 2002	P47: Loasby BJ; JEC 2001
P20:Ward TB; JBV 2004	P48: Eggers JP; Kaplan S; OS 2009
P21: Corbett AC; ETP 2005	P49: Rao H; MR 2009
P22: Kaplan S; OS 2008	P50: Taylor A, Helfat CE; OS 2009
P23: Chesbrough H; LRP 2010	P51: Akgun AE, Lynn GS, Yilmaz C; IMM 200
P24: Griffith TL; AMR 1999	P52: Eisenhardt KM, Furr NR; OS 2010
P25: Wright M, Hoskisson R, Busenitz LW; AMR 2000	P53: Beckert J; OS 2010
P26: Greve HR, Taylor A; ASQ 2000	P54: Akbar H; JMS 2003
P27: Corbett AC; JBV 2007	P55: Baron RA, Tang J; JBV 2011
P28: Nooteboom B; RP 1999	

Table 10.1.: The set of 55 articles ordered by frequency of citation (from most- to least-cited)

interesting points:

1. Organization Science (OS) is the most influential journal in the field, as one out of every three of the most important articles is published here.Strategic Management Journal (SMJ) and Academy of Management Review (AMR) follows in second and third places of the ranking, respectively.

2. There is a strong prevalence of empirical articles, mainly adopting qualitative case study methods.

3. Only two articles are published in Research Policy (RP), the only mainly innovation-centric journal.

4. Only one contribution is practitioner-oriented (Rao, 2009) while all the rest are published in journals with a more pronounced academic cut, with an emphasis on analysis rather than on normative prescription.

5. Half of the articles focus on organization and management studies and more than one out of every four deals with strategy and entrepreneurship studies.

Journal	Number of articles	%
OS	16	29.1%
SMJ	6	10.9%
AMR	4	7.3%
JBV	4	7.3%
ASQ	3	5.5%
ET&P	3	5.5%
RP	2	3.6%
JOB	2	3.6%
HR	2	3.6%
Others	13	25.2%
Total	55	100%

Table 10.2.: Publishing journals of the 55 articles

10.2. Statistics

In order to standardize the data and avoid possible scale effects, as well as reducing the number of zeros in the matrix, prior to the analysis I converted the raw co-citation matrix into a correlation matrix, using SPSS Version 20 to calculate Pearson's correlation coefficient for each cell of the matrix (Rowlands, 1999). Correlation coefficients represent a measure of similarity between two papers: the higher the positive correlation, the higher the perceived similarity between the two works. Once the correlation matrix was obtained, drawing on similar studies (Culnan, 1986; Brown and Gardner, 1985), I proceeded to apply three multivariate statistical techniques to the correlation matrix. First of all, non-metric Multidimensional Scaling (MDS) was employed, allowing us to map the relationships between papers. Secondly, I applied a cluster analysis, which groups the papers in terms of similarity, thus providing an indication on the most relevant research subfields. Finally, a Factor Analysis was used to associate single papers with a given factor (in this case a specific research thread) and their relevance in describing it as an approximation of the relative influence (loading) that each paper has within the stream of research. Multidimensional Scaling analysis consisted in projecting the papers on a two-dimensional map, using the data from the correlation matrix as input data. The result of this analysis was obtained using the ALSCAL routines of the SPSS statistical program. On the one hand, MDS shows co-citation links among contributions. Points positioned at the centre of the map represent contributions linked to many different schools of thought and thus with heterogeneous citation profiles. On the other hand, MDS reduces the data space by positioning the articles on a bidimensional space, making it easier to interpret the relative positioning of the clusters of contributions. The values obtained in the statistical analyses that exhibit goodness of fit (STRESS=0.15090) and the estimated variance percentage (RSQ=0,94381) permit us to state that this representation is a good approximation of reality. Next, a hierarchical cluster analysis was

applied to the data. This technique allows for obtaining a series of clusters (i.e., groups) of significantly related documents. The hierarchical clustering determines the belonging to a group by analyzing the distance between pairs of documents in the multidimensional co-citation space. The results are graphically displayed in the dendrogram showing which papers are closest. The Clustering Analysis clearly shows five groups of papers. In order to better visualize and frame them in a conceptualized space, the clusters were superimposed on the MDS graph. Along with the two previous techniques, I also employed Correspondence Factor Analysis. Its relevance in this context is based on the notion that papers which are related to one another will, in general, be repeatedly cited together in subsequent publications, while works which are rarely or never cited together will not. If this assumption is true, then Factor Analysis can use the correlation between the co-citation entries to determine which contributions are grouped together and which, therefore, share a common element. It does so by producing a number of "factors," each of which captures a common element of the documents that are grouped together. It is also capable, by producing numerical indicators of the relevance of the factors (i.e., eigenvalues), of telling us something about the relative importance of these underlying elements. Factors were extracted by principal component analysis (PCA), and the analysis was carried out using the Promax rotation, following previous works (Rowlands, 1999). The rotation of the axes in the factor analysis aims, as its ultimate goal, to obtain factors endowed with theoretical significance, as well as to achieve the simplest possible factorial structure (Hair et al., 1999). An oblique rotation was chosen because it is often more appropriate than an orthogonal rotation when it can be expected theoretically that the resulting factors (in this case, specialties) would in reality be correlated (Hair, Anderson, Tatham, & Black, 1998). The data to be used in this analysis were obtained from the correlation matrix (Culnan, 1986; Rowlands, 1999). Finally a parallel analysis was employed to identify a four factor best fitting model (Lautenschlager et al., 1989; Keeling, 2000). Although the use of the last two techniques may prove to be redundant,

each one of them has some specificity that may allow us to determine some additional aspects of the relationship between the papers.

11. Discussion of results

11.1. Multidimensional scaling and cluster analysis

Results of the analysis are depicted in figure 1, which shows the Multidimensional Scaling Map and the groups of papers revealed by the Cluster Analysis.

The map shows:

1. Positions of papers with respect to the map's axes,
2. Identifiable paper groups which represent research topics/lines of research,
3. Location of these groups with respect to each other, and
4. Proximities of papers within groups and across group boundaries ("border papers").

Commentary on each point follows (Fig. 11.1.1).

Although the construction of the axes is arbitrary, the position of the papers on the map suggests a meaning for the axes. The upper portion of the vertical axis seems to represent those papers dealing with organizational learning and problem solving related with networks. In turn, the lower portion comprises those papers which emphasize the entrepreneurial opportunities coming from individual cognition. Left to right on the horizontal axis, there is a transition about the origin from papers evaluating the impact

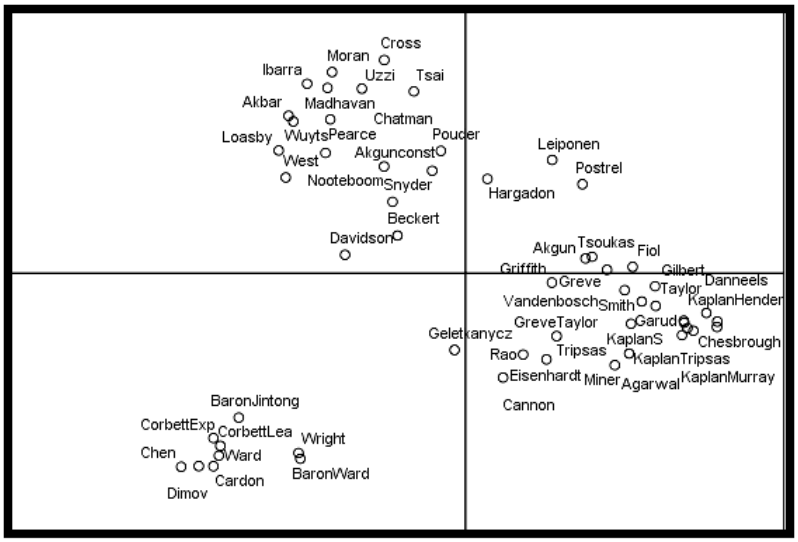


Figure 11.1.1.: Map obtained through Mds

of collaboration and connections (broad sense) to papers focusing on a organizational conflicts in innovation processes.

From bottom right counterclockwise I see six major groups (Fig. 11.1.2).

1. Group one (heavenly) is focused on collective mental frames, impacts on corporate paradoxical cognition management, and strategy. An analysis of the main contribution suggests that collective cognitive processes, understood as behavioral routines and ways that managers use to think about and respond to information (Weick et al. 1999), are viewed as a means for businesses to recognize and embrace contradiction in order to better overcome innovation, technological changes, and collective learning (Fiol, 1994). Different forms of collective cognition patterns influence organizational ability to manage diversity, strategies, technology trajectories, and life cycle.

