

Mapping the invisible colleges of innovation management field during the period from 1956 through 2012

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ABSTRACT

The aim of this paper is to find out the Innovation Management Researchers' main characteristics, which implies to determine the most productive ones, their categories according to production and impact, discover the invisible colleges, their research themes, and the most cited researchers in the field. A set of 387 articles was retrieved from the Social Science Citation Index corresponding to the period from 1956 to 2012, then by using Bibliometrics a classification of the corresponding research community according to production and impact was made, and were determined the invisible colleges. Next, the main invisible colleges were represented by using Social Network Analysis. Four main invisible colleges were determined, where Europe's supremacy as geographical region, and Product Development as topic of research are more than evident.

Keywords: Bibliometrics, co-authorship analysis, Innovation Management, invisible college, social network analysis

INTRODUCTION

Innovation Management is a hot topic nowadays. First, and since a long time ago, it was just the innovation issue. Nevertheless, it seems that little by little, there's a growing interest on how to administrate that innovation.

The capability that the firm has to innovate constitutes one of its resources, together with the financial, commercial and productive ones, and all of them (including innovation), must be well-administrated.^[1]

On the other hand, a globalization and diffusion of the academic community engrossed in the research of the Innovation Management field has continued to grow, and getting specialized.^[2]

Moreover, Candelin-Palmqvist *et al.*^[3] assert that the Innovation Management Research has gained ground over the years.

In the case of Spain, Junquera and Miter^[4] have found that there has been a positive evolution of Innovation Management Research since 1995.

Obviously, Innovation Management is an issue that has gained importance both for academics and entrepreneurs. That's the reason for which it deserves to be studied once again. In so doing, we've carried out a research that we plan to present in this paper. Then, the purpose of this study is to find out the Innovation Management Researchers' main characteristics, which implies to determine the most productive ones, their categories according to production and impact, discover the invisible colleges if there is any, their research themes, and the most cited researchers in the field.

The paper is divided into four main sections. The first is a review of literature; the second contains a description of the methodology employed; the third presents and discusses the results of the empirical study; and finally, the fourth section presents a summary and discussion of the conclusions to be drawn from this research, indicates its limitations, and suggests future research improvements.

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LITERATURE REVIEW

Several articles report the use of Bibliometrics techniques to study some areas of Innovation Management Research. For example, Husain and Sushil (1997)^[5] undertake a literature review exercise to identify the research issues in the area of Management of Technology. The articles reviewed were grouped under seven headings, which are strategic management of technology, technology planning and forecasting, technology transfer and acquisition, development and innovation management, technology and organizational issues, adoption and implementation of new technologies, and technology management: Implications for developing countries.

Later, Cheng *et al.* (1997)^[6] present a paper in Portland International Conference on Management of Engineering and Technology, which consisted of a citation-analysis based follow-up to the subjective survey conducted in 1993 by the Technology Innovation Management (TIM) Division of the Academy of Management. The purpose of both studies was to establish a hierarchical rating of journals publishing articles in the field of TIM.

Then, Cheng *et al.* (1999)^[7] publish their research in the IEEE Transactions on Engineering Management. That survey established a hierarchical rating of journals publishing articles in the field of TIM.

Linton and Thongpapanl (2004)^[8] conduct a citation analysis of the 10 leading TIM specialty journals to gain insights into the relative ranking of the journals.

Later, García *et al.*^[9] characterize the Journal of Technological Innovation, Entrepreneurship and Technology Management (Technovation) in its 25th anniversary, which celebrates it holding a prominent position within the field of TIM.

Gang *et al.* (2007)^[10] analyzes some characteristics of research on Innovation Management in China between 2000 and 2005, including the main institutions, key authors and regional distribution, based on China National Knowledge Infrastructure full paper Database, and by using Bibliometrics.

Biemans *et al.*^[2] analyze The Journal of Product Innovation Management from a knowledge-flow perspective by looking at the scientific sources used by JPIM authors to develop their ideas and articles. To this end a Bibliometrics

analysis was performed by analyzing all references in articles published in JPIM. It suggested a growing specialization of the field of TIM, with JPIM being firmly entrenched as the acknowledged leading journal.

Thieme^[11] using 959 articles reflecting the work of 1,179 scholars, ranks the world's top scholars in Innovation Management on the basis of the number of research articles published across 14 top academic journals in technology and innovation management, marketing, and management between 1990 and 2004.

Linton and Embrechts (2007)^[12] update the standing of the TIM journals as a specific domain,^[13] and use a Kohonen self-organizing map to show how journals relate to each other with respect to content.^[14]

In that very year, Junquera and Mitre^[4] assess the contribution to the international literature of Spanish scientific production in the research stream of innovation and technology management.

A year later, Pilkington^[15] explores the suitability of using diffusion S-curves to describe and compare the diffusion of citations within the innovation management discipline. The ISI Citation data on the ten leading journals in the Innovation Management field are modeled and compared using a wide range of distributions. The resulting grouping of journals appears to be a useful proxy for academic-practitioner involvement and warrants further research.

