UNIVERSIDAD POLITÉCNICA DE MADRID
ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA
AGRONÓMICA, ALIMENTARIA Y DE BIOSISTEMAS

**DEVELOPMENT OF A METHODOLOGY FOR SCIENTOMETRIC ANALYSIS.
APPLICATION TO STUDY WORLDWIDE RESEARCH ON HARDWARE
ARCHITECTURE AND CYBERNETICS**

TESIS DOCTORAL

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Master of Computer Applications

Madrid, mayo de 2017

DEPARTAMENTO DE INGENIERÍA AGROFORESTAL
ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA
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ACKNOWLEDGEMENTS

First and foremost, I would like to thank "Jwala Ji" a Hindu Goddess, for being with me at every step, to strengthen my heart and to enlighten my mind and have put on my way those people who have been present in my support and accompanied me throughout this study period.

I would like to thank forever my father Balraj Singh and mother Santosh Kumari despite being not physically present, always seek my welfare from my country, India, and if it were not the efforts made by them, my doctoral studies would not have been possible.

Thanks for my wife Laura Maria Stark Talavera, being the person who has shared most of the time with me, because in her company bad things become good, sadness becomes joy and loneliness does not exist.

Would like to gratitude my son Avik Singh who is now 3.5 years old, he had to endure long hours without the company of his father, unable to understand because of his young age, that why his father being in front of the laptop screen and not playing with him. However, whenever we could, we take beautiful moments, as his single smile always gives me, enormous courage and extra strength.

This doctoral thesis would not have been possible without cooperation, effort and dedication of Professor Dr. Ignacio Cañas Guerrero and Professor Dr. José Luis García Fernández, at each step, these are the people, who have been given me a very strong support in moments of anguish and despair.

In general, I would like to thank each and every one, who have lived with me in the realization of this thesis, despite of their ups and downs, so from the bottom of my heart I would like to thank you all for giving me support, collaboration and encouragement.

A special thanks to Dr. Fernando Ruiz Mazarrón for collaboration, patience and especially for the great friendship that gave me and gives me, lot of guidance and positive motivation.

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ACRONYMS

ACM	Association of Computing Machinery
ADO	ADO ActiveX Data Objects
CACM	Communication of Association of Computing Machinery
CSIC	Consejo Superior de Investigaciones Científicas
DB	Data Base
DBMS	Data Base Management System
ESF	European Science Foundation
ERIH	European Reference Index for the Humanities
GUI	Graphical User Interface
HLD	High-level design
HTML	Hypertext Markup Language
IEEE	Institute of Electrical and Electronics Engineers
IF	Impact Factor
ISI	International Scientific Indexing
IDE	Integrated development environment
ISBN	International Standard Book Number
ISSN	International Standard Serial Number
IPP	Impact Factor per Publication
JCR	Journal Citation Reports
NSD	Norwegian Social Science Data
MDAC	Microsoft OLE DB Provider for ODBC Drivers
MYSQL	Open-source relational database management system
ORCID	Open Research and Contributor Identifier
ODT	Open Document Text
OS	Operating System
OLE DB	Object Linking and Embedding, Database
ODBC	Open Database Connectivity
OECD	Organization for Economic Cooperation and Development
R&D	Research and Development
SJR	SCImago Journal Rank
SNIP	Source Normalized Impact per Paper
SCI	Science Citation Index
SCIE	Science Citation Index Expanded (Thomson Scientific)
SSCI	Social Sciences Citation Index (Thomson Scientific)
SQL	Structured Query Language
VBA	Visual Basic for Applications
VBE	Visual Basic Editor
WOS	Web of Science

ABSTRACT

The growth of scientific production in recent decades and indexing in bibliographic databases have boosted the use of scientometric approach and correspondingly generating indicators to measure results of scientific and technological activities. The study of scientific production in a subject area is always a continue indicator of research progress and knowledge generation.

The main objective of this thesis is to develop a methodology to carry out scientometric analysis of a global character, by combining different complementary approaches which permits to characterize the worldwide research of a study field in an integral and comprehensive form. This methodology for scientometric analysis overcomes some of the limitations of other existing tools, like inability to analyze simultaneously the keywords defined by the authors as well as the words that make up those keywords, grouping terms of keywords like singular and plural forms; weighing of scientific production with respect to participating research centres; production based qualitative classification of countries and research centres through the impact factor of their publications, etc.

Based on formulated methodology, to analyze research fields with thousands of published works, a computer application has been developed. It performs different types of analysis with effective algorithms and use different visualizations to interactively explore and understand huge datasets. Computer application provides keyword analysis functionality which allows researcher to identify and track the important and rapidly growing research topics. Moreover, the changes in the distribution and productivity, along with changes in collaboration, could help worldwide research institutions to evaluate research plans or investment strategies and to make decisions related to old or new research collaborations, based on worldwide rankings of leading research centres.

To determine the validity of the computer application, the methodology has been applied to the characterization of two specific research fields: hardware architecture and cybernetics; which are in the confluence of author technical education, the doctoral program and the department where the final thesis is developed. The results of this study may be very useful for decision-making in these research fields.

RESUMEN

El crecimiento de la producción científica en las últimas décadas y su indexación en las bases de datos bibliográficas han impulsado el uso de metodologías cuantitativas y, consecuentemente, la generación de indicadores para medir los resultados de las actividades científicas y tecnológicas. El estudio de la producción científica en un área de investigación es siempre un indicador del progreso de la investigación y la generación de conocimiento.

El objetivo principal de esta tesis es desarrollar una metodología que permita llevar a cabo análisis cuantitativos de carácter global, mediante la combinación de diferentes enfoques complementarios, caracterizando de forma integral la investigación mundial en un campo de estudio. Esta metodología para el análisis cuantitativo supera algunas de las limitaciones de otras herramientas actuales, como la incapacidad para analizar simultáneamente las palabras clave definidas por los autores y los términos que las componen, agrupando términos en singulares y plural; la ponderación de la producción científica en función de los centros de investigación implicados, la clasificación cualitativa de la producción científica de países y centros de investigación a través del factor de impacto de sus publicaciones, etc.

En base a la metodología formulada, se ha desarrollado una aplicación informática con el fin de analizar campos de investigación con miles de trabajos publicados. Esta aplicación lleva a cabo distintos tipos de análisis con algoritmos eficaces y utiliza diferentes visualizaciones para explorar y comprender interactivamente grandes conjuntos de datos. La aplicación informática proporciona un completo análisis de palabras clave que permite al investigador identificar y rastrear los temas de investigación importantes y en rápido crecimiento. Además, los cambios en la distribución y productividad, junto con los cambios en las colaboraciones entre centros, podrían ayudar a las instituciones de investigación a evaluar planes de investigación o estrategias de inversión y a tomar decisiones relacionadas con colaboraciones existentes y futuras, basadas en rankings mundiales de centros de investigación.

Para determinar la validez de la aplicación informática, la metodología se ha aplicado a la caracterización de dos campos de investigación específicos: arquitectura de hardware y cibernética; dichos campos se encuentran en la confluencia de la titulación inicial del autor, el programa de doctorado y la unidad donde se desarrolla la tesis. Los resultados de este estudio pueden ser de gran utilidad para la toma de decisiones en estos campos de investigación.

1. INTRODUCTION

1.1. SCIENTOMETRICS

According to Serenko (Serenko, 2013) the term scientometrics was invented by the Russian mathematician Vasilii Nalimov; *naukometriya* (scientometric) means the study of the evolution of science through the measurement of scientific information (Nalimov & Mulchenko, 1969). This term was not noticed in Western scientific circles until it was translated into English (Garfield, 2009). In 1978, an inaugural issue of scientometrics journal was published, and the term gained academic recognition.

Scientometrics researchers often attempt to measure the evolution of a scientific domain, the impact of scholarly publications, the patterns of authorship, and the process of scientific knowledge production. As per definitions, scientometrics is the study of measuring and analyzing science, technology and innovation e.g. impact measurement, reference sets of articles to investigate the impact of journals and institutes, understanding of scientific citations, mapping scientific fields and production of indicators for use in policy and management contexts.

Bibliometrics is statistical analysis of written publications, such as books or articles. Bibliometric methods are frequently used in the field of information science, including scientometrics.

Scientometrics and bibliometrics are methodological ways in which the scientific literature itself becomes the subject of analysis. In a sense, they could be considered a science of science, both are often involved in trend analysis of research, the assessment of the scientific contribution of authors, journals or specific works, as well as the analysis of the dissemination process of scientific knowledge. Researchers in such approaches have developed methodological principles on ways to gather information produced by the activity of researchers' communications, and have used specific methods such as citation analysis, social network analysis, co-word and content analysis, as well as text-mining to achieve these goals.

Bibliometrics and scientometrics are a set of methods for measuring the production and dissemination of scientific knowledge. The field grew out the information science, but it quickly carved out a place for itself in quantitative research evaluation.

Bibliometric methods is one of the best method to study the collaboration in scientific research (Subramanyam, 1983). Evaluating the performance of each research topic is necessary in order to indicate the impact of and contribution of authors to their respective fields (Wen-Ta & Yuh-Shan, 2007).

The use of bibliometric studies to comprehend and analyse scientific domains (Hjørland & Albrechtsen, 1995) together with the development and fine-tuning of new techniques and tools, facilitates decision-making in areas of scientific policy and reflects the "state of the art" of research at a given time.

Bibliometric analysis, which relies on a general search strategy, reflects a series of data that serve to characterize the scientific domain and lend it an identity of its own to better contextualize the study. This provides the decision-maker or policy maker with a point of departure for grasping the domain (Li et al., 2009).

Bibliometrics is a type of research method used which utilizes quantitative analysis and statistics to describe patterns of publications within a given topic, field, institute, or country. The bibliometric impact of a

publication is assessed in terms of the number of citations that it has received relatively to other outputs in the journal (Chiu & Ho, 2005).

According to Nederhof (Nederhof, 2006) bibliometrics uses three main types of indicator 1: Publication count: the number of articles published in learned journals during a specific time frame is an indicator of the output of a set or subset within the science system. It is also possible to compare numbers to gauge output intensity in specific fields (specialization index). 2: Citations and impact factor: number of citations can be used to evaluate the scientific impact of research. The number of citations received by learned journals is systematically compiled by Thomson ISI and sold under the trademark Journal Citation Reports (JCR). This product includes several indicators related to citations received by journals, and the impact factor is probably the one most commonly applied. 3: Many co-citation-based indicators are used to map research activity: through co-citation analysis, co-word analysis, and bibliographic coupling. Mapping is a means of studying the development of emerging fields using time as a variable. Co-citation and co-word indicators can be combined with publication and citation counts to build multifaceted representations of research fields, linkages among them, and the actors who are shaping them.