2. Group two (blue) assembles those papers focused on cognition responsibilities on corporate failures due to a lack of adaptation (Tripsas and Gavetti, 2000) or con-

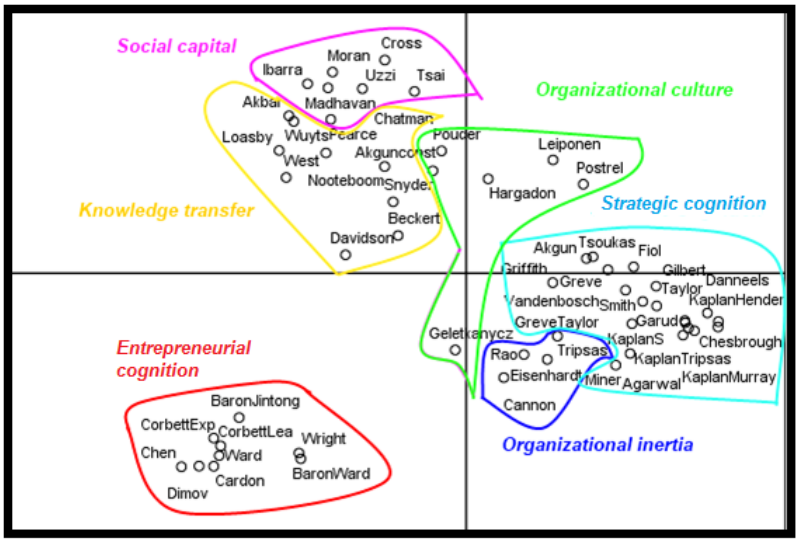


Figure 11.1.2.: Map obtained through Mds and Clustrer analysis

fidence (Griffith, 1999) to radical technological changes. The analysis of the main contributions suggests that managerial representations have a direct impact on learning and consequent new routines adoptions. Organizational inertia issues related to innovation trajectories are conjugated with companies' collective mental dimensions. Furthermore, shared tacit beliefs about appropriate responses to mistakes, problems, and conflict vary between organizational work groups and influence facing failure performances.

3. Group three (green) is the most central group on the map, and it focuses on the knowledge and cultures breadth advantages on problem solving (Leiponen, Postrel), collective creativity (Hargadon), managerial strategic skills (Pouder), and new product development capabilities (Akgun). Papers in this group synthesized opposite perspectives that have shaped the cognition thinking in the last few decades: the knowledge perspective and the cultural and contextual perspective. In this vein, the primer components of social cognition as information acquisition, dissemination, implementation, thinking, intelligence, improvisation, sense-making, and

memory form an interactive and determinant process model of the learning phenomenon, while another perspective examines the determinants and the influences of cultural values on corporate change.

4. Group four (yellow) deals with the issues related to how individual, team, and interfirm connections shape innovation in terms of creativity (Chatman, Akbar), processes (Pearce), social market structures (Beckert), and alliances (Nooteboom).These contributions focus on how the firm's boundaries of innovation are progressively shifting the focus from different notions of knowledge to a more specific discussion on creative human cognition. Following a dynamic theory of transactions and the external economy of cognitive scope notion by which people and firms need outside sources of cognition and competence to complement their own, they argue that the possible different strategies to link between individuals and firms are complementary and have a two-way shaped relation to cognitive mindsets building strengths.

5. Group five (pink) is focused on social capital and knowledge relationships able to create organizational access to actionable opportunities. Main contributions are drawn on a social network perspective of organizational coordination, and in order to examine, it investigates the effectiveness of coordination mechanisms and the impact of social capital characteristics on performance in terms of structural and relational embeddedness, co-petition, problem solving and reformulation, and new product development dynamics.

6. Group six (red) is the most isolated, and it focuses on how entrepreneurial cognitive mindsets impact opportunity alertness, recognition, creation, and exploitation. The objective of these papers is broadly to understand the role of the entrepreneurs' cognitive frames within the firm, new venture creation, or established ones, in favoring the innovation processes, decision making, and cooperative relationships. Through the analysis of the papers, it emerges that since the individuals represent

> the main determinant in activating innovation processes and intra-organizational relationships, it is important to understand which are the single and collective mental attributes that affect the discovery or creation of entrepreneurial opportunities. Furthermore, it is crucial to understand heuristics that increase the potential of business exploitation success.

Papers within group boundaries share similar co-citation profiles. Thus, this "relationship" only means that papers address the same broad questions without necessarily agreeing with each other in their findings. The proximity between the papers within group boundaries also provides interesting information. The group one (heavenly) and seven (red) are highly concentrated, reflecting the strong tendency to cite these documents together. In contrast, this is not observed in the group three (green) or group four (yellow), showing that some of them are still in their consolidation process, or they include diverse contributions from fields poorly related among themselves. It is also necessary to state that the links between the articles belonging to a group must be considered similar in the perception of the authors who have cited these works and who have, for one reason or another, tended to cite them together with others. Furthermore, generally papers and groups of papers near the extremes of the map are related, through co-citation, to fewer neighbors. Empty regions in this two dimensional space represent two types of significant information: differentiation or dissociation between clusters on the one hand, and/or the significant absence of objects on the other hand, which might mean that certain stimuli have been neglected or overlooked in a study or that no objects actually exist which have a particular combination of attributes.

Analyzing the groups' locations, I notice the centrality of group three (green), which represents the bridge group between knowledge and strategic focused contributions. The proximity to the map's origin indicates that the component papers are perceived to share features with many surrounding works. Indeed, as the concept of innovation is central for

all the different approaches trying to understand cognition performances, these papers are evenly cited among those belonging to the surrounding four groups. In fact, in order to incorporate the fields of cognition and innovation, not only it is crucial to understand the innovative process but, also, its characteristics that may play a major role in hampering or fostering the success of the cognition frames. Immediately on the right of group three are located all the papers belonging to group one (heavenly) and two (blue), labeled as strategic cognition and inertia impacts groups. These generally have a strong link with papers dealing with paradoxical cognition and diversity management. In this case, the graph shows little or no interaction with papers from group six (red). Identical dynamics exist for the groups on the left of group three (green). Group four (yellow) and five (pink) deal mostly with social cognition, capital, and resource capabilities enabling opportunities. The latter group six, perceived as having the least in common with others and consequently the most isolated, represents a small world in which to look for potential trailblazing ties.

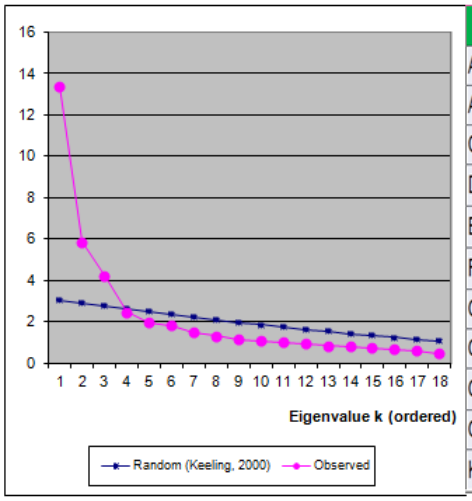
11.2. Factor analysis

Factor analysis can give us yet another piece of information on the structure of the field. If a structure is present in the data, it will show by being decomposed in its constituent factors (i.e., sub-fields/research areas/perspectives). Authors working in specialized areas of a given field of research tend to build on each others' ideas and are likely to be co-cited by other researchers in the same area (McCain, 1990). Such authors tend to contribute more (load) to the same factor. Therefore, the factor loadings provide an indication of the degree to which an author belongs to or loads on a factor. A factor is thus deemed to be a subfield whose theoretical underpinnings may be gleaned by examining the writings of the authors who load highly on it. The number of factors extracted

from our data was four. In order to define the structure of the field of research, the resulting model (explaining more than 58% of the total variance) was used to identify groups of strongly correlated papers. I have considered that a contribution (paper) should be included in a trend when its loading (on a -1 to 1 scale) is equal to or greater than |0.5|. Furthermore, if the loading is greater than |0.7|, then the paper is of great relevance within the corresponding research approach. Table 3 lists the four factors along with the authors that had a factor loading of at least |0.5|. Significantly, most of the contributions are loaded with a weight greater than 0.7, corroborating the relevance of these works within their respective paradigms. Likewise, it can be observed that few of the works exhibit considerable loading in more than one factor (greater than 0.5). These are the few bridges between research approaches, and they allow us to observe a broader spectrum of influences among those works that belong to the different research fronts, thus helping us to understand their evolution and the ties that have been forming between the different research trends.

If the factors are interpreted as "approaches," the results of the factor analysis presented in Table 11.1 reveal how and under which perspectives the cognition and innovation field has been studied. By analyzing the contributions loading on each factor, I named the four factors according to the following definitions: (1) strategy approach, (2) individual cognition approach, (3) network approach, and (4) improvisation approach (Fig. 11.2.1).

1. Factor 1 is the richest of the four extracted components in terms of number of papers with a qualitative case studies prevalent approach. The broad theoretical framework that encloses all the contribution in factor 1 pertains the collective cognition impacts on competitive advantage. In the past twenty years, several theories have been brought forward. The group underlines competitive interactions within and between rival firms. In doing so, it highlights the importance of the collective cognition environment and emphasizes internal sources to face it obtaining superior efficiency.