McMillan^[16] using co-citation analysis, identifies the invisible colleges associated with publications in R and D Management from 1986 through 2005 (he divides the period into four time sub periods to reveal changes in its intellectual base). The results indicate that Cohen and Levinthal's absorptive capacity model dominates the final two periods. The conclusions suggest how the absorptive capacity model might be more effectively utilized in future R and D Management research.

Tipu^[17] presents the classification of academic publications on Innovation Management in banks. And in 2012 four researches were identified: Yang an Tao (2012), an extension of Thieme's article published in 2007 in JPIM and already mentioned before; Choi *et al.*^[18] with a paper that presents an up-to-date ranking of the leading TIM specialty journals where citation data from the years 2006–2010 of the fifteen base journals are collected and

analyzed; Thongpapanl (2012),^[19] who presents an updated ranking of top journals specialized in TIM, using citation data corresponding to 15 base journals, from 2006 through 2010; and Schiederig *et al.*,^[20] with a paper that provides a current overview of the existing body of literature in the field of green innovations, identifying the most active scholars, institutions and relevant publications.

No researches on Innovation Management were found in 2013, just some related studies worthy of a mention: Shafique^[21] who's study presents a "global view" of the innovation field by combining longitudinal and structural perspectives from 1988 to 2008; and Zupic and Cater,^[22] who's main objective is to analyze the intellectual structure of high-technology research. They analyze journals that publish high-technology research, journals that publish most cited works by this research and most influential authors and documents, by means of citation and co-citation analysis, and social network analysis as visualization technique.

Inside of the theme of invisible colleges only, it's proper to say that Robert Boyle used that expression for the first time in letters he sent to other science men of the epoch, in 1646 and 1647, just to recognize themselves as a group that shared ideas and knowledge.^[23]

In 1660, Boyle and Wren, as well as some other men, created the Royal Society in London,^[24] which kept inside of it the primitive conception of an invisible college.

The idea of an invisible college became influent in Europe about the XVII Century, in particular in the shape of an interchange network of ideas amongst intellectual and wise men. There's a consensus in considering that one of the most common ways for them to communicate was through the margins of books, with written notes in personal copies of books which were lent, given or sold.

Diane Crane was an American sociologist, who later used the invisible college term, just to refer to informal communities of scientists who shared ideas, knowledge and projects.^[25] She based her analysis on the Derek J. de Solla Price's work which was about citation nets. This man has been considered the founder of scientometrics. The idea of informality underlying in the invisibility of the college is just characterized by the absence of a founding and binding institutional frame among the scientists who keep a certain kind of interchange and communication in a concrete line of inquiry.

The first purposes of Crane were mainly to investigate objectively the existence of social bonds among scientists, more than particular links about a specific theme of research. Her main thesis defends that it's possible to infer the existence of a social organization within a research area if: The scientists who have published in the area have more social bonds among them, than those who haven't published; and scientists who have published within the area can be differentiated by their participation degree.^[26] She considered that until that moment a very poor attention had been paid to a particular kind of social group within the scope of science: The one composed by those who work in similar research problems. Maybe the amorphous character of these kinds of groups, the geographical distance and mainly the absence of an agglutinative institutional frame make the borders, the limits of the research areas something very hard to define. That's why, sometimes the real existence of any kind of link among the authors is called into question. Nevertheless, it's known that within the scope of the development of researches, there are informal communication links among scientists who work in similar issues, and even there are attempts of systematizing their contacts and interchange of material.^[27]

In the XXI century, Caroline Wagner took up the idea of invisible colleges. She published "The new invisible college: Science for development" in 2008. She was a member of the Office of Technology Assessment, from USA Congress. This research, together with the others mentioned before, explain widely the diffusion of knowledge and the constitution of invisible colleges, within which the members recognize each other as equals, share information and knowledge even before finishing a work for a publication, and promote the incorporation of other scientists to the group who are admitted because of their present value or their promising future.^[28]

As a partial conclusion we'd be able to affirm that an invisible college is an informal group which can be detected throughout works in collaboration presented as publications in specialized journals. The members of these groups generally work together in a sporadic way. They base their researches on similar issues and usually try to systematize their contacts to interchange material among them.^[27]

There are some researches within the area of management that seek to find out the existence of invisible colleges in a certain field, with the intention of establishing the main authors and themes. It's something very important,

taking into consideration that having that information both managers and researchers are able to have a guide to develop the best practices in a specific discipline. Ramos-Rodríguez^[29] is an example of this. He identifies the invisible colleges within the field of entrepreneurship. Teixeira (2011)^[30] also tries to identify the same issue, and Vogel (2012)^[31] does something very similar for the field of management and organizational studies.

To the best of our knowledge, no such study has dealt with the issue of determining the invisible colleges in the Innovation Management field, at least not without the limitation of a single journal, or a relatively small period of time. Therefore this paper aims to fill a gap in Innovation Management literature by applying Bibliometrics techniques to a representative collection of research articles related to this disciplinary area, with the intention of complementing and enhancing the findings of other studies that have already described it from a more qualitative perspective.