Authorship is a primary bibliometric descriptor of a scientific publication. Its trends and patterns characterize the social and even the cognitive structure of research fields. The most characteristic tendency of recent times is intensifying scientific collaboration. Collaboration in research is reflected by the corresponding co authorship of published results, and can thus be analysed with the help of bibliometric methods (Glanzel, 2002). Collaboration, playing an ever growing role in contemporary scientific research, can usually manifest itself in internationally co-authored papers tracked by bibliometric tools (Braun et al., 1990).

To evaluate scientometrics analysis from collaboration point of view, scientific research is becoming an increasingly collaborative endeavour. The nature and magnitude of collaboration vary from one discipline to another, and depend upon such factors as the nature of the research problem, the research environment, and demographic factors. Earlier studies have shown a high degree of correlation between collaboration and research productivity, and between collaboration and financial support for research. The extent of collaboration cannot be easily determined by traditional methods of survey and observation.

Bibliometric methods offer a convenient and non-reactive tool for studying collaboration in research. This universalism of science and the interdependence of scientists across cultural and geographical interfaces provide us with a reliable framework to study the generation, processing, and communication of scientific knowledge.

According to researchers like Hood and Wilson (Hood & Wilson, 2001) scientometrics is a tool to measure science which concerned with the quantitative features and characteristics of science and scientific research. Often scientometrics is done using bibliometrics (a method of measuring science and its impact through publications).

The focus of scientometrics is the measurement of science and is therefore concerned with the growth, structure, interrelationship and productivity of scientific disciplines (Ugolini et al., 2010). Scientometric studies are systematically conducted to evaluate the relative importance of scientific production in a specific field. This

approach provides a pivotal tool to interpret the temporary evolution and the geographical distribution of research on a specific topic (Rosas et al., 2011).

Scientometric indicators can be used to take investment decisions related to R&D projects and to identify rate of change of the usage of specific technology, selection process of researchers, promotion of researchers and research centers, etc. At the management and policy level, bibliometric analysis has been identified as one of the tools that has potential to assist decision-makers in understanding the science and innovation, investing in science and innovation, and using the “science of science” policy to address national priorities (Khalsa, 2004).

Purpose of the scientometric analysis is to identify the current full extent of the selected studies published in research journals, including the specialized publications, to provide an accurate survey of the best research published and examine the trends within this research discipline.

The results of most of the research are disseminated through a process of written communication, in the form of scientific and research publications. Precise quantification of scientific output in the short term is not an easy task, but is critical to evaluate scientists, laboratories, departments and institutions (Kreiman & Maunsell, 2011). In the situation of high volume of scientific production, a concrete and focused methodology is required to carry out of scientometric analysis.

The classification of scientific literature into appropriate subject fields is, nevertheless, one of the basic preconditions of valid scientometric analyses (Glanzel & Schubert, 2003). After further literature review, it has been found that the bibliometric assessment of research performance is based on one central assumption: scientists, who must say something important, do publish their findings vigorously in the open, international journal literature. This assumption introduces unavoidably a bibliometrically limited view of a complex reality (Van Raan, 2005).

Impact factor and citation indexes are also one of the important parameters to understand methodology of scientometric analysis; as per the history of citation indexes and impact factors; the Impact Factor (IF) introduced by Eugene Garfield and regularly published in the annual updates of the Journal Citation Reports (JCR) is a fundamental citation-based measure for significance and performance of scientific journals.

To know the status of research in a particular field, the analysis of scientific publications is the most prevalent and at the same time one of most debated methods, particularly in relation to quality analysis (qualitative evaluation) rather than quantity (quantitative evaluation) (Rojas-Sola & Jorda-Albinana, 2009b).

Qualitative assessment of scientific publications can be performed in various ways, being the most utilized the number of received citations and the Impact Factor published by the Institute for Scientific Information (ISI). Despite the many criticisms that the IF may have, there is no other system which is widely accepted by the scientific community and academic administrators (Rojas-Sola & Jorda-Albinana, 2009b).

According to Glanzel and Moed (Glanzel & Moed, 2002) the Impact Factor and related journal impact measures can readily be reproduced from the data presented in the JCR, however, these very data proved at large not to be reproducible. Although it is difficult to theoretically define the concept of journal impact, there is a wide spread belief that the ISI Impact Factor is affected or ‘disturbed’ by factors that have nothing to do with

(journal) impact. Consequently, several attempts have been made to improve the impact factor or to develop additional or alternative journal citation measures.

Not only impact factor but also journal citation measures are designed to assess significance and performance of individual journals, their role and position in the international formal communication network, their quality or prestige as perceived by scholars.

Citations have increasingly been applied as indicators in research assessments. The basic assumption is that one should find a correlation if citations legitimately can be used as indicators of scientific performance (Aksnes & Tøxt, 2004). A paper which has been cited many times is more likely to be cited again than one which has been little cited. An author of many papers is more likely to publish again than one who has been less prolific. A journal which has been frequently consulted for some purpose is more likely to be turned to again than one of previously infrequent use.

A simple new indicator to characterize the cumulative impact of the research work of individual scientists: a scientist has index h if h of his/her N papers have at least h citations each, and the other $(N-h)$ papers have no more than h citations each. From the above definition follows that h is a measure of the absolute 'volume' of citations where by h^2 provides an estimation of the total number of citations received by a researcher. For instance, if a scientist has 21 papers, 20 of which are cited 20 times, and the 21st is cited 21 times, there are 20 papers (including the one with 21 citations) having at least 20 citations, and the remaining paper has no more than 20 citations (Hirsch, 2005).

Keyword analysis is also one of important contributor to results of a scientometric analysis, analysis of keyword words in research title could be used to make inferences of the scientific literature or to identify the subjective focus and emphasis specified by authors (Xie et al., 2008). The technique of statistical analysis of keywords and title-words might be aimed at discovering directions of science (Garfield, 1970). In this sense it proved to be important for monitoring development of science and programs.

Co-word analysis, that counts and analyses the co-occurrences of keywords in the publications on a given subject, on the other hand, has the potential to address precisely this kind of analytic problem (Callon et al., 1991). Co-word analysis reduces and projects the data into a specific visual representation with the maintenance of essential information containing in the data. It is based on the nature of words, which are the important carrier of scientific concepts, idea and knowledge (Tijssen, 1993).

Keyword analysis allowed important and rapidly growing research topics to be identified and tracked the changes detected in productivity, collaboration and impact scores over time could be used to provide a framework for assessing research activity in a realistic context.

Language is a significant parameter to be analysed in scientometric analysis, during literature review researcher has found that English language journals, have much higher impact factors and has been proved by many scientometric analysis research papers for example the result is a citation database weighted heavily in favour of English language American journals (Moed, 1989).

So finally, we can state that scientometrics is the science that studies scientific production (to measure and analyse the same); conducted through bibliometrics (meterage of scientific publications), in terms of collaborations, identification of fields of research interest, assignment of resources etc.

1.2. USAGE OF SCIENTOMETRIC APPROACH

1.2.1. Major Scientometric Databases

Special bibliographic database sources are Web of Science, SciVerse, Scopus, Compendex, PubMed, etc. The data can be retrieved from these databases for scientometric study in different format, as for example, csv, Refworks, Endnote, Tag format, etc. The major online databases on which scientometrics techniques can be applied are:

Database	Specialization	Web	Owner
Web of Science	Science, Technology, Social Sciences, Arts & Humanities	http://www.webofscience.com	Thomson Reuters
Scopus	Science, Technology, Medical, Engineering, Arts & Humanities	http://www.scopus.com/	Science Direct
Google Scholar	Medical, Scientific, Technical	https://scholar.google.com/	Google

Table 1: Major Scientometric online databases.

1.2.1.1. WOS Database

Web of Science (WOS) is an online subscription-based scientific citation indexing service maintained by Thomson Reuters that provides a comprehensive citation search. It gives access to multiple databases that reference cross-disciplinary research, which allows for in-depth exploration of specialized sub-fields within an academic or scientific discipline (Figure 1).

A citation index is built on the fact that citations in science serve as linkages between similar research items, and lead to matching or related scientific literature, such as journal articles, conference proceedings, abstracts, etc. In addition, literature which shows the greatest impact in a field, or more than one discipline, can be easily located through a citation index. For example, a paper's influence can be determined by linking to all the papers that have cited it. In this way, current trends, patterns, and emerging fields of research can be assessed.

Eugene Garfield, the "father of citation indexing of academic literature," who launched the Science Citation Index (SCI), which in turn led to the Web of Science, wrote "Citations are the formal, explicit linkages between papers that have points in common. A citation index is built around these linkages. It lists publications that have been cited and identifies the sources of the citations. Anyone conducting a literature search can find from one to

dozens of additional papers on a subject just by knowing one that has been cited. And every paper that is found provides a list of new citations with which to continue the search. The simplicity of citation indexing is one of its main strengths”.

Expanding the coverage of Web of Science, in November 2009 Thomson Reuters introduced Century of Social Sciences. This service contains files which trace social science research back to the beginning of the 20th century, and Web of Science now has indexing coverage from the year 1900 to the present. The multidisciplinary coverage of the Web of Science encompasses over 50,000 scholarly books, 12,000 journals and 160,000 conference proceedings (as of September 3, 2014). The selection is made based on impact evaluations and comprise open-access journals, spanning multiple academic disciplines. The coverage includes: the sciences, social sciences, arts, and humanities, and goes across disciplines.

However, Web of Science does not index all journals, and its coverage in some fields is less complete than in others. Furthermore, as of September 3, 2014 the total file count of the Web of Science was 90 million records, which included over a billion cited references. This citation service on average indexes around 65 million items per year, and it is described as the largest accessible citation database. Titles of foreign-language publications are translated into English and so cannot be found by searches in the original language.

Web of Science consist of several online databases. Conference Proceedings Citation Index covers more than 160,000 conference titles in the sciences starting from 1990 to the present day. Science Citation Index Expanded covers more than 8,500 notable journals encompassing 150 disciplines. Coverage is from the year 1900 to the present day.

Figure 1: Web of Science database GUI.

Description: This figure represents GUI of Web of Science database, where functionalities of Search field and usage of logical operators and search settings have been described. Source: Quick reference guide (www.wokinfo.com/media/pdf/qrc/webofscience_qrc_en.pdf).

Once search is completed, abstracts (brief articles descriptions) can be seen or full text of the article can be seen using "Full Text from Publisher" option, apart from this allows to have an option to save the results (Figure 2).

Titles
Full titles are indexed and searchable.

Authors
All authors are indexed. Search using last name and initials (e.g. garfield e").

Cited Reference
Click on the Cited Reference number to move to the Cited Reference view of this record.