Factor 1		Factor 2	Factor 3	Factor 4
Agarwal	KaplanMurray	BaronWard	Akbar	Cannon
Akgun	KaplanS	Cardon	Cross	Eisenhardt
Chesbrough	KaplanTripsas	Chen	Hargadon	Gilbert
Danneels	Nooteboom	CorbettExp	Ibarra	Miner
Eggers	Postrel	CorbettLea	Leiponen	Taylor
Fiol	Rao	Dimov	Madhavan	Tripsas
Garud	Smith	Ward	Moran	Wright
Greve	Tsoukas		Pouder	
GreveTaylor			Tsai	
Griffith			Uzzi	
KaplanHender			Wuyts	

Figure 11.2.1.: Parallel analysis

2. Factor 2 contains all the papers included in group six (red), which concerned entrepreneurial cognition and innovation dynamics. Papers in this group focus on individual, social, and contextual cognitive issues associated with heuristics relationships as possible efficient ways to discover, build, or recombine the innovation activities of a new or established firm.

3. The primary research interest common to all papers within the network perspective is to identify, categorize, and theorize relations and connections between and within firms (networks). "Firms in the network are defined as actors of dyadic (pair-wise) relations within the structure of the overall network of relations" (Granovetter, 1992). When a network perspective is adopted, the analysis of cooperation between organizations becomes primarily related to the social structure of the context where the process takes place, which is the space external to individual firms. Thus, the social structure takes on central importance and has important implications for understanding the formation of relational networks in high growth, technology-intensive industries.

4. Papers factor 4on analyzing inter-organizational relations have devoted special at-

tention to the issues related to organizational learning and improvisation. In this vein, learning and knowledge transfer are recognized as a principal source of technology adaptation. Managing knowledge is mainly a strategic objective as companies seek to enhance their competencies, capabilities, and processes in order to gain competitive advantage. The theoretical challenge is to interpret the knowledge of a firm as resulting from a set of capabilities that constitute its sources of competitive advantage. The creation of new knowledge does not occur in isolation from other organizations or team members. Instead, new learning (such as innovations) is the product of the firm's combinative capabilities to exploit its existing knowledge base, balancing and being aware of its own cognitive frames impacts and the unexplored potential of its technology in use (Kogut and Zander, 1992) and the relation and cooperation with other organizations.

Authors	F1	F2	F3	F4
KaplanTripsas	0,923			
KaplanMurray	0,909			
Garud	0,884			
Chesbrough	0,878			
Fiol	0,869			
Danneels	0,824			
Agarwal	0,81			
KaplanS	0,763			
Tsoukas	0,745			
Akgun	0,743			
GreveTaylor	0,724			
KaplanHender	0,683			0,378
Rao	0,664			
Griffith	0,592			
Eggers	0,577			0,416
Greve	0,569			
Smith	0,531			
Postrel	0,522		0,372	
Nooteboom	0,376			-0,355
Chen		0,889		
Dimov		0,864		
Cardon		0,85		
BaronWard		0,836		
Ward		0,825		
CorbettLea		0,765		
CorbettExp		0,738		
Cross			0,869	
Uzzi			0,778	
Madhavan			0,763	
Moran			0,742	
Tsai			0,733	0,382
Ibarra			0,706	
Akbar			0,521	
Leiponen			0,515	
Pouder			0,424	
Hargadon			0,36	
Wuyts			0,327	
Eisenhardt				0,878
Taylor				0,847
Gilbert				0,719
Wright	-0,363	0,53		0,65
Tripsas				0,584
Miner	0,343			0,548
Cannon				0,541

Table 11.1.: Factor Analysis

12. Limitations

Although quite rigorous, co-citation analysis is subject to some limitations that can bias the results of the research if not properly addressed, namely, homogeneity, immediacy, and stability (Brown and Gardner, 1985; Pierce, 1990). Homogeneity refers to the fact that each research field has its own peculiarities, so the criteria for the selection of papers for co-citation analysis have to be targeted to the field. Immediacy regards the conservative nature of the analysis that is based on the accumulation of a sufficient number of citations for a paper to be included in the study. Instability regards the unavoidable fluctuations in research analysis over time.

13. Conclusions

The findings put forward by the present quantitative analysis generally indicate that innovation and cognition related literature is fragmented and characterized by different and well defined research lines with a low degree of superposition. This is generally positive, since the multidisciplinary approaches for understanding the field provide a more thorough explanation than single-track theories. Nevertheless, excessive fragmentation can be a weakness, for it could compromise the future of the field as a unique discipline. The data also shows some empty regions in the co-citation space, which indicates the possibility of expanding current knowledge.

Part III.

Disentangling Strategic Cognition Through Patent Analysis

14. Abstract

While collective cognition has received increasing attention in the broader field of organization, academic research has largely overlooked its potential role on shaping innovation trajectories and technological change adaptation at a firm and industrial levels. Through a strategic lens and based on the patent bibliometrics and patent co-citation methods, I integrate and extend the cognition and technology strategy literatures by proposing an invention behavior map of leading companies and groups in the automotive industry. How collective cognition influence patent strategies? How economic trends impact on patent paths? Empirical evidence for these reasons is drawn from a longitudinal patent analysis quantitative approach of the period 1991-2013 considered overall and consequently subdivided into three sub periods of seven years each 1991-1997, 1998-2004, 2005-2013. About 581.000 patents, 1.309356 citations and 1.287.594 co-citations of 57 automotive assignees were collected from Derwent Innovations Index, the largest world patent and innovation database. Multidimensional scaling and cluster analysis techniques are employed to detect cognition homogeneity level and provide an overview of groups technology composition and companies innovation strategies trends. Finally, explorative findings are discussed below with suggestions about how they might be translated into managerial implications.

15. Introduction

Patents have many advantages for a successful business. By creating patents, firms can build entry barriers, earn profits through royalties, and increase brand awareness, ultimately shaping their own technological trajectories. The traditional line of research in this field has focused on analysis at the firm level, and the description of external context in competitive terms has typically assumed an atomistic notion of firms' evaluations of patent opportunities. However, a new body of research is suggesting that industry membership could be a fundamental determinant of innovative research and patent strategy (Leiponen and Drejer, 2007; Jacobides, Knudsen, and Augier, 2006; Dalziel, 2007). An industry may mobilize powerful forces that produce important effects on the individual firms within that industry (Nohria and Garcia-Pont, 1991). For instance, as firms collaborate and exchange resources over time they often develop a set of common beliefs, or collective cognition for the competitive landscape based on their shared history. With the prevailing perception that invention and the related development processes that can bring a patent are risky (Cheng and Van de Ven, 1996; Quinn, 1985), players seek to reduce their uncertainty through progressively collecting and using information in order to make better-informed decisions (Kapur, 1995). The empirical literature on technological regimes argues that firms within an industry behave in correlated ways because they share sources of information and technology (suppliers, universities, other industries), and perceive similar opportunities for innovation. The existence of a collective cognition shared by firms within a sector can also influence how inventions arise and how

quickly and completely they diffuse, and can give us another key to better understand the collective failure of some industries as a result of surprisingly unexpected technological changes, or the innovation trajectories that have characterized some sectors. Yet, while collective cognition has received increasing attention in the broader field of organizational theory (Johnson and Hoopes, 2003; Nadkarni and Narayanan, 2007), research on innovation and patent strategies has been largely silent about the cognition's role (Kaplan and Tripsas, 2008) and empirical studies thus far have not questioned how industry boundaries truly define technological trajectories and patent strategies. Moreover, although extant research documents note that firm behavior is clearly influenced by collective cognition across sectors, and researchers have emphasized the existence of a different degree of homogeneity/heterogeneity across sectors (Abrahamson and Hambrick, 1997), little is known about how this industry-level discretion can affect the ability of a firm to generate patents. To overcome the limitations of previous studies and to understand how industry structure and interaction among players can shape technological trajectories, I examine the case of the automotive sector from 1991 to 2013 and identify the dynamic evolution of patent paths among the principal actors in this sector. I chose the automotive sector for several reasons: first, the ability of firms to innovate is crucial to commanding a competitive advantage in this industry (Hall & Ziedonis, 2001); second, all relevant players in this industry must routinely patent their innovations; and third, the automotive market is characterized by high entry barriers able to isolate new entrants and incumbents' dynamic noise; finally, the emergence of a vast network of joint ventures, strategic alliances, and mergers and acquisitions among heterogeneous organizations has been one of the key distinguishing traits in the recent evolution of this industry. In order to understand the phenomenon at stake, I investigate how patents in the automotive sector have evolved over time using co-citation analysis. Previously, the most common method of patent analysis was to simply count patents and compare how many patents had been assigned to each entity (Wartburg et al. 2005). However, the current study goes