METHODOLOGY

We chose to use articles published in journals, because these can be considered “certified knowledge.” This is the term commonly used to describe knowledge that has been submitted to the critical review of fellow researchers and has succeeded in gaining their approval. Research articles play a fundamental role in the said certification process.^[32] The use of citations from articles in research journals, moreover, is a standard practice that enhances the reliability of results.^[33] To obtain a representative collection of Innovation Management Research articles, we decided to retrieve all the articles published in the Social Science Citation Index (SSCI) from 1956 to 2012 with the sequence of characters “innovation management” in their titles, keywords or abstracts. The reasoning behind this choice can be summarized as follows: (1) By their nature, all the published articles address social science issues, which saves us the arduous task of sifting through other databases in search of articles relating to the discipline that concerns us, as well as help us avoiding other publications corresponding to sciences we are not interested to include in the present study; (2) it is highly regarded by researchers in the field; (3) its entire contents have the type required for citation analysis techniques.

Once the set of articles was retrieved from the database (387 in total, from now on, citation sample), we then created a file with all the references cited in the said articles. There are, however, certain inconsistencies in the coding used in

the database. Since the Bibliometrics software (We used BIBEXCEL software, designed by Professor Olle Persson of the Institute of Information Sciences at the University of Ume°a (Sweden). Employed in this study recognizes only exactly coinciding strings of characters, a manual normalization process is required in order to guarantee accuracy, especially in the spelling of authors’ names, the journals in which the articles appear, and the first edition of each book cited.

Afterwards, a new file with the names of all the authors out of the citation sample was created. It required also a manual normalization process for the same reason explained before. Then, the most productive researchers were determined by counting the number of articles each one of them had published in the citation sample. The frequency distribution obtained permits to arrange researchers by their number of published articles.

Just to determine the quantity of citations each researcher had received, a search in the file of cited references was made. In this way, it was possible to find out how many times a researcher included in the citation sample, had been cited by other researchers.

Later, following the recommendations of Landström (2001),^[34] a categorization of researchers according to their production and impact was made [Figure 1]. This classification has been made before for Entrepreneurship researchers.^[29,34] Nevertheless, taking into consideration that no similar classification was found for Innovation Management researchers, we’ve considered useful and perfectly extrapolable the said classification for the present research, establishing a citation threshold of 2%, and a minimum quantity of citations of 5, just as Landström (2001)^[34] and Ramos-Rodríguez (2004)^[29] established in their respective researches.

Here’s a description of the researcher’s categories and the corresponding classification criteria:

Innovation Management researchers	Marginalizers
	Core group
	Craftsmen
	Contributors
Transient researchers	Influential
	Ad-hoc
Source: Adapted from Landström (2001)	

Figure 1: Categories of Innovation Management researchers

Innovation Management Researchers

Are those who have published more than one article on Innovation Management. However, this group is rather heterogeneous and can be divided into: Marginalizers, core group, craftsmen, and contributors.

Marginalizer researchers

They have two articles in the citation sample, and <5 citations (including the 5).

Core researchers

They have more than two articles and >8 citations. The threshold of 8 citations corresponds to the 2% of the total of articles of the citation sample.

Craftsmen researchers

They have more than two publications in the citation sample but <5 citations.

Contributor researchers

They have more than two articles published and receive between 5 and 8 citations.

Transient researchers

They have one article in the citation sample. According to the number of citation they receive, they can be divided into:

Influential Transient Researchers

With more than eight citations.

Ad-hoc transient researchers

With <8 citations - the next step was to analyze the collaboration links among authors, throughout the count of the number of articles that each couple had signed together in the citation sample (co-authorship). Only core researchers were included in this process, because of their relevance for the study.

The counts were then arranged in a square symmetrical matrix in which the main diagonal remains undefined, and where each coefficient represented the number of articles that the row author had with the column author within the citation sample.

Out of this matrix, and using Ucinet, as well as its associated application for graphical representations Net

Draw, the defined graph corresponding to the matrix was represented and all its components were identified, which means that every subset of authors that were united among them by any way, were represented (Wasserman and Faust, 1994).^[35]

Finally, once checked the identified components, then we analyzed in detail the structure of those which were numerous, and that represented the groups of researchers that worked together in collaboration, that is, invisible colleges.

RESULTS AND DISCUSSION

This section contains the characterization's results of the Innovation Management Research Community, composed by 879 authors within the citation sample, corresponding to the period from 1956 to 2012, and retrieved from the SSCI, as stated before. This characterization was made according to production and impact, just to be able to later classify them into one of the researcher categories explained before in the section of methodology. Finally, of all the subsets of researchers within the core group, we deepened in four of them, which we considered the most important ones.

The Most Productive Researchers From 1956 to 2012

Table 1 shows the most productive authors within the Innovation Management field. Although the total quantity of authors included in the citation sample is 879, for space limitations, here are only shown those who have three articles or more.

With the inherent limitations of this kind of analysis, the most productive authors during the period of study are Karkkainen and Verganti with five articles each, Tuominen, Piippo, O'Sullivan and Chiesa with 4, and the rest with 3.

As it can be observed, the most productive researchers come from Europe, except for Troshani, Plewa and Rampersad, who are Australians, Xu who's from China, Ichimura from Japan, and Song from U.S.A. This result might be biased for the place where these authors publish their article, as in the case of Blindenbach-Driessen, who has a publication in Netherlands, another in Belgium, and the last one in U.S.A.