Abstract
All abstracts are indexed as provided by the journal (1991 to present).

Author Keywords and KeyWords Plus
Author Keywords are indexed and searchable. KeyWords Plus are words and phrases harvested from the titles of the cited articles.

Addresses
All author addresses are indexed and searchable. Reprint author e-mail addresses are listed when available. Common address terms will be truncated (Univ, Coll, Hosp, etc.).

Funding Information
Funding agency, grant numbers, and the funding acknowledgement text is searchable (2008 to present).

ResearcherID
ResearcherIDs are searchable and displayed when available. ResearcherIDs are harvested from public profiles at www.researcherid.com.

Link to full text and/or library holdings information.

Times Cited Counts
Times cited counts for the Web of Science™ (all editions) and Web of Knowledge™ (including Web of Science, Biosis Citation Index, and Chinese Science Citation Database) are displayed on each record. Counts reflect all correct citations and are not limited by your subscription.

Web of Science®
Search | Author Finder | Cited Reference Search | Advanced Search | Search History
Record 7 of 387
Monoamine oxidase inactivation: From pathophysiology to therapeutics
Authors: Ruffalo, M (Baylor, Mayo), Chen, K (Chen, Mayo), Shih, JC (Shih, Jean C.)
Scientific ADVANCED DRUG DELIVERY REVIEWS Volume: 60 Issues: 12-14 Pages: 1527-1533 DOI: 10.1016/j.addr.2008.06.002
Times Cited: 24 (from Web of Science)
Cited References: 34 (view related records) | Citation Map
Abstract: Monoamine oxidases (MAO) A and B are mitochondrial oxidoreductases which catalyze the oxidative deamination of dietary amines and monoamine neurotransmitters, such as serotonin, norepinephrine, dopamine, histamine, epinephrine and other trace amines. The rapid degradation of these molecules ensures the proper functioning of synaptic neurotransmission and is critically important for the regulation of neuronal behaviors and other brain functions. The byproducts of MAO-mediated reactions include several chemical species with neurotoxic potential, such as hydrogen peroxide, ammonia and aldehydes. As a consequence, it is highly speculative that prolonged excessive activity of these enzymes may be conducive to mitochondrial damages and neurodegenerative disturbances. In keeping with these premises, the development of MAO inhibitors has led to important breakthroughs in the therapy of several neurodegenerative disorders, ranging from mood disorders to Parkinson's disease. Furthermore, the characterization of MAO knockout (KO) mice has revealed that the inactivation of this enzyme produces a number of functional and behavioral alterations, some of which may be harnessed for therapeutic aims. In this article, we discuss the intriguing hypothesis that the alleviation of the oxidative stress induced by the inactivation of either MAO isoform may contribute to both antidepressant and antiparkinsonian actions of MAO inhibitors. This possibility further highlights MAO inactivation as a rich source of novel strategies in the treatment of mental disorders. (C) 2008 Elsevier B.V. All rights reserved.
Document Type: Review
Language: English
Author Keywords: Monoamine oxidase; Depression; Parkinson's disease; Oxidative stress
KeyWords Plus: ADOLESCENT; MICE; OBSESSIVE-COMPULSIVE DISORDER; POSTTRAUMATIC STRESS DISORDER; OXIDATIVE STRESS; AGGRESSIVE BEHAVIOR; ANTIOXIDANT ENZYME; MAJOR DEPRESSION; DOUBLE-BLIND; HYPERACTIVITY DISORDER; NEUROLOGICAL DISORDERS
Reprint Address: Shih, JC (reprint author), Univ So Calif, Sch Pharm, Dept Pharmacol & Pharmacol Sci, Rm 018, 1885 Zim Walk, Los Angeles, CA 90089 USA
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2. Univ So Calif, Med Sch Med, Dept Cell & Neurosci, Los Angeles, CA 90089 USA
E-mail Address: jcsih@ucla.edu
Funding: Funding Agency: Grant Number: R01MH07666; R37MH058665 (Show funding text)
Publisher: ELSEVIER SCIENCE BV, P.O. BOX 211, 1000 AE AMSTERDAM, NETHERLANDS
Subject Category: Pharmacology & Pharmacy
ISSN Number: 0169-4727

Times Cited: 25
This article has been cited 25 times in Web of Knowledge.
MacLeod, Ana. Principles in the Treatment of Depression: A Meta-Analysis. CLINICAL DRUG INVESTIGATION, 2011.
Zhong, Hailin. Selective Acetylcholinesterase Inhibitor Activated by Acetylcholinesterase Releases an Active Chelator with Reprogramming and Anti-Amyloid Activity. ACS CHEMICAL NEUROSCIENCE, NOV 2016.
Huang, Yan-Hong. Genistein reduced the neuronal apoptosis in the brain of neurodegenerated rats by modulating mitochondrial oxidative stress. BRITISH JOURNAL OF NUTRITION, NOV 2016.
[View all 25 citing articles]

Related Records:
Find similar items of knowledge records based on shared references.
[View related records]

Cited References: 34
View the bibliography of this record (from Web of Science®).
Citation Map

Additional information
• View the journal's Table of Contents (in Context Connect®)
• View the journal's Impact Factor (in Journal Citation Reports®)

Figure 2: Web of Science search functionality details GUI.

Description: This figure represents Web of Science Search functionality details GUI, where Titles, Authors, Cited reference, Abstract, Author keywords, Addresses, Funding Information, ResearcherID, links to full text and Time Cited counts fields have been described. Source: WOS quick reference guide (http://wokinfo.com/media/pdf/qrc/webofscience_qrc_en.pdf).

In the Citation Page, citation information, abstract (brief article description), additional keywords for searching, author info, times cited (who has cited this article), cited references (articles this one has used), related articles can be seen (Figure 3).

Web of Science®

Cited Reference Search (Find the articles that cite a person's work)

Step 1: Enter information about the cited work. Fields are combined with the Boolean AND operator.

* Note: Entering the volume, issue, or page in combination with other fields may reduce the number of cited reference variants found.

in **Cited Author**

in **Cited Work**

in **Cited Year(s)**

Step One

Search by Cited Author, Cited Work, Cited Year, Volume, Issue, or Page

Use the Journal Abbreviations List for help with abbreviations

Current Limits: (To save these permanently, sign in or register.)

Timespan: (Updated 2015-03-16)

From: **To:** **CONTENTS BY YEARS**

Citation Databases: Science Citation Index Expanded (SCI) Index (ASCI) Conference Proceedings Citation Index-Science (CPCI-S)

Step 2: Select cited references and click "Finish Search".

Next, look for cited reference records (sometimes different pages of the same article are cited separately).

CITED REFERENCE RESULTS

References: 1 - 11 of 11

Select	Cited Author	Cited Work	Year	Volume	Page	Article ID	Timespan	View Record
☐	MAUD I	SCIENCE	1981	5536	1761		1	
☐	MAUD I	SCIENCE	2003	358	1483		1	
☐	MAUD I	SCIENCE	1984				1	
☐	MAUD I	SCIENCE 0413	2003				2	
☐	MAUD I	SCIENCE 1318	1981				1	
☐	MAUD I	SCIENCE/PHOS	2003				1	
☐	MAUD I	SCIENCE	2001	13	19		1	
☐	MAUD I	SCIENCE	2003				2	
☐	MAUD I	SCIENCE	1981	388	1761	10112067661889608	308	View Record
☐	J.A. MAUD I	SCIENCE	2010	329	842	10112067661889608	1	View Record
☐	MAUD I, V.S.	SCIENCE	1981	358	1481		75	View Record

Step Two

Select the references, including variants, to include in your search, then click "Finish Search" to display your search results.

View the Full Record

Figure 3: Web of Science citation functionality details GUI.

Description: This figure represents GUI of Web of Science citation search, where functionalities of cited reference search i.e. cited author, cited work, cited year, volume, issue or page fields have been described.

Source: WOS quick reference guide (http://wokinfo.com/media/pdf/qrc/webofscience_qrc_en.pdf).

Once search in web of science core collection is done, criteria to view and analyze the records can be chosen, like Authors or Journals on a Topic, Analyze Results by Author, Source Title (Journal Title), Institution, etc. and to view records to see the references and patterns in the data (e.g. researchers from the same labs, common institutions etc.) (Figure 4).

ANALYZE RESULTS in Web of Science Core Collection (NOT All Databases)

The Analyze Results link can help you figure out which authors, journals, and institutions are publishing a lot on a subject, and which places are funding recent research, amongst other things.

For advanced refine options, use

Analyze Results

Analyze Results

Create Citation Report

Once you have done a search in the Web of Science Core Collection, choose the Analyze Results Link beneath the Refine Results sidebar or the sorting dropdown.

Choose the criteria to analyze by, e.g. Author, Source Title (Journal Title), Institution, etc and click Analyze to see results

Rank the records by this field:

Set display options:

Show the top 10 Results

Minimum record count (threshold): 2

Sort by:

* Record count

Selected field

Analyze

Use the checkboxes below to view the records. You can choose to view those selected records, or you can exclude them (and view the others).

View Records

Exclude Records

Field: Authors	Record Count	% of 2934	Bar Chart
KLUGER N	59	2.011 %	
ANONYMOUS	47	1.602 %	
ANDERSON RR	38	1.295 %	
LANDHALER M	32	1.091 %	
BAUMLER W	27	0.920 %	
RAULIN C	26	0.886 %	
VASOLD R	21	0.716 %	
GERONEMUS RG	19	0.648 %	
ARMSTRONG ML	19	0.648 %	
KONG B	16	0.545 %	

Save Analysis Data to File

Data rows displayed in table

All data rows (up to 200,000)

(967 Authors value(s) outside display options.)

(1 records(0.034%) do not contain data in the field being analyzed)

View Records

Exclude Records

Field: Authors

Record Count

% of 2934

Bar Chart

Save Analysis Data to File

Data rows displayed in table

All data rows (up to 200,000)

Choose the criteria you want and click View Records to see the references. You'll often see patterns in the data (e.g. researchers from the same labs, common institutions, etc).

Figure 4: Web of Science authors or journals on a topic, results analysis feature GUI.

Description: This figure represents GUI of Web of Science Authors or Journals on a topic, Analyze Results, where details result of Analysis field has been displayed. Analyze Results link can help user to figure out which authors, journals, and institutions are publishing a lot on a subject, and which places are funding recent research, amongst other things i.e. it allows user to choose the criteria to analyze by, e.g. Author, Source Title (Journal Title), Institution, etc. and to view records to see the references and patterns in the data (e.g. researchers from the same labs, common institutions, etc.). Source: Cornell University (<http://guides.library.cornell.edu/webofscience>).