beyond this simple identification of trends in patent statistics. I analyze the evolution of the technological trajectory in the automotive sector by utilizing bibliometric information such as patent co-citations. This approach displays a larger picture of the overall knowledge structure and the technology linkages among players and groups' technology positioning, thereby shedding light on the patterns of patent strategies within an industry. Therefore, I identify important technology trajectories by examining citation links among the different patents in a technology industry, drawing from longitudinal patent bibliometrics and patent co-citation quantitative approaches for the period from 1991 to 2013. In total, a 21-year period, subdivided as three sets of years in seven-year time spans from 1991 to 1997, 1998 to 2004, and 2005 to 2013, are visualized. About 581.000 patents, 1.309356 citations, and 1.287.594 co-citations of 57 automotive assignees were collected from the Derwent Innovations Index, the world's largest patent and innovation database. Multidimensional scaling and cluster analysis techniques are employed to detect the cognition homogeneity level and to provide an overview of the groups' technology composition and companies' innovation strategy trends. Finally, explorative findings are discussed below with suggestions about how they might be translated into managerial implications. This study adds to the literature in multiple ways. First, it contributes to the patent literature showing the evolutionary patterns of patent strategies inside a specific industry using patent co-citation analysis. Second, it contributes to innovation literature by enhancing our understanding of how technological firms and group positioning evolve and are influenced by collective cognition. Third, it also contributes to the still-inadequate understanding of the drivers of patent strategies and innovation trajectories. The paper is organized as follows. In section two, I describe the patent co-citation methodologies employed; in section 3, I present the bibliometric results and provide a graphical representation of firms' and groups' proximities performed by multidimensional scaling (MDS) and cluster analysis; in section 4, I discuss the results and offer several conclusions; I discuss the limitations of the study; and I identify implications for research

and practice, and recommend avenues for future research.

16. Theoretical background

16.1. Patent analysis

Patents, defined as contracts whereby an invention is disclosed in exchange for potential economic exploitation by an inventor or assignee, are fundamental assets able to determine companies' competitive advantages (Lai, 2005; Lo, 2008). Academic scholars have used patents as a measure of technological innovation outputs in relation to productivity, economic performance, or profits (Seol, 2011). As indicators of the R&D output measurement, patents have advantages and disadvantages (Tseng, 2011). Patents have worldwide coverage, are directly related to the inventive process, are granted after a formal and codified prior art analysis, allow for robust statistical measurements, and are public and increasingly available (Archibugi and Pianta, 1996; Frietsch , 2010). In addition, according to the World Intellectual Property Organization (WIPO), patent applications are constantly increasing. The disadvantages are that not all inventions are patentable, the patentability rate is heterogeneous across industries, and there is no homogeneity between the patenting criteria (Archibugi and Pianta, 1996; Narin, 1994; Narin and Olivastro, 1998). Furthermore, there are many international classification systems that discriminate in terms of numbers, structures, borders, definitions, and denominations of classes. This strong element of heterogeneity associated with the difficulty of standardization and the consequent existence of significant elements of subjectivity increases the potential for assessment inaccuracies. From a technological point of view,

prior art analysis usually generates significant discrepancies in broad patent analysis (Abraham and Moitra, 2001).

However, patents represent a significant percentage of companies' patentable invention outputs, between 60 percent and 90 percent. In this context, patent analysis is a discipline that aims to study the past, present, and future of patents through multiple approaches, measures, techniques, and methodologies. Patent analysis is a method used to transform patent data into useful information about a product's developmental status, the market-competition landscape, competitive intelligence, technology strategies, commercialization strategies, R&D planning, and the management of intellectual property. It can be used to study technologies (Brockhoff, 1991) focusing on single patents or classes of patents but also on firms' patent strategies through the patent portfolio analysis (Ernst, 2003), defined as a set of patents that are related to a specific subject or technology. Combining approaches, analysts can obtain a patent landscape (Brockhoff et al., 1999).

Furthermore, patent analysis is often used to analyze the competition and trends in technological changes in national and international context (Paci and Sassu, 1997), to estimate technological strengths and weaknesses of competitors (Narin and Noma, 1987), and to evaluate the potential of foreign markets (Shipman, 1967). Patent analysis is also a valuable approach that uses patent data to derive information about a particular industry or technology used in forecasting (Kim, 2008). Jaffe (1986) used patent analysis to characterize the technological position of US firms, while Cheung et al. (2004) used it to investigate the evolution of the technological capabilities of Korean semiconductor firms. Analyzing companies' own patent indicators in terms of quantity, content, and quality measures can lead to a better understanding of the capabilities and strategies of that company. Tseng (2011) divided patent indicators into three typologies on the basis of why, how, and what companies and inventors decide to initiate a patenting process. Furthermore, the author subdivided potential indicators as basic, citational, and science linkage. Most adopted are the number of patent applications, the average patent qual-

ity, patent strength, relative technology share, citation frequency (CI), ratio of granted patents, technological time cycle, and so on (Narin, 1994). Patent applications are the indicators of patent quantitative activity, while patent quality is measured by calculating an index of patent indicators. Patents granted, valid patents, and patent citations have frequently been identified as indicators of patent quality (Narin and Olivastro, 1998; Tseng, 2011).

16.2. Bibliometrics and patent citation analysis

Patent citation analysis is an academic set of bibliometric methods directly derived from methodology that seeks to link patents in the same way that science references link papers. Papers and patents are both research instruments that adopt citation-count measurement systems (Narin, 1994). Moreover, in bibliometrics, the use of a citation approach for the assessment of similarity for the classification of documents is a mature methodology, and for this reason, it is feasible to apply the citation analysis of bibliometrics to patent analysis (Meyer, 2000; Zhao, 2013). Patent citation analysis deals with the count of citations of a patent in subsequent patent or non-patent literature. Citations are indicators of the importance of the prior art to subsequent inventions, and citation means adoption (Karki, 1997). The key idea behind patent citation analysis is that when a patent is very frequently cited by subsequent patents, then that highly cited patent is likely to include an important technological advance and one that many subsequent patents are built upon. Therefore, the count of citations is an indicator of the technological impact of the patented invention. Patent citation analysis's advanced techniques allow analysts to assess not only the quality and impact of cited material but also the linkages among cited and citing countries, companies, and scientific and technological areas (Zhao, 2013). It is also a useful competitive intelligence tool. Narin et al. (1994) have demonstrated how to use patent citation counts to identify technical complemen-

tarities and competition among patenting firms by adopting techniques of competitor assessments like citing and cited patents, citation impact, and technology profiles and maps. Patent citation analysis has been used to evaluate research performance (Garfield 1983; Moed 2005), and economic studies suggest that patent citation counts correlate to economic value (Harhoff et al. 1999; Sampat and Ziedonis 2002; Hagedoorn and Cloodt 2003; Lanjouw and Schankerman 2004; Jaffe and Trajtenberg 2005). Interesting studies have adopted patent analysis in order to demonstrate that new knowledge comes from combinations of previous knowledge in terms of local and far distances and results (Fleming, 2001, Sternitzke 2009). Successful innovation balances re-using familiar components—an approach that is likely to succeed—and combining elements that have rarely been used together—an approach that often fails, but produces more radical improvements. Patent citation analysis has been used as a measure of technological quality and influence and to study the diffusion of technological information. Patent citations are also used to construct technological indicators. Most researchers have established indicators of patents based on the quantity of patents and citation data as the citation index (CI), the number of citations (NC), the current impact index (CII)—namely, the number of times a company's previous five years of citations are analyzed by different industry sectors and the technology strength able to evaluate quality-weighted portfolio size and adopted as a derived indicator that can measure the scale of influence of a company in a specific technological field. Finally, technology cycle time (TCT), which is the median age in years of US patent references cited on the front page of the company's patents, is used to measure the speed of innovation or how fast the technology is turning over. A shorter TCT indicates that companies may gain an advantage by innovating more quickly or undertaking incremental innovations (or replacing outdated former technologies). In summary, the higher these indices of a company are, the better patent quality it has, which means that its patents have higher economic and technological value (Tseng, 2011). In sum, the higher these indexes of a company, the better patent quality it has,

which means its patents have higher economic and technological value (Tseng, 2011).