That of determining Europe as the most productive authors' location, coincides with the study of Schiederig *et al.*^[20] As we already said before, they determined that the most active researchers are in Europe, mainly in

Table 1: The most productive authors in the innovation management field

Authors	Nationality	Articles included in the citation sample
Karkkainen	Finland	5
Verganti	Italy	5
Tuominen	Finland	4
Piippo	Finland	4
O'Sullivan	Ireland	4
Chiesa	Italy	4
Troshani	Australia	3
Xu	China	3
Plewa	Australia	3
Keskin	Turkey	3
Moenaert	Belgium	3
Van der Duin	Netherlads	3
Trott	England	3
Hobday	England	3
Song	U.S.A.	3
Akgun	Turkey	3
Cormican	Ireland	3
Ichimura	Japan	3
Blindenbach-Driessen	Netherlands	3
Boer	Denmark	3
Corso	Belgium	3
Rampersad	Australia	3
Bessant	England	3
Rohrbeck	Germany	3

Netherlands, Italy and Germany, although that study was rather focused on Green Innovation Management.

Usually, scientific productivity is used as a measure of relevance within a given field of research (Shane, 1997),^[36] but it isn't the most appropriate measure. That's the reason for which a combination of this measure with the quantity of citations is much more advisable.

The Most Cited Authors From 1956 to 2012

Citations received by the authors who had any work within the citation sample are shown in Table 2. Chesbrough, from Harvard Business School, Boston, U.S.A, is the most cited author; Cohen, from Carnegie Mellon University, Philadelphia, U.S.A, is the next one; and Cooper, from McMaster University, Canada, the third one. A rapid glimpse throughout the list allows us to accept the American author's leadership.

Categories of Innovation Management Researchers

As it has been explained in the section of methodology, some author categories have been defined by combining

Table 2: Most cited authors by innovation management researchers

Authors	Citations received from the citing sample
Chesbrough	162
Cohen	89
Cooper	74
Eisenhardt	64
Freeman	59
Griffin	58
Henderson	58
Kogut	57
Linton	54
Nelson	52
Nonaka	49
Porter	48
Rogers	46
Rothwell	43
Schumpeter	43
Takeuchi	37
Teece	36
Tidd	36
Tushman	36
Utterback	35
Von Hippel	35
Yin	35

the volume of scientific production (measured by the number of articles within the citation sample), and the academic impact (measured by the number of citations received from the citation sample). We accept that there's a limitation in this process, because the corresponding outcomes will be based exclusively on the treatment of the citation sample, and it's composed by a small part of the Innovation Management Research. We are, however, reasonably confident that the articles analyzed are a representative sample of this field of research.

So, following the classification of Landström (2001),^[34] it was found that the core researchers represent a little more than a 26% of the total (87 Innovation Management Researchers). Craftsmen researchers nearly a 12%, contributors a little more than a 9%, and marginalizers more than a 50% [Table 3].

On the other hand, just a very small part of the transient researchers (10, 60%) have been classified as influential. Although this result could be biased because the citations they receive are not necessarily related to innovation management topics.

Researchers included within each category, with their production and impact, are listed from Tables 4-8.

Table 3: Number and percentage of researchers by category

Innovation management researchers 87 (%)			
Core group	Craftsmen	Contributors	Marginalizers
23 (26, 44)	10 (11, 49)	8 (9, 20)	46 (52, 87)
Transient researchers 792 (%)			
Ad-hoc		Influentials	
708 (89, 40)		84 (10, 60)	

Table 4: Core group researchers

Authors	Production	Citations
Tidd	2	64
Griffin	2	57
Reisman	2	27
Song	3	42
Moenaert	3	25
Bessant	3	23
Hobday	3	20
Chiesa	4	16
Nambisan	2	16
Verganti	5	15
Xu	4	15
Herstatt	2	13
Biemans	2	13
Porter	2	12
Mcadam	2	12
Trott	3	11
Gadelha	2	11
Jones	2	10
Ram	2	9
Hidalgo	2	9
Boer	3	8
Rohrbeck	3	8
Smits	2	8

Collaboration Relations Analysis on Scientific Articles' Authorship. To the Searching of Invisible Colleges

From the very beginning of the present century the co-authorship approach has gained relevance within the scientist's networks analysis.^[37] Thus, it's usual to study these networks by using bibliographical citations as a measure of relation. Although Crane (1972)^[25] points out that the articles co-authorship should be combined with other measures, for example, the tutoring of doctoral thesis, the congress participation, and the simple informal communication.

Co-authorship analysis starts by assessing the distribution of works within the citation sample according to the corresponding number of its authors [Table 9].