1.2.1.2. Scopus

Scopus is the largest abstract and citation database of peer-reviewed literature (scientific journals, books and conference proceedings), delivering a comprehensive overview of the world's research output in the fields of science, technology, medicine, social sciences, and arts and humanities. Scopus features smart tools to track, analyze and visualize research. To visualize and analyze the research results, login is required with Elsevier credentials (Figure 5).

Figure 5: Login of Scopus database.

Scopus features smart tools to track, analyze and visualize research. Main features of Scopus are described below:

Search Feature

Finding the right result is the essential first step to uncovering trends, discovering sources and collaborators, and building further insights. Effective search tools in Scopus help researcher to quickly identify the right results from over 57 million records.

Document search: search directly from the homepage and use detailed search options to ensure researcher to find the document(s).

Author search: search for a specific author by name or by ORCID (Open Research and Contributor Identifier) ID.

Affiliation search: Identify and assess an affiliation's scholarly output, collaborating institutions and top authors.

Advanced search: narrow the scope of researcher's search using field codes, proximity operators and/or Boolean operators.

Refine results: Scopus makes it easy to refine researcher's results list to specific categories of documents.

Language interface: Scopus interface is available in Chinese and Japanese. Content is not localized, but researcher can switch the interface to one of these language options (and switch back to English, the default language) at the bottom of any Scopus page.

Discover Feature

Scopus includes the following features to help researcher to uncover and track important trends, field experts, key sources and impactful or related research, so researcher can keep an eye on global research.

Alerts: create search, document and author alerts to stay up-to-date at researcher's desired frequency. Researcher must be registered to create alerts.

Browse sources: browse an alphabetical list of all journals, book series, trade publications and conference proceedings available in Scopus.

My list: select documents and save them for later use within a session, or save them to permanent list. Building customized lists of documents allows to export, track and analyze a set of results at one time.

Reference managers: export data to reference managers such as Mendeley, RefWorks and EndNote.

View cited by: discover documents that cite researcher selected articles.

View references: see the list of references included in selected articles.

Scopus APIs: expose curated abstracts and citation data from all scholarly journals, books and conferences indexed by Scopus.

Analysis Feature

Scopus features analytical tools help researcher to better understand and gain important insights into the inside data. These tools include graphical displays, charts and tables that can be manipulated to view specific parameters.

Analyze search results: understand researcher's search metrics better with a visual analysis of researcher search results broken up into seven categories (year, source, author, affiliation, country or territory, document type and subject area)

Compare journals: gain a more complete analysis of the journal landscape. Select up to 10 journals to upload into graphs for comparative analysis and compare using a variety of metrics.

Article metric module: quickly see the citation impact and scholarly community engagement for an article. A sidebar on the article page highlights the minimal number of meaningful metrics a researcher needs to evaluate both citation impact and levels of community engagement. Clicking on <View all metrics> can open the metrics details page displaying all available metrics and the underlying content for further analysis and understanding.

Citation overview: can analyze the citation trend for any given article, set of results or for a list of author documents. The overview displays, in table format, the number of citations per year for each selected article.

Author profile page: researcher can easily analyze and track an individual's citation history. From their profile page, an author's total citation and document count, h-index, ORCID record can be viewed and collection of in-depth and visual analysis tools designed to provide a better picture of an individual's publication history and influence can be accessed.

APIs are available for Scopus

Abstract Citation Count: Scopus cited-by count image for a specified Scopus document(s).

Citation Overview: Citation metadata, including counts and citation summaries.

Serial Title: Metadata for a specified serial title (s), including journal metrics (IPP, SJR and SNIP).

Subject Classifications: Subject classifications associated with Scopus content.

Abstract Retrieval: Scopus abstract for a specified document (s) which includes links to various resources associated with an abstract, such as author and affiliation profiles.

Affiliation Retrieval: Scopus affiliation profile for a specified affiliation(s).

Author Retrieval: Scopus author profile for a specified author(s).

Author Search: Allows user to search Scopus author profiles based on a specified search criteria.

Scopus Search: Allows user to search Scopus abstracts based on a specified search criteria.

1.2.1.3. Google scholar

Google Scholar provides a simple way to broadly search for scholarly literature (Figure 6). From one place, researcher can search across many disciplines and sources: articles, thesis, books, abstracts and court opinions, from academic publishers, professional societies, online repositories, universities and other web sites. Google Scholar helps to find relevant work across the world of scholarly research.

Google Scholar includes journal and conference papers, thesis and dissertations, academic books, pre-prints, abstracts, technical reports and other scholarly literature from all broad areas of research. One can find works from a wide variety of academic publishers, professional societies and university repositories, as well as scholarly articles available anywhere across the web. Google Scholar also includes court opinions and patents.

Google scholar indexes research articles and abstracts from most major academic publishers and repositories worldwide, including both free and subscription sources.

To check current coverage of a specific source in Google Scholar, search for a sample of their article titles in quotes. Google scholar searches robots generally try to index every paper from every website they visit, including most major sources and many lesser known ones. That said, Google Scholar is primarily a search of academic papers. Shorter articles, such as book reviews, news sections, editorials, announcements and letters, may or may not be included. Untitled documents and documents without authors are usually not included. Website URLs that aren't available to google scholar search robots or to most web users are, obviously, not included either.

Google scholar indexes many of these papers from other websites, such as the websites of their primary publishers. The "site:" operator currently only searches the primary version of each paper. It could also be that the papers are located on examplejournals.gov, not on example.gov. Google scholar indexes papers, not only journals. Many coverage comparisons are available if user search for [title in "google scholar"], but some of them are more statistically valid than others.

Figure 6: Google Scholar GUI.

Features of Google Scholar

Search all scholarly literature from one convenient place.

- Explore related works, citations, authors, and publications.
- Locate the complete document through library or on the web.
- Keep up with recent developments in any area of research.
- Check who's citing publications, create a public author profile.

Google Scholar Citations

Google Scholar Citations provide a simple way for authors to keep track of citations to their articles. Researcher can check who is citing his/her publications, graph citations over time, and compute several citation metrics.

Researcher can also make other's profile public, so that it may appear in Google Scholar results when people search for name, e.g., Virender Singh Scientometrics. Best of all, it's quick to set up and simple to maintain even if researcher have written hundreds of articles, and even if researcher name is shared by several different scholars.

Researcher can add groups of related articles, not just one article at a time; and his/her citation metrics are computed and updated automatically as Google Scholar finds new citations to researcher work on the web. Researcher can choose to have his/her list of articles updated automatically or review the updates or to manually update his/her articles at any time.

1.2.2. Quality and Impact of publications

1.2.2.1. Indicators for measuring the quality of scientific production

a) Impact Factor

The most widely used impact indicator used is the journal Impact Factor (IF). The IF of an academic journal is a measure reflecting the yearly average number of citations to recent articles published in that journal; is the average number of times articles from the journal published in the past two years have been cited in the JCR year. It allows comparing the journals and helping to establish rankings based on this factor and reflects the relative importance of each title.

The Impact Factor is calculated by dividing the number of citations in the JCR year by the total number of articles published in the two previous years. An Impact Factor of 1.0 means that, on average, the articles published one or two year ago have been cited one time. An Impact Factor of 2.5 means that, on average, the articles published one or two year ago have been cited two and a half times. The citing works may be articles published in the same journal. However, most citing works are from different journals, proceedings, or books indexed by Web of Science.

For example, Impact Factor can be calculated as following:

- Citations in 2010 to articles published in;2009 = a ,2008 = b
- Number of articles published in;2009 = x ,2008 = y
- Impact factor in 2010 is calculated by:

$$\text{Impact Factor} = \frac{a+b}{x+y}$$

The impact factor can be found in **Journal Citation Reports (JCR)**. The JCR is a tool that keeps track of the numbers of citations to articles published in top-tier scholarly journals in the hard and social sciences. Impact factor is not the only indicator of impact provided by JCR. Because the value of information in a discipline differs per how it is produced, disseminated, and used by members of a scholarly community, comparing the different indicators of several journals can help to better understand their relative importance.

The impact factor relates to a specific period; it is possible to calculate it for any desired period, and the Journal Citation Reports (JCR) also includes a five-year impact factor.

b) 5-Year Journal Impact Factor

The 5-year journal Impact Factor is the average number of times articles from the journal published in the past five years have been cited in the JCR year. It is calculated by dividing the number of citations in the JCR year by the total number of articles published in the five previous years.

c) SJR (SCImago Journal Rank Indicator)

SCImago Journal Rank (SJR indicator) has been developed by research group of Spanish National Research Council (*Consejo Superior de Investigaciones Científicas, CSIC*) and the universities of Granada, Extremadura, Carlos III (Madrid) and Alcalá de Henares respectively. With SJR, the research area, quality and reputation of the scientific journal have a direct impact on the value of the citation. Therefore, the citation of a journal with a high SJR is worth more than the citation in a journal with a lower SJR. Same can be consulted in SCImago Journal Rank, Scopus.

d) h-Index Indicator

Hirsch indicator is one of the most relevant indicators to evaluate the scientific production of a researcher. h-index is based on the set of the scientist's most cited papers and the number of citations that they have received in other publications. For example, if we have a researcher with 5 publications A, B, C, D, and E with 10, 8, 5, 4, and 3 citations, respectively, the h index is equal to 4 because the 4th publication has 4 citations and the 5th has only 3. In contrast, if the same publications have 25, 8, 5, 3, and 3, then the index is 3 because the fourth paper has only 3 citations. It can be consulted in the Web of Science, Scopus and Google Scholar.

Among the variants of this indicator are:

- The h-core of a publication is a set of top cited h articles from the publication. These are the articles that the h-index is based on. For example, the publication above has the h-core with three articles, those cited by 17, 9, and 6.
- The h-median of a publication is the median of the citation counts in its h-core. For example, the h-median of the publication above is 9. The h-median is a measure of the distribution of citations to the articles in the h-core.
- The h5-index, h5-core, and h5-median of a publication are, respectively, the h-index, h-core, and h-median of only those of its articles that were published in the last five complete calendar years.

e) SNIP (Source Normalized Impact per Paper)

This Indicator has been designed at the University of Leiden; it allows to compare the impact of journals from different subject areas, while correcting the differences in the probability of being cited between journals of different subjects and even between journals of the same knowledge area.

f) G Index

It is an indicator which quite like h-index indicator, quantifies the bibliometric productivity based on the history of publications of the authors. It was proposed by Leo Egghe in 2006; it is also calculated from the distribution of citations received by the publications of a specific researcher. As it is like the h-index, but more complex in its calculation, being bigger and more variable, it allows us to distinguish between authors with similar h-index. It can be consulted in h-Index Scholar.

g) Immediacy Index

It measures the speed with which the articles of a scientific journal are cited and allows the identification of leading journals in research of wide repercussion. To find it, we must carry out the following calculation: $A = B / C$, where A is the immediacy index of the Journal X in 2009 B, the number of citations received in 2009 of articles published in Journal X in 2009, and C Number of articles published in the Journal X in 2009. It can be consulted through JCR.

h) Quartiles and Tertiles

It is an indicator or position measurement indicator of a Journal in relation to all its area, for example if we divide in 4 (quartiles) or 3 (tertiles) parts equal to a list of journals which are ordered from highest to lowest impact factor, then each of these parts will be a quartile or tertile respectively. The journals with the highest impact factor will be in the first quartile / tertile.