16.3. Patent co-citation analysis

Co-citation analysis is a measure of the frequency of how many times A and B units are co-cited by third units such as papers, authors, institutions, and in our study patents, inventors, or assignees (Lai, 2005; Wang et al., 2011). The assumption of co-citation analysis is that documents that are frequently cited together cover closely related subject matter (Small, 1973; Garfield, 1993; Narin, 1994). In this vein, the co-cited frequency of patents can be used to assess the similarities or relatedness and to post evaluation and less-subjective unobtrusive patent maps and classification systems (Lai, 2005). Co-citation analysis (Small, 1973; Garfield, 1993) is an advanced bibliometrics method specular to bibliographic coupling one (Kessler , 1963). The first focuses on cited documents' potential infinite measures, while the latter is limited to citing references. In bibliometrics, it is used to assess document similarities in order to analyze the intellectual structure of science studies and identify cluster specialties and sub-fields (Culnan, 1987; Culnan, OReilly, & Chatman, 1990; Eom, 1996; Hoffman & Holbrook, 1993; McCain, 1990; White & Griffith, 1981; Nerur, 2008; Di Stefano et al. 2012). In patent analysis, the co-citation approach has been used to study the structure of knowledge in various specific fields, such as nanotechnology (Huang et al. 2003, 2004; Meyer 2001; Kostoff et al. 2006), semiconductors (Almeida and Kogut 1997), biotechnology (McMillanm et al. 2000), engineering (Murray 2002) and topology (Wallace et al., 2009). Lai and Wu (2005) adopted co-citation as a tool capable of increasing the objectivity of the patent classification system and to assist patent managers to better understand the basic patents for a specific industry and the relationships and evolution of technology categories. Although these research efforts have focused mainly on single patent or technology classes, there is a gap in the level of co-citation analysis with the aim to show the strategic positioning

of an entire industry over time through the development of cognition and its relation to economic and market trends. For these reasons, the main goal of this line of research is to shift the focus to assignees in order to understand in detail the development of a specific industry sector.

17. Research setting and methodology

17.1. The automotive industry

The global auto industry is a key sector of the economy for every major country in the world. It employs about 9 million people and Invests over € 84 billion in research and development. The production of passenger cars, light commercial and heavy industrial vehicles is consistently growing since 1960. In 2013 he received the results of a positive sign. The demand for cars was 85.7 million vehicles, an increase of approximately 4.7% compared to 2012, which had already recorded a 5% increase on 2011. The demand for light motor vehicles on the other hand is estimated at around 80 million units (+4.7 %) in 2012. Than 75 % of total sales for motor vehicles, in 2013 focused almost 65 million units (+4.7% on 2012). The passenger car market in 2013 was supported in particular by sales in China (+13.9%) and NAFTA (+7.1 %). The area of greatest difficulty was the EU (-1.4%), in particular the EU15 + EFTA (-1.6 %). In 2013 the demand for cars in China accounted for more than $\frac{1}{4}$ of the entire world market for cars, while the entire Asian continent is equivalent to 44% of global demand. It is a continent that is home to almost 60% of the world's population, approximately 3.8 billion people out of 7 billion, with economic growth rates of 7.7% for China and 4.4% for India. The demand for cars is expected to increase even more than 4% in 2014. The triad (Western Europe, USA and Canada, Japan), which is the traditional producer countries, weigh in 2013 for 42 % of all worldwide sales. The production of motor vehicles, then supported by the

positive demand, totaled over 87 million units, representing a growth of approximately 3.7% over 2012. Vehicles lightweight products were 83 million (+3.8%) to 2012 (80 million). 52.5 % of the vehicles is produced in Asia-Oceania, 22.6% in Europe and about 19% in the NAFTA region, 6% in the Rest of the World. China is the biggest producer in the world (25% of world production), followed by the U.S. (12.6%), which had already surpassed Japan in 2011 (11%), followed by Germany, South Korea, India, Brazil, Mexico. Thailand has gained a position, overtaking Canada. The BRIC countries with 31.9 million vehicles (+9.9% on 2012) accounted for 36.5% of world production (it was 34.5% in 2012). Traditional economies in USA + Canada, Western Europe and Japan, the production of light vehicles in 2000 accounted for 81% of total global production, while in 2012 down to 51% in 2013 and 49.5%. The BRIC countries on the other hand increased from 9.7 % share in 2000 to 35.3% in 2013. Forecasts for 2014 are pushing a new production record (91 million , up 4.2 % on 2013), supported by countries Asian and from NAFTA while in Western Europe, with a saturated market and replacement demand will still long to remain at levels lower than those of 2007-2008; in the New Member States the application is not able to absorb the surplus production of the entire area, which will be far both for production and for the market from pre-crisis levels. As was pointed out earlier economic and population growth, will lead to an increase in motorization in developing countries and among them, those with well-established economies such as China and Brazil. Trends s forecast a car park exponential growth in China by 2020, followed by an increase in density at automotive in South America and Southeast Asia, excluding Japan/Korea. The car park of China weighed on the world total in 2012 to 10.3% and is expected to grow to 22% by 2020. Circulating in Europe today 41.4% of the global car fleet and will fall to 33.5% in 2020. Finally I underline two large declines in trends are registered in the automotive sector in the two periods 1997-1998 and 2008-2009 to the Asian crisis to coincide with the European one.

In the Oica top-50 rankings in 2012,Toyota, GM and Volkswagen appear in the first 3

places followed by Hyundai, Ford, Nissan and Honda. At 15th place is the first company in China in terms of production (SAIC Motor), followed by another 12 between 16th and 35th place, a symptom of the great commercial Importance of the Eastern Market.

17.2. Mergers and acquisitions (M&As) and Joint Ventures (JVs) group histories

Players in the automotive sector are characterized by a strong propensity for the development of strategic alliances, mergers and acquisitions, and joint ventures (Garcia-Pont and Nohria, 2002; Nohria and Garcia-Pont, 1991). The search for patenting/innovation and commercial bonds increases business potentials by making more efficient technology transfer processes, competition capabilities, information-management skills, knowledge, and trust (Zhao, 2005; Teece, 2007). The nature of these relationships also deeply affects the individual and collective cognition of the industry and the groups to which companies belong (Kaplan, 2008). In this light, a historical analysis of the most relevant and established formal relations that have occurred since 1991 in the automotive industry follows. In this 22-year period, the shape and properties of automotive manufacturers have deeply changed. Currently, the Toyota group comprises Hino Motors and Daihatsu (since 1998). Volkswagen owns Audi, Skoda, SEAT, Bentley, Lamborghini, and since 1998, Bugatti, Scania (2011), and MAN (2011), and after a long series of disputes, even Porsche (2012). Hyundai and Kia jointly formed the main South Korean automotive group in 1998. Ford, until the crisis in 2007, has owned a series of relevant automobile manufacturers such as Jaguar and Land Rover, which currently belong to the Indian group Tata, and Volvo from 1999 until 2009, which is currently owned by Chinese carmaker Geely, and finally Aston Martin, which currently is owned independently. Honda, Suzuki, PSA, Mazda, Mitsubishi, Fuji Subaru, Isuzu, and the Indian company Mahindra & Mahindra have maintained their independence in the time period considered. The latter entered into a

major joint venture with the American company Navistar between 2005 and 2013. Nissan and Renault signed an important strategic alliance in 1999, and the latter acquired Dacia Motors in 1998. Chrysler, independent until 1997 along with Jeep and Dodge, was in a major merger with Daimler from 1998 to 2007, and then, because of the crisis of 2008, began a journey that has led today to its merger with the Italian group Fiat. Daimler AG with the exception of the temporary bond with Chrysler has consistently maintained its integrity, as has the Fiat group. The latter is composed of a number of prestigious brands such as Ferrari, Maserati, Alfa Romeo, and Lancia. BMW now owns the prestigious Rolls Royce and between 1995 and 2006 also owned the Land Rover manufacturer. Since 1999, the Volvo group has exclusively produced heavy commercial vehicles and has acquired Renault trucks. Finally, the main Chinese enterprises are characterized by a large number of joint ventures with Japanese, European, and American groups. The main groups are Saic with Saic-Iveco, Saic Volkswagen, and Saic-GM-Wuling. Dongfeng Motor cooperates with PSA, Honda, and Nissan, and Kia Changan maintains relations with Suzuki, Mazda, Ford and PSA. Baic formally participates with Beijing Hyundai, Beijing Benz Daimler AG, and Beijing Foton Daimler in joint ventures. The FAW Motors group is engaged in relationships with Toyota and Volkswagen, BMW with Brilliance Automotive, and finally the GAC group with Fiat, Toyota, Mitsubishi, Honda, and Isuzu. Gaig (Guangzhou Automobile Industry Group) has a commercial relationship with Toyota and Honda, while Great Wall and Lifan Motors have no current formal collaborations with other international groups.

17.3. Sample and unit of analysis selection

Our analysis, following the bibliometric co-citation and patent co-citation methods prescriptions (McCain, 1990; Nerur, Rasheed, & Natarajan, 2008; Di Guardo and Harrigan, 2012; Wang, Zhang and Xu, 2013) and in order to correctly select the unit of analysis

started by tracing the history of most relevant M&As and alliances automotive industry milestones. This allow us to consequently identify in Derwent database the standard and non standard assignees codes for the overall and intermediate periods and correctly formulate compound Derwent Innovation Index and Derwent World Patent Index search queries (Wang, 2011). A retrieving of assignees patent bibliometrics and assignees patent citation counts and finally co-citation frequencies is followed. Operationally, the compilation of the raw co-citation matrix and its convertion to correlation matrix allow us to run multivariate analysis and consequently interpreting the findings. In the case of academic bibliometric studies, the unit of analysis may consist of scientific articles, authors and institutions (Small, 1973). Symmetrically in the study of the citations behavior in the patent analysis, the unit of analysis can be identified by single patents, inventors, institutions or assignees (Lai, 2005). Our research aims to show the strategic positioning and similarities between the leading automotive companies in four different timespans and for these reasons I adopted assignees and as unit of research.