Table 5: Craftsmen researchers

Authors	Production	Citations
Piippo	4	5
Blindenbach-Driessen	3	3
Cormican	3	3
Ichimura	3	3
Plewa	3	3
Troshani	3	2
Van der Duin	3	1
Keskin	3	0
O'Sullivan	4	0
Byrne	3	0

Table 6: Contributor researchers

Authors	Production	Citations
Akgun	3	7
Nightingale	2	7
Rampersad	3	7
Salomo	2	7
Corso	3	6
Karkkainen	5	6
Pohlmann	2	6
Tuominen	4	6

There are 2, 3 authors per article as average, although there's an article with 14 authors which increases the mean. If we discard that paper, the average would be 2, 2, which is a practically insignificant effect. It's possible that a dynamic or a comparative study might have revealed a fact observed in other disciplines, which is that as long as a determined maturity degree is achieved, then the number of authors per article increases, as a consequence of the elaboration of these articles within research groups with external financing.^[29]

A social network analysis revealed the most central authors and the underlying collaboration relations among them. Taking into consideration that the interest of the study was focused on Innovation Management Researchers, a new file with the 87 corresponding authors was made, and the new collaboration links were identified. Collaboration networks found are listed in Table 10. Although in general they are small networks, it's completely sure that they represent the most important units of analysis of the present study.

The most numerous and important components are then represented from Figures 2-5. In these graphs the diameter of the nodes is directly proportional to the production of the corresponding author, and the thickness of the vertices is directly proportional to the quantity of articles each couple of authors signs together. The position of nodes

Table 7: Marginalizer researchers

Authors	Production	Citations
Huang	2	4
Majchrzak	2	4
Midler	2	4
Becker	2	3
Coughlan	2	3
Dahlgaard	2	3
Durisin	2	3
Nambisan	2	3
Wagner	2	3
Wong	2	3
Dewolf	2	2
Farris	2	2
Lee	2	2
Meissner	2	2
Beaume	2	1
Chen	2	1
Choi	2	1
Gieskes	2	1
Hoecht	2	1
Lettice	2	1
Smart	2	1
Van Der Bij	2	1
Wallenburg	2	1
Wonglimpiyarat	2	1
Xie	2	1
Calabretta	2	0
Chin	2	0
Frattini	2	0
Hallikas	2	0
Hartmann	2	0
Kaudela-Baum	2	0
Kaufmann	2	0
Lu	2	0
Magnusson	2	0
Martin	2	0
Milling	2	0
Motwani	2	0
Ortt	2	0
Ronchi	2	0
Schultz	2	0
Thongpapanl	2	0
Tsangari	2	0
Van der Duin	2	0
Voss	2	0
Vrontis	2	0
Zippel-Schultz	2	0

Table 8: Influential transient researchers

Authors	Citations
Cooper	193
Von Hippel	112
Eisenhardt	80
Teece	77
Rothwell	75
Tushman	75
Porter	70
Chesbrough	67
Schumpeter	65
Oecd	63
Cohen	61
Christensen	58
Nelson	55
Freeland	53
Utterbac	53
Henderson	46
Yin	43
Linton	42
Nonaka	41
Rogers	40
Amabile	39
Pavitt	39
Hamel	37
Kogut	36
Leonard-Barton	36
Roberts	36
Takeuchi	36
Clark	33
Dosi	33
Mintzberg	33
Allen	32
Barney	32
Damanpour	32
Weick	32
Milling	31
Prahalad	31
Abernathy	30
Brown	30
Burgelman	30
Dougherty	30
Kanter	30
Gupta	29
Maidique	29
Simon	29
Day	28
March	28
Wheelwright	28
Lundvall	27

in the graph has been obtained through the algorithm of maximum repulsion of the application NetDraw 2.136.

Contd...

Table 8: Contd...

Authors	Citations
Mansfield	27
Van De Ven	26
Drucker	25
Gulati	25
Miles	24
Souder	21
Gallouj	21
Calantone	18
Gassmann	17
Linstone	16
Edvardsson	16
Harhoff	14
Hauschildt	13
Hoegl	13
Gemunden	12
Oke	11
Martinsons	11
Cheng	11
Etzkowitz	11
Shane	11
Berkhout	10
Sawhney	10
Luthje	10
Basadur	10
Ulijn	10
Mahajan	9
Miller	9
Hultink	9
Martensen	9
Thom	9
Toivonen	8
Meyer-Krahmer	8
Goffin	8
Frese	8
Maier	8
Anderson	8

The College of Biemans, Griffin, and Moenaert

This component has been chosen fundamentally because of the presence of three of the main authors of the present study (corresponding to the core group). Core authors are seldom present within the rest of the identified colleges. Two of the authors are from Netherlands and one from USA, which means that this is a European-American college. The most strong relation is established among core researchers, and it's completely evident the lack of other kinds of relations. The institutional affiliation of each one of them is listed in Table 11, and the corresponding graph is represented in Figure 2.