1.2.2.2. Relative quality of journals

a) Journal Citation Reports

Journal Citation Reports offers a systematic, objective means to critically evaluate the world's leading journals, with quantifiable, statistical information based on citation data. By compiling article's cited references, JCR helps to measure research influence and impact at the journal and category levels, and shows the relationship between citing and cited journals.

Thomson Scientific (formerly ISI, Institute for Scientific Information) analyzes journal citation patterns to determine "Impact Factors". These values are used to measure the importance of individual journals relative to other titles in their field. The annual Journal Citation Reports for Sciences and Social Sciences journals compile these data into ranked lists of journals.

Journal Citation Reports is an annual publication by the Intellectual Property and Science business of Thomson Reuters. It has been integrated with the Web of Science and is accessed from the Web of Science-Core Collections. It provides information about academic journals in the sciences and social sciences, including impact factors. The JCR was originally published as a part of Science Citation Index. Currently, the JCR, as a distinct service, is based on citations compiled from the Science Citation Index Expanded and the Social Science Citation Index.

Journal Citation Reports provides easy access to data that helps to evaluate and compare scholarly journals. It is an essential, comprehensive, and unique resource tool for journal evaluation, using citation data drawn from over 7,500 journals from over 3,300 publishers in over 60 nations. Journal Citation Reports is the only source of citation data on journals. It includes virtually all specialties in the areas of science, technology, and the social sciences.

Incites Journal citation reports, master search feature enables user to search for journal titles using the JCR abbreviated journal title, the full journal title, ISSN or eISSN number, etc. From the results, title of choice or journal's profile page can be selected. Clicking any of the hyperlinked years listed for a journal will take to a ranked list of journals for the year selected.

Categories by Rank page (Figure 7) allows user to customize information displayed within both the network graph and its accompanying data table to provide a tailored view of interrelationships between subject categories and the supporting indicators. Combination of the filters described below allows user to construct a view to meet the according needs (Figure 8).

Go to Journal Profile	Journals By Rank		Categories By Rank				
	Master Search		All Journal Categories ranked by Number of Journals				
Select Journals			1 - 25 of 234				
			Customize Indicators				
Select Categories	Category	Edition	#Journals	Total Cites	Median Impact Factor	Aggregate Impact Factor	
Select JCR Year	1	ECONOMICS	SSCI	345	608,521	0.829	1.336
2015	2	MATHEMATICS	SCIE	312	405,433	0.614	0.735
	3	BIOCHEMISTRY & MOLECULAR BIOLOGY	SCIE	289	3,273,965	2.670	4.093
Select Edition	4	MATERIALS SCIENCE, MULTIDISCIPLINARY	SCIE	271	2,561,259	1.642	3.984
	5	ENGINEERING, ELECTRICAL & ELECTRONIC	SCIE	257	1,039,294	1.277	1.847
☒ SCIE ☒ SSCI	6	NEUROSCIENCES	SCIE	256	2,053,415	2.706	3.900
	7	PHARMACOLOGY & PHARMACY	SCIE	255	1,342,294	2.330	3.039
Clear Submit	8	MATHEMATICS, APPLIED	SCIE	254	424,549	0.801	1.064
	9	EDUCATION & EDUCATIONAL RESEARCH	SSCI	231	202,093	0.896	1.059
	10	ENVIRONMENTAL SCIENCES	SCIE	225	1,412,031	1.737	3.107
	11	ONCOLOGY	SCIE	213	1,634,966	2.915	4.315
	12	PLANT SCIENCES	SCIE	209	927,887	1.351	2.664
	13	SURGERY	SCIE	200	1,000,968	1.566	2.233
	14	CLINICAL NEUROLOGY	SCIE	193	1,064,433	2.291	3.186
	15	MANAGEMENT	SSCI	192	470,513	1.278	1.896
	16	CELL BIOLOGY	SCIE	187	1,901,313	3.181	5.602
	17	GEOSCIENCES, MULTIDISCIPLINARY	SCIE	184	894,708	1.659	2.631
	18	LINGUISTICS	SSCI	181	105,399	0.568	1.007
	19	PUBLIC, ENVIRONMENTAL & ...	SCIE	173	718,123	1.628	2.463

Figure 7: Incites interface for categories by rank.

Description: Figure represents GUI categories by rank allows user to customize information in data table format to view of interrelationships between subject categories and the supporting indicators.

Go to Journal Profile	Journals By Rank		Categories By Rank				
	Master Search		All Journal Categories ranked by Number of Journals				
Select Journals			1 - 25 of 234				
			Customize Indicators				
Select Categories	Category	Edition	#Journals	Total Cites	Median Impact Factor	Aggregate Impact Factor	
Select JCR Year	1	ECONOMICS	SSCI	345	608,521	0.829	1.336
2015	2	MATHEMATICS	SCIE	312	405,433	0.614	0.735
	3	BIOCHEMISTRY & MOLECULAR BIOLOGY	SCIE	289	3,273,965	2.670	4.093
Select Edition	4	MATERIALS SCIENCE, MULTIDISCIPLINARY	SCIE	271	2,561,259	1.642	3.984
	5	ENGINEERING, ELECTRICAL & ELECTRONIC	SCIE	257	1,039,294	1.277	1.847
☒ SCIE ☒ SSCI	6	NEUROSCIENCES	SCIE	256	2,053,415	2.706	3.900
	7	PHARMACOLOGY & PHARMACY	SCIE	255	1,342,294	2.330	3.039
Clear Submit	8	MATHEMATICS, APPLIED	SCIE	254	424,549	0.801	1.064
	9	EDUCATION & EDUCATIONAL RESEARCH	SSCI	231	202,093	0.896	1.059
	10	ENVIRONMENTAL SCIENCES	SCIE	225	1,412,031	1.737	3.107
	11	ONCOLOGY	SCIE	213	1,634,966	2.915	4.315
	12	PLANT SCIENCES	SCIE	209	927,887	1.351	2.664
	13	SURGERY	SCIE	200	1,000,968	1.566	2.233
	14	CLINICAL NEUROLOGY	SCIE	193	1,064,433	2.291	3.186
	15	MANAGEMENT	SSCI	192	470,513	1.278	1.896
	16	CELL BIOLOGY	SCIE	187	1,901,313	3.181	5.602
	17	GEOSCIENCES, MULTIDISCIPLINARY	SCIE	184	894,708	1.659	2.631
	18	LINGUISTICS	SSCI	181	105,399	0.568	1.007
	19	PUBLIC, ENVIRONMENTAL & ...	SCIE	173	718,123	1.628	2.463

Figure 8: Incites interface for categories by rank for selected categories filter.

Description: Figure represents GUI categories by rank for selected categories filter All metrics related to a subject category in the Journal Citation Record are provided, including: number of journals and articles in the category, total cites, median Impact Factor, Aggregate Impact Factor, Aggregate Immediacy Index, Cited and Citing category half-life. Each entry reflects data for that JCR year.

Select Journals-Enables to search for journals by full journal title, JCR Abbreviated Title, ISSN. The network graph and table will update for those journals selected and depict the relationships represented by the subject categories within which those journals are indexed. Select Categories- Allows to view relationships between those subject categories. The network graph will display interrelations between the categories selected and table will update with indicator data for each subject category.

- Select JCR Year: Selects year to see JCR information.
- Select Edition: Select edition for to see results.

Go to Journal Profile		Journals By Rank	Categories By Rank			
<div>Master Search</div> <div></div>		Journal Titles Ranked by Impact Factor				Show Visualization +
Compare Journals		Compare Selected Journals		Add Journals to New or Existing List		Customize Indicators
View Title Changes		Select All	Full Journal Title	Total Cites	Journal Impact Factor	Eigenfactor Score
		☐	1 IEEE Transactions on Cybernetics	2,246	4.943	0.01020
Select Journals		☐	2 HUMAN-COMPUTER INTERACTION	1,123	3.700	0.00130
Select Categories		☐	3 USER MODELING AND USER-ADAPTED INTERACTION	655	2.292	0.00099
Select JCR Year		☐	4 IEEE Transactions on Affective Computing	520	1.873	0.00279
Select Edition		☐	5 IEEE Transactions on Human-Machine Systems	239	1.800	0.00079
Open Access		☐	6 BIOLOGICAL CYBERNETICS	4,172	1.611	0.00294
Category Schema		☐	7 IEEE Transactions on Systems Man Cybernetics-Systems	3,462	1.598	0.00723
		☐	8 INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES	3,015	1.476	0.00287

Figure 9: Incites interface for journal by rank.

Description: Figure represents GUI journals by rank allows user customize information in data table format to view inter relationships for journals in a selected subject category as well as specific indicators relating to each title.

Journals by Rank page enables to see the relationships for journals in a selected subject category as well as specific indicators relating to each title, displayed within a customizable table (Figure 9).

Figure 10: Incites interface for journal by rank for customize indicators.

Description: Figure represents GUI journals by rank with customize indicators that allows user to customize information in data table format to view interrelationships between indicators like Total cites, Journal Impact factor, Eigenfactor score etc.

Customization of indicators that allows user to tune the information in data table format to view interrelationships between indicators like Total cites, Journal Impact factor, Eigenfactor score etc. (Figure 10).

b) Scimago Journal Rank (SJR)

This portal form analyzes, from the journals included in the Scopus, the bibliometric indexes of about 16,000 journals. It is an open access platform for the evaluation of the impact and scientific performance of journals and countries, developed by the Scimago research group.

c) Scielo (Scientific Electronic Library Online)

Scientific library of journals is from Latin American and Caribbean countries. It includes editorial data and impact data from each journal: impact factor, half-life, received citations and granted citations. After locating the journal, enter "statistics" to see the indicators of its use and its impact.

1.2.3. Statistical Tools

The main databases have been developed through tools to perform statistical analysis of articles, for conducting basic scientometric analysis.

1.2.3.1. Statistical Tool of Web of Science

After obtaining the list of author's publications using from the Web of Science

- While viewing the list of author's publications in the Author Search Results window, click on Analyze results (Figure 11).

Figure 11: Statistical tool of WOS GUI.