The underlying assumptions of this choice are that:

1. The greater the number of citations received by a single assignee or assignee-code the greater is its scientific impact or quality;

2. The greater the number of citations received the entire patent portfolio, the greater is the impact of technology and research and development of automotive assignees;

3. Finally, the greater the number of simultaneous citations or co-citations between assignees, the higher is the level of similarity and proximity perceived by citing world assignees.

Basically if two firms are cited together by third citing assignees, I assume that they have a strong technological relationship which should be seen in the technology position

map (multi dimensional scaling) and in the other multivariate analysis. In this study, I explored the Derwent Innovation Database with the two indices DII (Derwent Innovations Index) and DWPI (Derwent World Patent Index) databases, representing the most complete and comprehensive patent information source in the world. Active since 1963, it fully covers the last 50 years of patent history and comprises more than 14 million patents worldwide. It continuously monitors more than 40 international and national authorities involved in the management and licensing of the world patent system. It offers the possibility to search for patents based on international classifications as well as having its own patent classification systems. Furthermore, it offers a range of additional services that allow not only the patent, inventors, and assignees citation analyses but also fully instrumental tools to retrieve cited and citing actors' statistics. In this regard, I adopted assignee traditional and non-traditional Derwent codes to search queries to detect patent bibliometrics and citations statistics. Starting from the OICA 2013 report ranking, I selected the top 80 global companies in the automotive industry of manufacturers based on the number of commercial, passenger, and industrial vehicles produced. I examined the companies' websites and identified the number of brands for each company and its automotive groups. In the Derwent database, I checked individually for brands, single companies and groups, and the number of patents of the application date for the period 1991 to 2013. In this way, I divided the commercial brands by independent enterprises capable of producing technology. Then I looked back across the brands' histories, alliances, and M&As that occurred in the years between 1991 and 2013. Operationally, the major companies have a unique standard code "C". The lesser known or smaller companies and those of the Chinese market are identified by non-standard codes that have been precisely identified through a manual assignee search. For accuracy, 37 companies of 60 have unique four-digit character identifications, while for the remaining 23 it was necessary to formulate ad hoc search queries. In addition, in order to avoid the traditional limitations due to strategic and formal changes in companies and group structures,

Derwent provides a comprehensive data set of joint ventures drawn up within industries in the period considered. Unfortunately, from the operational point of view, that research is not yet coded or currently linearly provided by Derwent, and for this reason, I have followed the correct search strategy proposed by Wang et al. (2011). In the research, I took into consideration 18 joint ventures formalized during the period among 21 companies. Then, I launched an investigation of patent bibliometrics and identified the number of citations of the top 60 car manufacturers. At this point, I launched the number of citation queries and identified and measured the impact of the patent portfolios of businesses. Finally, I analyzed the significant differences between car production, technology production, and the impact of the latter on the automotive industry. For the period 1991 to 2013, I chose to analyze individual companies found without taking into account the group to which they belonged. In this way, I was able to verify the contribution of each individual firm on patent portfolios in terms of group-similarity level. Then I divided the whole period into three sub-periods of 7 years (1991–1997, 1998–2004, and 2005–2013), considered suitable to fill the well-known methodological bias due to the fact that the process of patent granting gives operating results usually after three years. The final period is one year longer because citations and patent applications are maturing slower in recent years. Furthermore, in the hope of exploring the potential effects of the crisis in the strategic positioning of technology groups, I considered these in conjunction with the Asian crisis of 1997–98 and just before the start of the crisis of 2007–2008. Moreover, I took into account the M&A histories that showed that in these three periods, the most influential automotive group changes were concentrated. Finally, by analyzing the three periods, it was possible to analyze and map the structure and the strategic positioning of patent groups according to their conformation and by assessing the impact of structural changes.

17.4. Patent data and multivariate analysis

By screening the Derwent Innovation database and according to the above search criteria, I selected data from about 581.000 patents, 1.309.356 citations and 1.287.594 co-citations of 60 automotive assignees in the period 1991-2013. Given our interest in defining the hard core of the technology firm positioning, I selected only the most cited patent portfolios (Acedo, Barroso and Galan 2006, Wang, 2011). Coherent with other bibliometric studies (Culnan, 1986; Rowlands, 1999) and patent co-citations (Wang, 2011), the selection was set at 100 citations for patents issued between 1991 and 2009, 80 citations for patents applied to 2010. The filter has highlighted the 60 most cited companies on which it was carried out and retrieve the co-citation matrix. Finally firms whose columns in the table of co occurrence had a higher number of two-thirds of equal zero were eliminated. For the same reasons and following the same method but applied not to individual companies but to groups in the period 1991-1997 were selected 28 variables, in 1998-2004 another 28, and in the last 34. In order to standardize the data and avoid possible scale effects, prior to the analysis I converted the raw co-citation matrix into a correlation matrix, using SPSS Version 20 to calculate Pearson's correlation coefficient for each cell of the matrix (Rowlands, 1999). Once the correlation matrix was obtained, drawing on similar studies (Culnan, 1986; Brown and Gardner, 1985), I proceeded to apply three multivariate statistical techniques to the correlation matrix. First of all, non-metric Multidimensional Scaling (MDS) was employed, allowing us to mapping the relationships between technological positioning of assignees. With this map you can have an indirect measure of similarity between the companies and groups based on co-citations received by a third parties. Furthermore, the evolution of the assignees relationships may be discerned by examining changes in the structure of such maps over time. Secondly, I applied a Cluster analysis analysis, which groups the papers in terms of similarity thus providing an indication on the most relevant patent positioning subfields.

Cluster Analysis can be used to determine which companies and groups are jointly related and therefore share a common elements. It does so by producing a number of "clusters", each of which captures a common element of the documents that are grouped together. Additionally, it produces numerical indicators of the relevance of the clusters thus telling us something about the relative importance of these underlying elements. Clusters were extracted by hierarchical Ward method (Rowlands, 1999).

18. Discussion of results

18.1. Patent bibliometrics

Patent bibliometrics highlights substantial differences in the world's car production rankings. Essentially, the most efficient technology manufacturers do not coincide with the major manufacturing sellers. In this vein and considering JVs, the analysis shows clearly what the commercial relationships are and the alliances, rather than those with goals of a technological nature. Car manufacturers who mainly patented in the reference period are Toyota, Hyundai, and Honda, with 120.680, 87.428, and 55.801 patents respectively. These were followed by Nissan, Daimler, and General Motors, and finally Ford, Mazda, and Volkswagen closed the top 10. Geely is the first manufacturer of Chinese technology, followed by Chery and Dongfeng. Under the top 20 patent ranking, are positioned Aston Martin, Lamborghini, Alfa Romeo, Bugatti, and Maserati. Japanese and Western companies hold supremacy in technological leadership. JVs with Chinese manufacturers have a mainly commercial nature. The data show clearly that only in recent years have the Chinese experienced patent production. By consolidating wherever possible up to 2012, the ranking of the groups did not change significantly. Toyota, Hyundai, and Honda remain firmly in the top three, while Volkswagen moved from tenth to sixth place and Fiat from 26th to 22nd. The analysis of patent citations generated by companies highlights the impact not only of the patent portfolio but also of patent strategies. The measurement of total citations in the period 1991 to 2013 shows that Toy-

ota, Nissan, and Honda occupy the first three places respectively with 196.478, 139.144, and 138.975 citations. They are followed by Daimler AG, General Motors, Ford, and Chrysler. Finally, Volkswagen, BMW, and Mazda complete the top 10. The citation impact of Chinese groups is absolutely reduced and proof of this is the Geely group in 39th place and of the latest 5 posts occupied by Chinese companies. The analysis of the impact of patents on the basis of quotations significantly changes the ranking to show that the number of patents does not always generate greater impact and also that not all patent strategies comply with the principle of parsimony but also have the objective of protection. In this ranking for the group, Paccar, Navistar, and Ford occupy the top three spots followed by Fiat, General Motors, Porsche, and MAN. Particularly disappointing results in terms of the impact of Chinese enterprises were most of Daewoo Motor, Mahindra, Scania, and Daihatsu.