Table 9: Distribution of articles per number of authors

Quantity of authors	Quantity of articles
1	109
2	139
3	92
4	34
5	8
6	2
7	1
8	1
14	1

Table 10: Groups of authors according to scientific collaboration relations

Innovation Management co-authorship network components
Beaume; Midler
Biemans; Griffin; Moenaert*
Blindenbach-Driessen; Van den Ende
Calabretta; Durisin
Chiesa; Frattini; Voss
Chin; Wong
Choi; Lee
Corso; Boer; Coughlan; Gieskes; Magnusson; Ronchi; Verganti*
Kaudela-Baum; Meissner
Kaufmann; Tsangari; Vrontis
Keskin; Byrne; Akgun
Nambisan; Nambisan
Ortt; Trott; Hartmann; Smits; Hoecht; Van der Duin*
O'Sullivan; Cormican
Piippo; Tuominen; Karkkainen; Hallikas; Ichimura*
Reisman; Motwani
Schultz; Salomo; Zippel-Schultz
Smart; Lettice; Bessant
Song; Van der Bij; Xie
Tidd; Nightingale
Troshani; Rampersad; Plewa
Those with an asterisk will be further analyzed

Table 11: Institutional affiliation of the college of Biemans, Griffin, and Moenaert

Authors	Most recent institutional affiliation
Moenaert	Faculty of Economics and Business, University of Groningen, P.O. Box 800, NL-9700 AV Groningen, Netherlands
Griffin	David Eccles School of Business, University of Utah, Salt Lake City, UT 84112, USA
Biemans	Faculty of Economics and Business, University of Groningen, P.O. Box 800, NL-9700 AV Groningen, Netherlands

Going over the titles, abstracts and keywords of the articles published by the authors of this group again, it's possible to assert that they are dedicated to study Product Development practices, Innovation Management in general, Intellectual Structure and Citation Analysis.

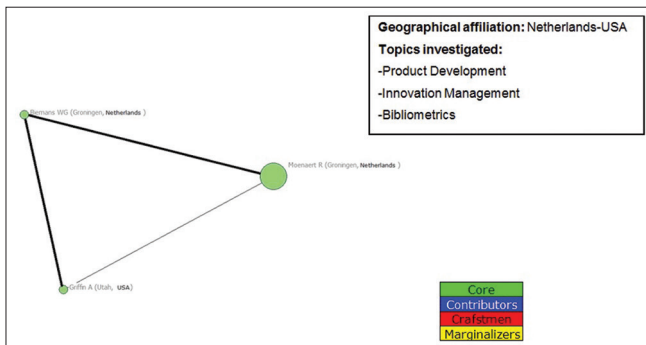


Figure 2: The College of Biemans, Griffin and Monaert

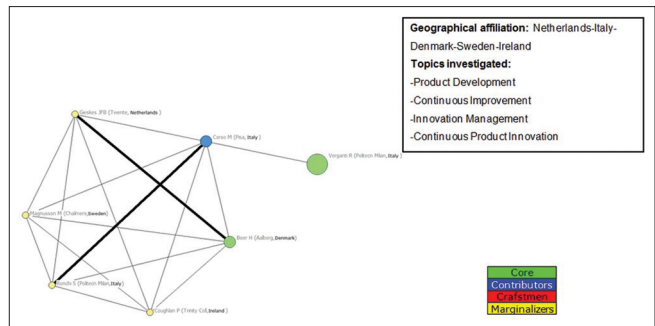


Figure 3: The College of Corso, Boer and Ronchi

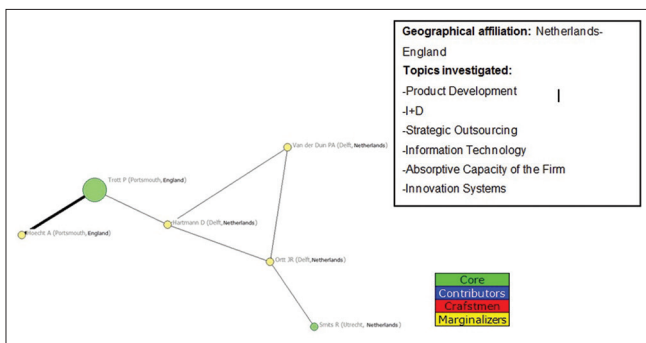


Figure 4: The College of Trott, Hartmann and Ortt

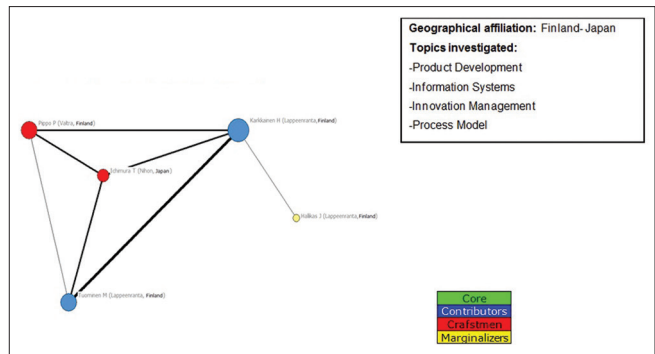


Figure 5: The College of Karkkainen, Tuominen and Ichimura

In fact, there are three more authors within this college, but they haven't been classified as core researcher. That's why they aren't included in this analysis.

The College of Corso, Boer and Ronchi

Verganti, one of the two most productive authors of the current study, is within this group. Despite he doesn't label the college because according to the calculation of the corresponding centrality degree, he is not one of the three most central authors of the graph. In fact, Verganti is included within this graph because of his connection with Corso, who's a bridge between him and the rest of the network [Figure 3].

There are two core researchers on the graph: Verganti, from Italy; and Boer, from Denmark. Besides, there's a contributor one: Corso, from Italy; and four marginalizers: Gieskes, from Netherlands, Coughlan, from Ireland, Ronchi, from Italy, and Magnusson, from Sweden.