- In the Results Analysis window, there are various ways to analyze the results depending on the option chosen under the Rank the records by this field column (Figure 12).

Figure 12: Result analysis GUIs of WOS statistical tool.

- Under the Set display options, entire list of analyzed results can be seen, ensure that the number of results chosen tallies with the number of records to be analyzed and change the default setting of Minimum record count (Figure 13).

Figure 13: Result analysis GUIs of WOS statistical tool, query results.

- In this example, select up to 500 results and set the Minimum record count (threshold) to 2 (Figure 14). In the same Results Analysis window, under the Rank the records by this field column: select Authors. Leave the default as Sort by: Record count and click on Analyze. From the analyzed results, it is possible to filter: Countries/Territories and Organizations and Enhanced organizations and Publication years.

Figure 14: Result analysis GUIs of WOS statistical tool, selection 500 max records.

1.2.3.2. Statistical Tool of Scopus

Scopus is the largest abstract and citation database of peer-reviewed literature, and features smart tools that allows user to track, analyze and visualize scholarly research. Scopus includes content from more than 5,000 publishers and more than 105 different countries.

Statistical application of Scopus allows to perform following functions:

- Scopus database provides search interface, to find the right result and to uncover trends, to discover sources and collaborators, and to build further insights. Scopus carries search in multiple ways like document search, Author search, Affiliation search, Advanced search, Refine results, Language interface etc. (Figure 15).

The screenshot shows the Scopus search interface. At the top, there's a navigation bar with 'Search', 'Alerts', 'My list', and 'Settings'. A callout box highlights a message: 'To see a complete list of the sources available, click the **Browse Sources** link on the Search page.' Below this, the 'Document search' tab is selected. The search bar contains the text 'Eg., "heart attack" AND stress'. To the right of the search bar, there's a dropdown menu for 'Article Title, Abstract, Keywords' and a search button. Below the search bar, there's a 'Limit to:' section with options for 'Date Range (inclusive)' (Published, Added to Scopus in the last 7 days) and 'Document Type' (ALL). There are also checkboxes for 'Subject Areas' (Life Sciences, Health Sciences, Physical Sciences, Social Sciences & Humanities). At the bottom, there's a footer with links for 'About Scopus', 'Language', 'Customer Service', and 'About Elsevier'.

Figure 15: Statistical tool Scopus: search interface for document search.

- Scopus database provides features analytical tools to help to better understand and gain important insights into the data. These tools include graphical displays, charts and tables that can be manipulated through multiple features, like Analyze search results, Compare journals, Article metric module, Citation overview, Author profile page etc. Analyze search results tool is used to understand search metrics better with a visual analysis of search results broken up into seven categories (year, source, author, affiliation, country or territory, document type and subject area) (Figure 16).

Scopus john user | Logout

Search | Alerts | My list | Settings Live Chat | Help | Tutorial

Subject Area: All Subject Areas Source Type: All Sources Display sources

Search: inc: Title Search

ABCDEF... Aa Ab Ac Ad Ae Af Ag Ah Ai Aj Ak Al Am An Ao Ap Aq Ar As At Au Av Aw Ax Az | All

Results: 20

You can browse all source titles alphabetically or by subject.

Source title	JR	SNIP
1 AAA, Arbeiten aus Anglistik und Amerikanistik	0.027	0.000
2 AAC: Augmentative and Alternative Communication	0.039	0.522
3 AACE International. Transactions of the Annual Meeting	0.027	0.016
4 AACN Advanced Critical Care	0.087	0.227
5 AACN clinical issues (coverage discontinued in Scopus)		
6 AACN clinical issues in critical care nursing (coverage discontinued in Scopus)		
7 AANA Journal	0.046	0.145
8 AANNT journal / the American Association of Nephrology Nurses and Technicians (coverage discontinued in Scopus)		
9 AAO Journal	0.027	
10 AAOHN Journal	0.045	0.143
11 AAPG Memoir (coverage discontinued in Scopus)		
12 AAPJ Nexus (on CSA Illumina) (coverage discontinued in Scopus)		
13 AAPPO journal : the Journal of the American Association of Preferred Provider Organizations (coverage discontinued in Scopus)		
14 AAPS Journal	0.312	0.874
15 AAPS PharmSci (coverage discontinued in Scopus)		
16 AAPS PharmSciTech	0.070	0.318

Figure 16: Statistical tool Scopus: result analysis interface.

- Scopus database provides research metrics tool that gives a balanced, multi-dimensional view for assessing the value of published research, to offer an evolving basket of metrics that complement more qualitative insights, which is divided in to three categories Journal metrics, Author metrics, Article level metrics, e.g. journal metrics offers the value of context with their citation measuring tools (Figure 17).

Scopus john user | Logout

Search | Alerts | My list | Settings Live Chat | Help | Tutorial

EBSCO Host(opens in a new window) | SpringerLink(opens in a new window) | BIBSYSx document delivery service(opens in a new window)

AAPS Journal
Formerly known as: AAPS PharmSci
Subject Area: Pharmacology, Toxicology and Pharmaceuticals: Pharmaceutical Science
Publisher: American Association of Pharmaceutical Scientists
ISSN: 1550-7416
Scopus Coverage Years: from 1999 to 2009

Follow this source Receive emails when new documents are available in Scopus

Journal Metrics
Scopus Journal Metrics offer the value of context with their citation measuring tools. The metrics below allow for direct comparison of journals, independent of their subject classification. To learn more, visit www.journalmetrics.com.

SJR (SCImago Journal Rankings) (2008) : 0.312
SNIP (Source Normalized Impact per Paper) (2009) : 0.874

Compare with other Sources in Journal Analyzer

Documents available from

Latest issue:	Volume 15, Issue 1 (January 2013)
2013	2 documents
2012	16 documents
2011	8 documents
2010	7 documents
2009	12 documents
2008	11 documents
2007	6 documents

Figure 17: Statistical tool Scopus: journal metric interface.

1.2.3.3. Statistical Tool of Google Scholar

Google Scholar Metrics provide an easy way for authors to quickly search the visibility and influence of recent articles in scholarly publications. Scholar Metrics summarize recent citations to many publications, to help authors as they consider where to publish their new research. The available statistics are h-index, h-core, h-median, h5-index, h5-median (Figure 18).

Google Scholar

cybernetics

Search Scholar

Metrics

Top 20 publications matching *cybernetics* [Learn more](#)

Publication	h5-index	h5-median
1. IEEE Transactions On Systems, Man And Cybernetics Part B, Cybernetics	61	90
2. IEEE Transactions on Systems, Man, and Cybernetics Part C, Applications and Reviews	47	75
3. IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans	40	53
4. IEEE Transactions on Cybernetics	30	43
5. International Journal of Machine Learning and Cybernetics	25	42
6. Biological Cybernetics	23	44
7. IEEE International Conference on Systems, Man and Cybernetics	22	27
8. IEEE Transactions on Systems, Man, and Cybernetics: Systems	17	24
9. International Conference on Machine Learning and Cybernetics	16	24
10. Cybernetics and Systems	14	19
11. International Conference on Intelligent Human-Machine Systems and Cybernetics	11	17
12. Control and Cybernetics	11	14
13. Economic Computation and Economic Cybernetics Studies and Research	10	16
14. Cybernetics and Systems Analysis	10	12
15. IEEE International Conference on Computational Cybernetics	9	12

Figure 18: Statistical tool of Google scholar: h5-index and h5-meidan results interface.

1.2.4. Bibliometric reference management tools

There are numerous of bibliometric references management tools like Aigaion, Bebop, BibSonomy, Bibus, Citavi, CiteULike, Docear, Mendeley, Pybliographer, Qiqqa, Reference Manager, SciRef, Wikindx, WizFolio and Zotero etc can store, manage and cite thousands of references. This thesis has used EndNote because of compliance features like operating system support, Import file formats, Reference list file formats, database connectivity, password "protection" etc. and easy availability of this tool in research department of Technical School of Agronomic, Food and Biosystems Engineering.

1.2.4.1. EndNote

Search online bibliographic resources and retrieve references directly in to the EndNote library. EndNote groups citations into "libraries" with the file extension *.enl and a corresponding *.data folder. There are several ways to add a reference to a library: manually, exporting, importing, copying from another EndNote library, connecting from EndNote.

The program presents the user with a window containing a drop-down menu to select the type of reference they require (book, newspaper article, film, congressional legislation, etc.), and fields ranging from the general (author, title, year) to those specific to the kind of reference (ISBN, abstract, reporter's name, running time, etc.).

Most bibliographic databases allow users to export references to their EndNote libraries. This enables the user to select multiple citations and saves the user from having to manually enter the citation information and the abstracts. There are some databases (e.g. PubMed) in which the user needs to select citations, select a specific format, and save them as.txt files.

By then going to EndNote, the user can then import the citations into the EndNote software. It is also possible to search library catalogues and free databases such as PubMed from within the EndNote software program itself. If the user fills out the necessary fields, EndNote can automatically format the citation into whatever format the user wishes from a list of over two thousand different styles. In Windows, EndNote creates a file with an *.enl extension, along with a *.data folder containing various MySQL files with *.myi and *.myd extensions.

EndNote can be installed so that its features, like cite while user write, appear in the tools menu of Microsoft Word and OpenOffice.org Writer.

EndNote can export citation libraries as plain text, Rich Text Format, HTML or XML. The current version of EndNote has networking capabilities, and files can reside on a central server. It does not, however, have multi-user capabilities for editing a single bibliographic file.

Endnote can also organize PDFs on the user's hard drive (full text on the web) through links to files or by inserting copies of PDFs. It is also possible to save a single image, document, Excel spreadsheet, or other file type to each reference in an EndNote library.

Starting from EndNote X version 1.0.1, formatting support for OpenDocument files (ODT) using the Format Paper command is supported. EndNote X7 support multiple features like search, insert citations, share library, organize references, sync library, view and annotate pdfs (Figure 19).

With the Online Search command, user can search online bibliographic databases just as easy as to search an EndNote library on computer. The results of search can be downloaded (Figure 20), into a temporary EndNote library or directly into EndNote library. EndNote 7 provide following functionalities:

- Selecting a display mode
- Searching a database-WOS
- Reviewing references
- Deleting references
- Finding full text for a reference
- Selecting an import filter and importing data into EndNote
- Downloading records
- Exporting records from Web of Science

Figure 19: EndNote7 and supported features and EndNote 7query window GUI.

Description: Endnote query window with graphical user interface details like search, reference organization, lib sync, insert citations, lib share functionalities.

Source: EndNote user guide (<http://endnote.com/training/mats/enuserguide/>).

Figure 20: EndNote 7 search results GUI.