18.2. Patent landscape

The analysis of co-citations highlights the strategic positioning of the 49 major technological automotive companies in the global market in the period 1991 to 2013, 28 of the main groups in the periods 1991 to 1997 and 1998 to 2004, and finally the 34 major groups between 2005 and 2013. During the full period, the unit of analysis is the single automaker, while in the three time spans it is the automotive group through the extraction of aggregate data. The analysis of the complete map and the trends and changes in technology portfolios in the three time spans, considering the M&A histories and joint ventures, are discussed below through the results of multidimensional scaling and cluster analysis. MDS and Cluster Analyses patents within group boundaries share similar co-citation profiles. Thus, this 'relationship' means only that patents address the same broad questions, without necessarily agreeing with each other in their findings. The proximity of the items within the groups implies a conceptual proximity too; however, a

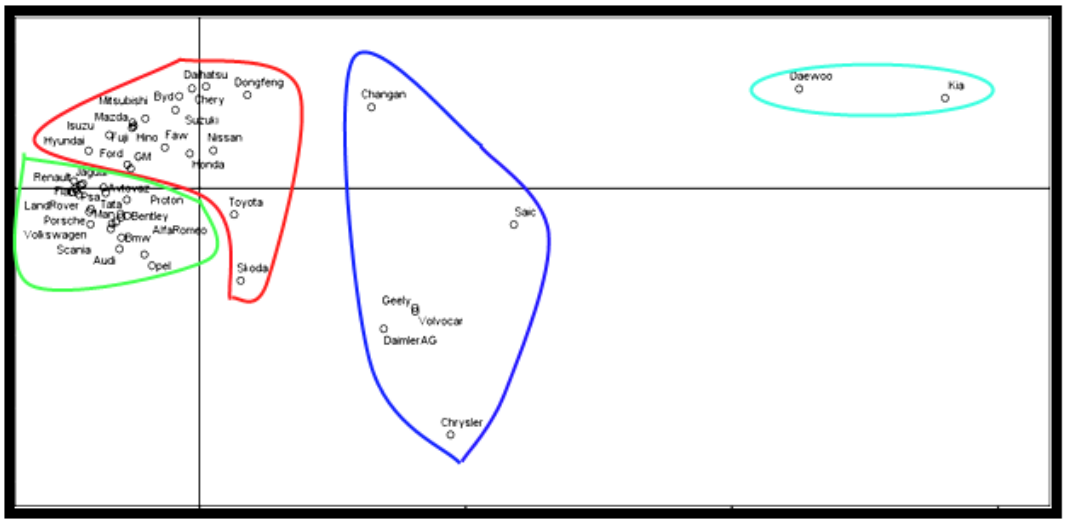


Figure 18.2.1.: Map obtained through Mds and cluster analysis 1991-2013

joint analysis of the concentration and positioning of groups in the axes is needed and consequently performed.

18.2.1. 1991-2013

Through the analysis of the peculiarities of individual companies and emerging distances among the enterprises' portfolios within the groups, the centrality, the empty spaces, as well as the more peripheral nodes, finally bridge and part with higher density and extension. The values obtained in the statistical analyses that exhibit goodness of fit (STRESS=0.06020) and the estimated variance percentage (RSQ=0,99472) permits us to state that this representation is a good approximation of reality (Fig. 18.2.1).

On the left, the map shows an area of high concentration and high technological similarities, while on the right, the distances among firms increase. In this scenario, cluster analysis clearly highlights four groups. The Japanese firms Toyota, Honda, and Nissan are the most central companies and belong to a larger international group comprised of Japanese, Chinese, Korean, and US companies. On the bottom left of the map, Euro-

pean manufacturers emerge, such as Volkswagen, Fiat, Porsche, Renault, BMW, PSA, and MAN, among which are India's Tata and the Soviet Avtovaz and the Malaysian Proton and its Lotus brand. Ford, GM, and Hyundai represent a technological bridge between the two areas. An important peculiarity of some company outliers such as Chrysler, Daimler AG, Geely, Volvo, and Chinese Saic and Dongfeng that belong to cluster 3 is seen, while peripheral positioning is occupied by Daewoo and Kia at the top right. The automakers that make up the current groups have sometimes focused more decentralized placement between them. The analysis relates how the level of similarity varies from group to group. Toyota, Hino, and Daihatsu have a significant distance in their positioning technology as well as the Hyundai group joined by Kia Motors in 1998. The Volkswagen group is heavily concentrated in the lower part of the map that houses companies like Audi and Porsche, but especially with the automotive manifacturers recently acquired as Porsche, Scania, and MAN as if to consolidate its position rather than acquiring technologies more distant. The group supported since 2001 by GM Daewoo has a high level of heterogeneity. Interesting is the distance in positioning between Nissan and Renault, despite the alliance that has joined the two groups since 1999. Among the Chinese automakers stands the central positioning of Faw Motor Company, probably due to the significant joint ventures with the Volkswagen and Toyota brands.

18.3. Patent trends

18.3.1. 1991–1997

The values obtained in the statistical analyses that exhibit goodness of fit (STRESS=0.12974) and the estimated variance percentage (RSQ=0,96575) permits us to state that this representation is a good approximation of reality (Fig. 18.3.1).

The map shows a major cognition concentration among firms, with the exception of

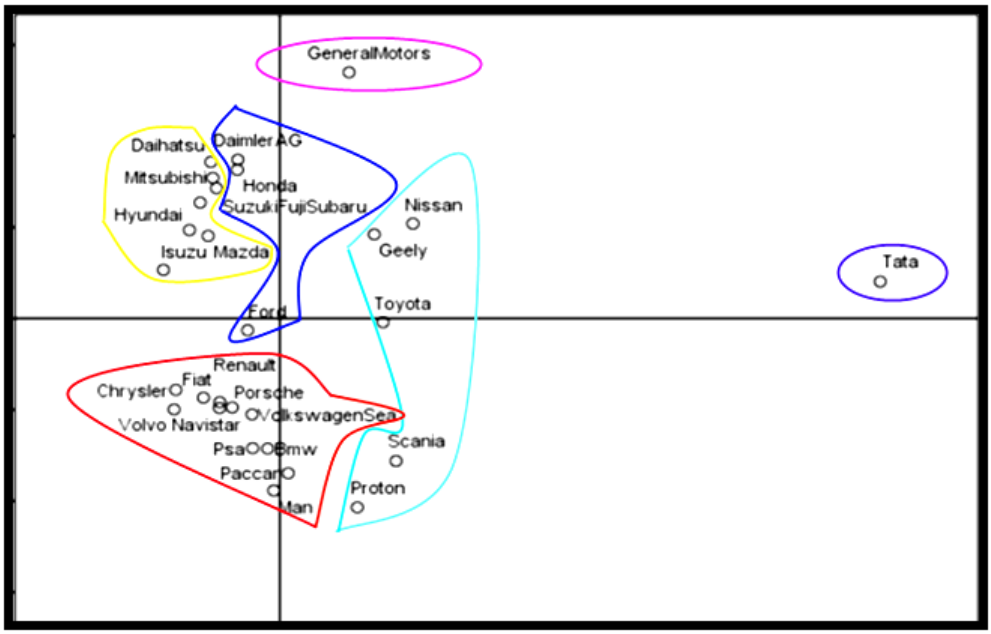


Figure 18.3.1.: Map obtained through Mds and cluster analysis 1991-1997

the Indian company Tata on the right side. Ford, Toyota, and Renault are the major groups of centrality. Geely is the only Chinese enterprise present. Cluster analysis clearly shows six groups. General Motors is highly decentralized, a symptom of the uniqueness of its patent portfolio. Daimler and Hyundai are central, positioned in the two groups at the top along with the major Japanese companies, while at the bottom are MAN, Navistar, Volvo, and Paccar, which are all specialized in truck production, just below the European Union automakers. Interesting is the proximity of technology for Fiat and Chrysler, now belonging to the same group, and vice versa, the distance between Toyota and Daihatsu as separate companies at that time and since 1999 part of the same group. Of note is the proximity between Porsche and Volkswagen. Finally, the Volvo Group, at this stage not yet divided between truck and car production, is positioned at the left side near Navistar.

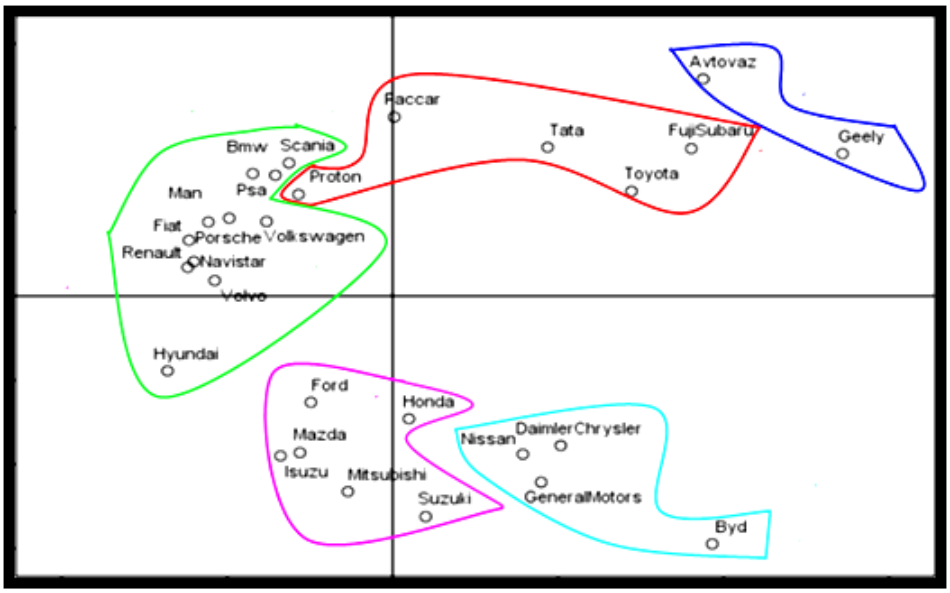


Figure 18.3.2.: Map obtained through Mds and cluster analysis 1998-2004

18.3.2. 1998–2004

The values obtained in the statistical analyses that exhibit goodness of fit (STRESS=0.17057) and the estimated variance percentage (RSQ=0,87121) permits us to state that this representation is a good approximation of reality (Fig. 18.3.2).