The strongest relations are established among those who are contributors and those who are marginalizers, as well as among those who belong to the core group and those who are marginalizers. On the other hand, the relations among marginalizers are less strong than the rest, and

there are no direct relations among core researchers, just through contributors.

The institutional affiliation of each one of them is listed in Table 12.

Considering the countries included on the graph, there are no doubts that this college is eminently European.

Going over the titles, abstracts and keywords of the articles published by the authors of this group again, it's possible to assert that they are dedicated to the study of Product Development, Innovation Management, Continuous Improvement, and Continuous Product Innovation.

The College of Trott, Hartmann and Ortt

There are no contributor researchers within this group, as it clearly can be seen on the graph of Figure 4. There are two core authors: Trott, from England; and Smits, from Netherlands. And then there are four marginalizer authors: Hoecht, from England; Hartmann, Van der Duin, and Ortt, from Netherlands.

The strongest relations within the group are those established among core researchers and marginalizer

researchers (left part of the graph, both from England). There are no direct relations among core researchers, but through marginalizer researchers.

Considering the countries included on the graph, there are no doubts that this college is also eminently European.

Going over the titles, abstracts and keywords of the articles published by the authors of this group again, it's possible to assert that they are dedicated to the study of Product Development, I + D, Strategic Outsourcing, Information Technologies, Innovative Capacity of the Firm, and Innovation Systems.

The institutional affiliation of each one of the authors is listed in Table 13.

The College of Karkkainen, Tuominen and Ichimura

The other most productive author of the study is within this group (Karkkainen). There are also others that have been classified as the most productive authors (Tuominen and Piipo). All of them come from Finland, except for Ichimura, who comes from Japan [Figure 5], thus Finland's predominance is much superior.

It can be observed on the graph of Figure 5 that there are 2 contributor authors: Karkkainen and Tuominen; as well as, there's a marginalizer one: Hallikas. The strongest relations are established among contributors, then among contributors and craftsmen. The weakest relations are established among contributors and marginalizers. There are no direct relations among marginalizers and craftsmen.

Considering the researchers' nationality stated in the corresponding article within the citation sample measured by their institutional affiliation, this is a Netherlands-Japan college, that is, a European-Asian college.

We want to emphasize that there is no core researcher included in this group. Nevertheless, this lack is compensated by the presence of some authors who have already been classified as the most productive ones within the sample of study.

Going over the titles, abstracts and keywords of the articles published by the authors of this group again, it's possible to assert that they are dedicated to the study of Product Innovation Management, Process Model, Product Development, and Information Systems.

The institutional affiliation of every author is listed in Table 14.

CONCLUSIONS

Identifying invisible colleges within a field of research is a very interesting and important task. Price rescued the term "invisible college" in 1961. Originally, the mentioned expression referred to a scientific club from which the

Table 12: Institutional affiliation of the College of Corso, Boer and Ronchi

Authors	Most recent institutional affiliation
Corso	University of Pisa, I-56127 Pisa, Italy
Boer	University of Aalborg, Aalborg, Denmark
Coughlan	Trinity College Dublin, Dublin 2, Ireland
Gieskes	University of Twente, NL-7500 AE Enschede, Netherlands
Magnusson	Department of Technology Management and Economics, Business Innovation Center, Chalmers, SE-41296 Gothenburg, Sweden
Ronchi	Department of Economics and Production, Politecnico di Milano, Piazza Leonardo da Vinci 32, I-20133 Milan, Italy
Verganti	Politecnico di Milano, Milan, Italy

Table 13: Institutional affiliation of the College of Trott, Hartmann and Ort

Authors	Most recent institutional affiliation
Ortt	Faculty of Technology Policy and Management, Delft University of Technology, Jaffalaan 5, NL-2628 BZ Delft, Netherlands
Trott	Portsmouth Business School, University of Portsmouth, Portsmouth PO1 3DE, Hants, England
Hartmann	Faculty of Technology Policy and Management, University of Technology, NL-2628 BX Delft, Netherlands
Smits	Department of Innovation Studies, Utrecht University, P.O. Box 80125, NL-3508 TC Utrecht, Netherlands
Hoecht	Business School, University of Portsmouth, Portland Street, Portsmouth PO1 3DE, Hants, England
Van der Duin	Faculty of Technology Policy and Management, Delft University of Technology, NL-2600 AA Delft, Netherlands

Table 14: Institutional affiliation of the college of Karkkainen, Tuominen and Ichimura

Authors	Most recent institutional affiliation
Karkkainen	Department of Industrial Engineering and Management, Lappeenranta University of Technology, P.O. Box 20, Lappeenranta, Finland
Tuominen	Innovation Management Institute, Helsinki University of Technology, Espoo 02015, Finland
Ichimura	School Business and Commerce, Nihon University, Chiyoda Ku. 8-24 Kudan Minami 4 Chome, Tokyo 1028275, Japan
Piippo	Valtra Inc, R and D Centre, R and D Proc. Dev., POB 557, Jyvaskyla 40101, Finland
Hallikas	Business School, Lappeenranta University of Technology, FI-53851 Lappeenranta, Finland

Royal Society was constituted. Price used the expression “New Invisible College” (later just Invisible College), to refer to groups of scientists engaged in similar areas of research and with an exchange of information by means different from printed literature.^[38]

In our case, we have identified four invisible colleges within the field of Innovation Management: A European-American one, two Europeans and a European-Asian. This result is consistent with the findings of Reader and Watkins (2001)^[39] and Schildt and Sillanpää (2004)^[40] which show that in the partnerships among scientists underlie reasons of geographical proximity.