Often when user search a database, the matching references display as text, with no clear indicator between each piece of bibliographic information. There is no clear indicator for EndNote to be able to differentiate a title from an address or an abstract. To use this information effectively, user must consistently tag each piece of the information so that EndNote can direct it to the correct EndNote field. Database providers typically offer several different download formats. Regardless of which system user is searching, need to save the references in a tagged format to a text file. Later, each tag to a corresponding EndNote field can be mapped. If the data are inconsistently tagged, or poorly delimited, it may not be possible to import all the data accurately.

To use this information effectively, user must consistently tag each piece of the information so that EndNote can direct it to the correct EndNote field. Database providers typically offer several different download formats. Regardless of which system is searched, need to save the references in a tagged format to a text file.

By default, a reference is considered a duplicate if the Author, Year, Title, and Reference Type match a reference already in the library. The duplicates criteria under EndNote Preferences can be changed. We will import all references regardless of duplicates.

Bibliographic records from the Web of Science platform can easily exported. A subscription to Web of Science is required. The system exports the records to a temporary group called Imported References. Having the database open EndNote, export 500 records each time (Figure 21).

Figure 21: Window EndNote 7 exported record views.

1.3. SCIENTOMETRICS STUDY HIGHLIGHTS

1.3.1. Overview through highly cited research papers

Literature review is an objective analysis of contributions made by authors, researchers, experts including technical specialists on a subject area or research topic. The very purpose of a literature review is to understand the experimented methods, techniques and skills of a phenomenon and its procedural presentation. This is believed to guide the researcher to formulate and identify the objectives, hypothesis, methods for collection and analysis of data. So, in this literature review more than 2400 articles and reviews have been found while searching for title “scientometric” and “bibliometric” under the research domain of science technology, without specific time.

Considering the large number of publications, to get an overview of methodologies and indicators used in scientometrics, this chapter is focused on most cited research articles, along with interesting articles which have been published recently. The following is a series of conclusions on the methodological aspects of the articles analyzed. In Annex 2 a summary can be consulted related to highlights of each of the articles.

It has been found that majority of articles with higher number of citations have utilized unique database in their studies [e.g. (de Solla Price, 1976; Glanzel & Moed, 2002; Glanzel & Schubert, 2003; King, 1987; Moed et al., 1995; Nederhof, 2006; Persson et al., 2004; Van Raan, 2005, 2006; vanRaan, 1996)]. The most common are those contained in WOS (Science Citation Index (SCI), Social Science Citation index (SSCI) and Arts & Humanities Citation Index (A&HCI) databases, etc.).

However, in the articles published in recent years, it is becoming more common to use other databases such as Scopus, Google Scholar, etc.

Broadly speaking, the scientometric articles analyzed can be classified into two main groups: studies focusing on methodological aspects (like usefulness and relevance of indicators, proposal for new indicators, databases etc.) and second one applied research works which are focused on the analysis of research subject in a specific context (region, periods etc.).

In reference to applicable research work, the analyzed research disciplines are quiet diverse like health care (Grant et al., 2000), biomedical (Khalsa, 2004), homeopathy (Chiu & Ho, 2005), microbiology (Vergidis et al., 2005), humanities and social and behavioral science (Nederhof, 2006), telecommunication (Chao et al., 2007; Nederhof, 2006; Schubert et al., 1989), tsunami research (Chiu & Ho, 2007), international scientific cooperation (Glanzel et al., 1999), mathematics, engineering, chemistry and physics (Braun et al., 1995), tropical medicine (Falagas et al., 2006), world aerosol research (Xie et al., 2008), stem cell research (Li et al., 2009), algae and bio-energy (Konur, 2011), renewable and sustainable energy (Montoya et al., 2014), Zika (Martinez-Pulgarin et al., 2016), fuzzy logic (Merigo et al., 2015), paracetamol (Zyoud et al., 2015b), etc.

In addition, it has been observed that most of these researches have been carried out in advanced countries like USA, European countries or G-8 Countries; for example USA (de Solla Price, 1976; Subramanyam, 1983; Vinkler, 2009), UK (Hamers et al., 1989; King, 1987; Rip & Courtial, 1984), Belgium

(Garfield, 2009), Hungary (van Eck & Waltman, 2010), Netherlands (Cantos-Mateos et al., 2012), Spain (Montoya et al., 2014), etc. However, there is great variability in the areas studied, including worldwide studies.

Also, time period used by the authors of listed research articles is quite diverse, for example, 1 year (Glanzel & Schoepflin, 1999), 6 years (Aksnes & Taxt, 2004), 8 years (Grant et al., 2000), 10 years (van Leeuwen et al., 2003), 13 years (Chiu & Ho, 2005), 14 years (Wen-Ta & Yuh-Shan, 2007), 16 years (Xie et al., 2008), 20 years (Uzun, 2002), 30 years (Vinkler, 2000), 36 years (Moin et al., 2005), 42 years (Khalsa, 2004), etc. Given its importance, the following section explores about the indicators used and performed analysis.

1.3.2. Principal indicators and analyzed aspects

The objective of this study is to justify the research activity through defined methodology and indicators, according indicators are distinguished via three major groups are as following:

1.3.2.1. Quantitative Indicators

These indicators serve to quantify the productivity of an author, research group, institution, region and / or country, same like the world production in a predetermined period. The most commonly used indicator is Number of publications in indexed journals [e.g. (Aleixandre-Benavent et al., 2012; Annibaldi et al., 2010; Ascanio & Puime, 2007; Bordons & Barrigon, 1992; Bornmann & Mutz, 2015; Bornmann et al., 2009; Colantonio et al., 2015; Jehoda, 2006; Merigo et al., 2015; Wiles et al., 2012; Zyoud et al., 2015a), etc.].

This indicator counts productivity regardless about the number of authors and / or institutions those have participated in the related research work. To quantify the participation of different authors, many research works calculate the number of authors [e.g. (Abramo et al., 2009; Abrizah et al., 2012; Al et al., 2006; Glanzel, 2002; Glanzel et al., 2004; Hirsch, 2010; Zhou et al., 2007), etc.]. Also frequent number of research centers (Bordons & Barrigon, 1992; Montoya et al., 2014; Rojas-Sola & Jorda-Albinana, 2009a; Rojas-Sola & San-Antonio-Gomez, 2010b; Rosas et al., 2011; Voracek & Loibl, 2009) and / or number of countries participating in each article (Chen et al., 2007; Katz & Hicks, 1997; Keiser & Utzinger, 2005; Uzun, 2004).

However, there are few studies about calculated weigh productivity with respect to the participation of number of authors and institutions [e.g. (Buela-Casal et al., 2003; Canas-Guerrero et al., 2013b; Greenberg et al., 2010; Rojas-Sola & Aguilera-Garcia, 2014, 2015; Rojas-Sola & Jorda-Albinana, 2009a, 2009b; Rojas-Sola & San-Antonio-Gomez, 2010a, 2010b, 2010c)].

1.3.2.2. Qualitative indicators

These indicators are used to determine the impact and quality of research carried out by an authors/coauthors research groups, institutions, regions and / or countries, etc.

The most commonly used indicator is the number of citations received [e.g. (Canavero et al., 2014; Cardona & Marx, 2007; Cartes-Velasquez V et al., 2012; Costas & Bordons, 2005; Fernandez Baena & Garcia Pccrz, 2003; Garcia Rio et al., 1998; Jemec & Nybaek, 2006; Lomonte & Ainsworth, 2002; Narin & Hamilton, 1996; Petrak, 2001; Rodriguez-Navarro, 2011; Rojas-Sola & Jorda-Albinana, 2009a; Rojas-Sola et al., 2009; Sagar et al., 2014; Schloegl & Stock, 2004; Tortosa Serrano et al., 1998; Vanecek, 2008)].

This indicator has different variants depending on whether or not the self-citations are considered [e.g. (Bakri & Willett, 2009; Blagus et al., 2015; Cabrini Gracio et al., 2013; Fernandez-Fernandez et al., 2013; Glanzel & Thijs, 2004; Gopalakrishnan et al., 2015; Gurbuz et al., 2015; Heneberg, 2014; Kulasegarah & Fenton, 2010; van Mark et al., 2011; van Raan, 2008, 2012)].

Some research papers use impact indicators from journals in the year of publication to determine the impact of published papers. Thus, several authors assigns the IF of the JCR to each research work, while calculating the average IF [e.g. (Rojas-Sola & Aguilera-Garcia, 2014, 2015; Rojas-Sola & Jorda-Albinana, 2009a; Rojas-Sola et al., 2009; Rojas-Sola & San-Antonio-Gomez, 2010a, 2010b, 2010c, 2010e)].

Another indicator h-index which is based on the set of the scientist's most cited papers and the number of citations that they have received in other publications. The index can also be applied to the productivity and impact of a scholarly journal as well as a group of scientists, such as a department or university or country (Aznar & Guerrero, 2011; Costas & Bordons, 2007; Rojas-Sola & Aguilera-Garcia, 2014, 2015; Saad, 2006; Van Raan, 2006).

1.3.2.3. Other indicators and analysis

The literature review highlights the importance of studying the existing types of collaborations in a given discipline, or between research centers and / or specific countries [e.g. (Beck, 2012; Fathi et al., 2015; Guilera et al., 2013; Guozhu et al., 2015; Kademani et al., 2001; Kalaiappan et al., 2010; Moed, 2000; Moreno-Cabo & Solaz-Portoles, 2008; Noruzi & Abdekhoda, 2014; Ohlendorf et al., 2015; Pajares Vinardell & Freire Macias, 2007; Rojas-Sola & Jorda-Albinana, 2011; Ruiz et al., 2002; Siwach & Kumar, 2015; Vilibic, 2009)].

Additionally, researchers specified some specific findings importance of collaborations. Subramanyam (Subramanyam, 1983) has found that the degree of collaboration in a specific discipline is defined as the ratio of the number of collaborative research papers to the total number of research papers published in a certain period of time.

Glanzel (Glanzel, 2002) has concluded that multi-authored papers are more likely to be cited, and attract more citations, than single-authored papers was strongly supported and proved to be universal.

Katz and Hicks (Katz & Hicks, 1997) has derived calibrated bibliometric model that demonstrates that collaborating with an author from the home institution or another domestic institution increases the average impact by approximately 0.75 citations while collaborating with an author from a foreign institution increases the impact by about 1.6 citations. Research article has concluded that papers involving collaboration with a foreign institution have greater impact than papers with collaborations with an author from the same or another domestic

institution. It has been found that various types of collaborations have been used to evaluate the collaboration factor in scientometrics; the results show the importance of the carried-out collaborations, justifying the need for further study like matrix of collaborations between countries and between research centres or average number of authors participating in the research articles of the country or research centre, etc.