The map transposes the effects of the Asian crisis of 1997–1998 and has a strong dispersion compared to the previous period's technology structures. The distances between companies are larger. To highlight the lack of a technological leader and a high level of technological heterogeneity, the central part of the map is empty. BYD, Geely, and Avtovaz represent the outliers in the areas to the right with low levels of concentration. Toyota and Subaru Fuji lose their centrality compared to the previous period and depart significantly from Japanese firms showing strong technological differentiation from their competitors. Tata acquires centrality, while General Motors approaches Daimler AG and Nissan. Hyundai acquired Kia Motor Company, and now it is in a bridge position with Ford, while some American and European companies together with the Malaysian

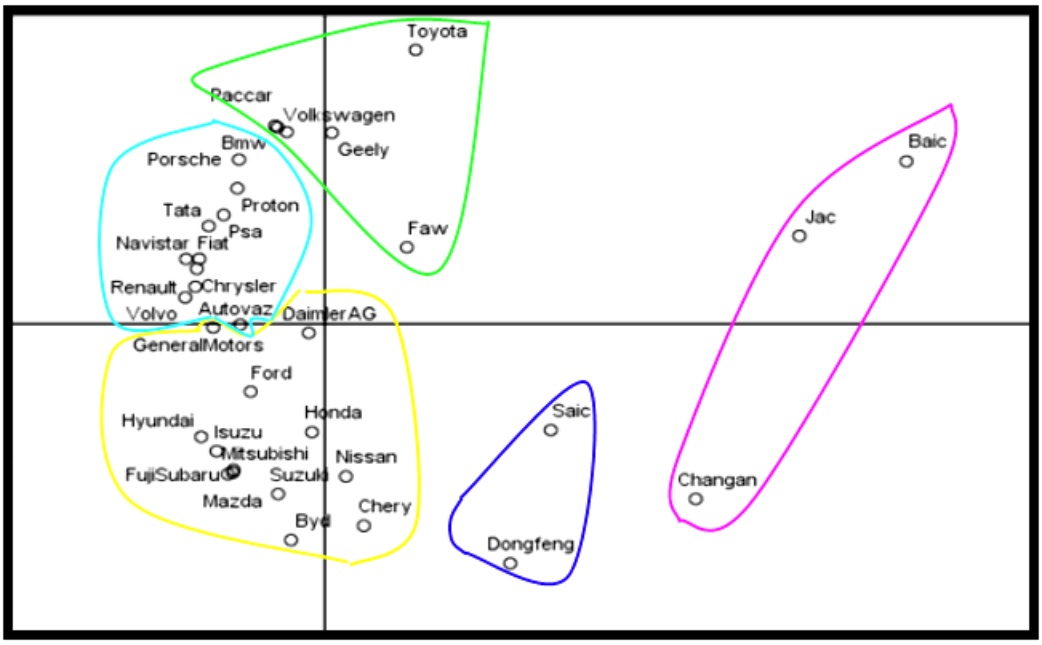


Figure 18.3.3.: Map obtained through Mds and cluster analysis 2005-2013

company Proton occupy the top left of the map. It confirms the proximity of technological enterprises that form the Volkswagen group like Porsche, Scania, and MAN and the merger between Daimler and Chrysler. Daimler-Chrysler does not cause distortions in the particular positioning of Daimler AG. Cluster analysis clearly shows five groups with a highly heterogeneous level in terms of nationality composition with respect to the previous period. Toyota increases the distance between traditional Nissan competitors. Ford gets closer to Mazda, and Hyundai and Tata enter the Toyota cluster.

18.3.3. 2005–2013

The values obtained in the statistical analyses that exhibit goodness of fit (STRESS=0.07810) and the estimated variance percentage (RSQ=0,98875) permits us to state that this representation is a good approximation of reality (Fig. 18.3.3).

The map includes the effects of the strong economic performance and global sales of

the previous five years to have a stronger concentration symptomatic of technological proximity than in the previous period. During this period, Daimler AG, Ford, and GM occupy the most central locations on the map. General Motors, in particular, takes a decidedly opposite path in the three periods compared to Toyota. The American company tends to centralize its positioning technology, while Toyota tends to move within the confines of the map. Peripheral positions are occupied mainly by Chinese companies in this period, beginning to produce not only cars but also technology. Volvo and Renault approach its position, and Tata emerges and centralizes its position, probably due to the acquisition of the Jaguar and Land Rover brands. In this phase, Daimler and Chrysler return as two separate entities while maintaining proximity in technology. Cluster analysis clearly shows five groups. For the first time and probably because of strong joint ventures, Toyota and Volkswagen belong to a similar cluster with Faw Motor, the most centrally positioned Chinese firm. Chrysler, after the split with the Daimler AG group, joined the group of European companies as Ford; General Motors and Daimler are the automakers that bridge between the cluster at the bottom and those at the top. Finally, the two rising peripheral clusters on the right side of the map consist exclusively of Chinese enterprises.

19. Conclusion and limitations

This exploratory study increases the awareness of scholars by detecting and visualizing the cognitive structure, operationalized as companies' technological distances, of the automotive sector between 1991 and 2013. It reveals innovation similarities, technology positioning, and trends of assignees and groups, and makes it possible to hypothesize patent strategies and latent relationships among them. Through bibliometric study, it has been shown that there is a major discrepancy between the leading companies in the production and sale of automobiles, trucks, and commercial vehicles, and those that are capable of producing technology through the application and granting of patents. In addition, these studies have shown more differences between the patent portfolios of companies in terms of quantity and quality. The companies with the most important patent portfolios quantitatively differ from those with a portfolio of more impact citations, demonstrating significant strategic and performance discrepancies between single companies and groups. Visualization and technology positioning maps of companies in the period from 1991 to 2013 and automotive groups in three seven-year periods open wide spaces to trail blaze. First, a contribution to the patent strategy and cognition literature has emerged on the basis of differences in positioning among companies and groups during the entire period and divided into time spans. In the overall map, this has emerged as some groups are composed of firms with heterogeneous positioning and consequently heterogeneous patent portfolios, while other groups have steadily increased over the years by acquiring high map closeness with companies with similar technological

characteristics. Second, the analysis of the three subdivided periods has highlighted how the level of similarity or distance among the groups, namely the collective cognition, changes continuously. The high concentration level that characterizes the first period is changed in the second, which is more dispersed and where there are not central or technological leader groups. Yet the third one returns to a concentration level similar to the first period. Such behavior of the map, if considered in relation to the economic performance of the production and sales of the industry, reveals how, in times of crisis, companies tend to look for a heterogeneous technology portfolio to obtain competitive advantages, while in positive economic periods, conformity tends to prevail. It is as if the collective cognition profoundly affects the technology positioning and behavior of firms at the expense of objective assessments of patent strategy decisions. Third, research has highlighted significant strategic differences in positioning in the various periods in which such central enterprises move to the suburbs and vice versa, and some change their technology cluster membership by moving into another and finally emerge or disappear because of a failure or because of an M&A. Fourth, an explorative contribution originates from the evaluative study of the groups' conformation in terms of brands and partnership formal contracts. In fact, it opens new horizons to researchers who want to analyze the impact of M&As or JVs on technological map positioning and, for example, in Foreign Direct Investments (FDI) and technology strategy literature.

Fifth, this study offers a contribution to strategic cognition, patent strategy, and technology positioning literature by adopting an unusual and nontraditional methodological lens for assignees' patent co-citation analysis.

Finally, several limitations must be mentioned. Although quite rigorous, co-citation analysis is subject to some limitations that can bias the results of the research if not properly addressed, namely, homogeneity, immediacy, and stability (Brown and Gardner, 1985; Pierce, 1990). Homogeneity refers to the fact that each research field has its own peculiarities, so the criteria for the selection of papers for co-citation analysis have to be

targeted to the field. Immediacy regards the conservative nature of the analysis that is based on the accumulation of a sufficient number of citations for a paper to be included in the study. Instability involves the unavoidable fluctuations in research analysis over time.

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