Product Development constitutes the most studied topic among those investigated by these colleges. Innovation Systems, Information Technology, Absorptive Capacity of the Firm, Innovation Management in general and Continuous Improvement, are other important topics among those studied by them.

The most productive authors are European. That finding is consistent with the research of Schiederig *et al.*,^[20] who already determined that the most productive authors are located in Europe, mainly in Netherlands, Italy and Germany; although it was a Green Innovation Management Research.

On the contrary, the most cited authors are American. It means that although the level of production in Europe is high (we’ve got to remember that production doesn’t necessarily mean quality), the level of impact in America is high (which doesn’t mean quality either, just influence).

The field of Innovation Management Research shows an exponential growth with a large number of researchers entering the field, many of whom can be regarded as “transient researchers” who only conduct Innovation Management Research for a short period of time. On the other hand, the “core group” of researchers within the field seems to be small, whereas the majority of researchers within the field only rarely publishing their work and seldom being cited. Besides, the works by the “core group” of researchers seem to fade out rather quickly, indicating that the field is rather ahistorical, and the knowledge accumulation within the field can therefore be questioned.^[34]

Finally, following the reasoning of Landström,^[34] a very important conclusion of the study is that the field of Innovation Management Research has proved to be in

a pre-paradigmatic phase of development – lacking a strong paradigm and with a transient research community. However, it is in this pre-paradigmatic phase that it will have an accumulation of knowledge with a balance between exploration and exploitation, which may be a primary factor for the long-term future success of the research field.

This study unavoidably has some limitations. There are two kinds of sources generating these limitations: The research design and the Bibliometrics techniques. One of the most important weaknesses related to the research design was the decision of selecting just a single database and the inclusion of the Innovation Management Researchers in the study only. By selecting one database only and thus conditioning the researchers to be studied, we inexorably place a boundary on the prospective scope of our results, since the documents that were analyzed were a portion of all Innovation Management Research references. It’s probable that substantial variations in these outcomes could appear if Innovation Management articles from a wider range of databases were incorporated. Nevertheless, we are completely sure that the literature analyzed here embodies the foremost research efforts made in this field.

On the other hand, this research is also limited by aspects related to Bibliometrics techniques. Therefore, just for commenting about one of them, when compiling citations, it is really difficult to find out the intentions of them: Maybe the author’s purpose was to mention previous researches and analyze the existing theoretical framework, or he wants to criticize the documents, or perhaps demonstrate the author’s knowledge, decorate the text or, basically, refer to one of his/her own researches. In opposition to this, omitting references to certain works may be a result of obliteration, which means, the exclusion of references to works that have become so familiar to such a degree by the scientific community that they are no longer explicitly cited, or for some unclear intention are intentionally excluded. Although it’s something completely sure that these limitations are successfully reduced to a considerable degree by the deep review process to which the implicated journal subjects articles before making any decision to publish them.

In addition, it’s proper to point out that the citations used to fulfill the objectives of this study are taken from a given period. That’s the reason for which the works which have been published toward the end of this period have not been visible to the scientific community for as long as those

published earlier. Therefore, they receive fewer citations than the others. This is an irrefutable reality but, the number of citations is not considered as a sign of quality in this research, but a sign of influence. It's fair to admit the fact that more recent works may not have had enough time to influence the literature of the field.^[29]

There are no solutions for most of the limitations we've commented before. Nevertheless, we prefer to emphasize that these limitations are not exclusive characteristics of Bibliometrics, but are easily found in any nonexperimental discipline and in Management in particular.

Others, nevertheless, can be reconsidered just to improve the techniques used in this study. In this regard, we plan, in future research, to widen the sample to include other databases and thus extend the study period and increase the number of authors presented on the maps; we pretend to improve the interpretation of the maps in particular by applying social network analysis, in order to identify clusters and measure their density and centrality within the network of co-authorship within which they are inserted.

In any case, the present research validates the use of a technique that has a great importance and applicability within the field of Innovation Management Research. According to Ramos-Rodríguez and Ruíz-Navarro (2004)^[33] it could also usefully be applied to other forms of scientific and technical writing, such as congress proceedings, doctoral theses and in particular, patents.

To summarize, these kinds of researches represent a complement to develop a quantitative analysis of the state of the art of a certain discipline, taking into consideration that the traditional qualitative methods to review literature must not be substituted. Bibliometrics can be used to identify researchers, journals, documents, etc., that are most consulted in a given field and in a certain period of time, and thus discover any possible links among them. That's why the scientist can use these methods just to discover the most influential literature in any discipline, map its intellectual structure, and get a wide view of the field mirrored through the behavior of its own actors.

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