Another aspects are addressed through the usage of keyword indicator in respective research's keywords like way to identify the most relevant research topics& trends and their evolution over time [e.g. (Canas-Guerrero et al., 2013a; Cruz-Ramirez et al., 2014; Fiala & Ho, 2015; Gao et al., 2015; Huibin et al., 2013; Koganuramath et al., 2004; Lee & Sang, 2007; Mesdaghinia et al., 2015; Mijac & Ryder, 2009; Morrone & Guerrero, 2008; Noyons & Vanraan, 1994; Ran-Chou et al., 2009; Sanz-Valero et al., 2014; Sinha, 2012; Suraud et al., 1995; Tomas-Castera et al., 2010; Uribe et al., 2014; Zhou & Zhao, 2015)].

Ding et al. (Ding et al., 2001) has utilized Science Citation Index (SCI) for retrieval of specific research articles in the time period of 10 years. It has been stated in this research that Co-word analysis enables the structuring of data at various levels of analysis: as networks of links and nodes; as distributions of interacting networks; and as transformation of networks over time periods. This study demonstrates the feasibility of co-word analysis as a viable approach for extracting patterns from, and identifying trends, in large corpora where the texts collected are from the same domain or sub-domain and are divided into roughly equivalent quantities for different time periods. Also, Cantos-Mateos et al. (Cantos-Mateos et al., 2012) answered the research questions about co-word categories and its related supply complementary information like usage of keywords as an adequate unit of analysis for thematic delimitation at the document level. He has also visualized this concept using software VOSviewer, while taking a matrix of co-occurrence of the more than 6,199 unique Keywords Plus, which were standardized by the measure of strength of association.

Nevertheless, in most of the cases the articles we have cited do not decompose keywords. The study of the journals where the articles of a given discipline are published is also dealt with by several authors [e.g. (Agudelo et al., 2004; Franceschini & Maisano, 2010; Harper, 1991; Leminor & Dostatni, 1991; Primo et al., 2014)].

Some authors also have performed analysis on the language in which the research works have been published [e.g. (BrachoRiquelme et al., 1997; Diekhoff et al., 2013; Rodríguez & Rodríguez, 2013; Rojas-Sola & Aguilera-Garcia, 2014; Singh et al., 2007; Vakilian et al., 2015; Yue et al., 2014; Zell et al., 2010)].

The results analysis tools of the main databases allow the calculation of general values of some of the mentioned indicators. Thus, for example, from a selection of articles, WOS allows to obtain information on the number of articles published by the different Authors, articles published per Countries / Territories, number of articles per Databases, number of articles by research Institutions, number of articles per Languages and number of articles in the different journals.

The question of the appropriateness of the methodology is certainly in both a scientific and in a practical sense most crucial. Scientometric approaches can be combined to a broader and powerful methodology to observe scientific advancement and the role of actors (vanRaen, 1996). So, reviewed research studies are very diverse and heterogeneous, researcher has found that it is necessary to develop a methodology to conduct a

study of a global nature, to analyze simultaneously the main indicators used by other authors and improve certain limitations (like weighting the number of articles, the research impact of countries or centers, composite keywords etc.). Note that the arguments that justify our study and differentiate this research from the rest are as follows:

- ✓ Research of global character that attempts to address all indicators simultaneously.
- ✓ Assess number of publications while considering the number of countries or institutions involved.
- ✓ Calculates a Year Impact Factor (YIF) for a group of papers (from a research area, country, research centre), which assesses the average quality of publications.
- ✓ Analyze the keywords both composite form and analyzing the component words, unifying singular and plural keywords.
- ✓ Determine the collaborations not only between countries but also between research centers.
- ✓ Study of percentage of publications in major journals to detect certain inbred behaviors.

2. OBJECTIVES

The main objective of this thesis is to develop a methodology to carry out scientometric analysis of a global character, by combining different complementary approaches which permits to characterize the worldwide research of a study field in an integral and comprehensive form. Thus, the characterization of research activity is based on the following specific objectives:

To reveal the evolution of the most frequent research topics in a category or scientific area through the processing of keywords. The analysis of keywords might be important for monitoring development and directions of science and research activity, helping researchers to identify research areas that are gaining strength and the research topics which are relegated into disuse.

To reveal the evolution of geographical distribution of publications, through productivity, impact and collaborations analysis. The results provide a framework for assessing research activity in a specific and realistic context.

To determine the institutional distribution of publications, through productivity, impact and collaborations analysis, creating a worldwide ranking of leading research centres. This information could help worldwide research institutions to evaluate research plans or investment strategies and to make decisions related to old or new research collaborations.

To establish the effectiveness of the diffusion and internationalization of the worldwide research journals of the field.

Also, for the accomplishment of the outlined objectives it is necessary to develop a computer application to carry out the analysis from the same reference frame, and to overcome some of the limitations of actual existing tools (like inability to analyze simultaneously the keywords defined by the authors as well as the words that make up those keywords, grouping terms of keywords like singular and plural forms; weighing of scientific production with respect to participating research centres or countries; production based qualitative classification of countries and research centres through the Impact Factor of their publications, etc.).

Finally, to determine the validity of the developed methodology, it will be applied to the characterization of specific fields. To achieve this, two research fields have been selected from available Web of Science (WOS) categories; which are in the confluence of author technical education ("Master of Computer Applications"), the doctoral program (PhD in AgroEngineering) and the departmental unit where the final thesis is developed (Energy and Electrical Engineering). Thus, the research activity is characterized in the fields of hardware architecture and cybernetics:

- Hardware architecture can be defined as the representation of an engineered electronic or electro mechanical hardware system, and the process and discipline for effectively implementing the design for such system.
- Cybernetics can be defined as the study of analogies between control and communication systems of living things and machines; and the technological applications of biological regulatory mechanisms.

3. MATERIALS AND METHODS

3.1. DESIGN OF METHODOLOGY TO PERFORM A GLOBAL SCIENTOMETRIC ANALYSIS

3.1.1. Introduction

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Typically, it encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques (Irny & Rose, 2005).

A methodology to carry out scientometric analysis of a global character, by combining different complementary approaches which permits to characterize the worldwide research of a study field in a comprehensive form, is to be developed. The methodology will be based on four basic pillars:

- To reveal the evolution of the most frequent research topics.
- To reveal the evolution of geographical distribution of publications.
- To determine the institutional distribution of publications.
- To establish the effectiveness of the diffusion and internationalization of the worldwide research journals of the field.

The methodology has been structured in three phases (Figure 22):

- 1) Choose a set of indicators to analyze four planned pillars.
- 2) Define an output template to synthesize and visualize a large amount of information comprehensively.
- 3) Develop a computer application to process millions of data sets, to calculate scientometric indicators and to generate related metric and graphical outputs.

Figure 22: Main stages with respect to development of the methodology.

3.1.2. Main resources utilized

Among different existing databases, researcher has chosen to use WOS because it is the most widely used and because of the reason that UPM (Universidad Politécnica de Madrid) has access to it, unlike others such as Scopus database. Each article has been downloaded with the following information: Reference Year, Keywords, Journal, Alternate Journal, Notes, Times Cited, Language, Author Address.

Researcher has used the Impact Factor as a basis for quantifying the impact of publications, as it is the most widespread one.

Journal Citation Report (JCR) comprises citation data, impact and influence metrics and millions of cited and citing journal data points from the Web of Science. So, JCR has been selected as a citation data resource because through this, researcher could perform a comprehensive, rich and deep explorative analysis of journals and its specific articles within a publication.

Statistical Analysis tool of Web of Science has been used as a mean of verification (for comparing certain indicators, like production according unweighted production, etc.).

To track the references and searchable database of references, for importing data, for downloading and exporting records from Web of Science, etc., EndNote software has been selected by researcher.

3.1.3. Scientometrics indicators

To achieve the described purposes, it is necessary to define some scientometric indicators to characterize the research activity both quantitatively and qualitatively.

It incorporates advances in the calculation of traditional indicators. These are, among others, the weighting of the number of research papers depending on the number of centres involved in each document, IF allocation to each research paper, the calculation of all existing contributions between countries and centres, combined treatment to the set of keywords with respect to singular and plural forms, or the analysis of the constituent words of composite keywords.

Following scientometric indicators are the basic pillars for the development of methodology with respect to scientometric analysis:

- Keywords Number.
- Number of weighted published research papers by the country or research centre.
- Contribution of each country or research centre to world production.
- Year impact factor of country or research centre.
- Number of citations of country or research centre.
- Established collaborations.
- Language Analysis.
- Journal internationalization.

a) Keywords Number (N_k)

The most frequent themes and topics of research are determined through the processing of the keywords which characterize each paper, scoring each one of them throughout the years. Generally, keywords are provided by the authors, and the extra plus information on the keywords is produced by ISI based on research paper's citations and references. Both author keywords and plus keyword is analyzed, through mathematically formulated "Keywords Number" Scientometric indicator.

This scientometric indicator must have following functionalities to perform the right evaluations:

- Mechanism to differentiate those keywords which have been defined previously.
- Interpretation mechanism of compound keywords, avoiding the differences in keywords for the simple presence of a dash, for example: "Artificial-intelligence" and "Artificial intelligence".
- Unify terms in uppercase and lowercase.

In described analysis, counts keywords as they have been defined by the authors, whether keywords are isolated words or compound words, have been called "compound keywords".

In addition to the one above "Keywords Number" indicator, can perform additional analysis, which accounts separately for the words that comprise the keywords; for example, count of "cortex", would include different composite keywords in which each word appears, including visual cortex, cerebral cortex, striate cortex, and prefrontal cortex. This analysis has been defined as "individual keywords".

After conducting both analyses, this indicator identifies the singular and plural forms, accounting for the sum of both in a single keyword. Combining these analyses, a more realistic and representative account of research topics defined by the authors must be obtained. In simple words, it can be explained as following:

- Analysis 1: Interpretation mechanism of "compound keywords". Accounts keywords as they are defined by the authors (whether it is a single word or compound words). In this analysis, the differences between keywords for the simple presence of a dash are avoided. In addition, upper and lower case terms are unified. Moreover, singular and plural terms are first studied separately and then in unified manner.
- Analysis 2: Interpretation mechanism of "individual keywords". Accounts separately for the words that comprise the keywords. In this analysis, terms in uppercase and lowercase are unified. Moreover, singular and plural terms are first studied separately and then unified.

b) Number of weighted published research papers by Country or Research centre (N_p)

This indicator quantifies the production of a country or research centre considering the work distribution. In this way, we prevent penalizing the countries or institutions that contribute with a whole work and favor those who publish in collaboration with many other entities while realizing small parts of their work. Furthermore, it ensures that the sum of research papers published by the total number of countries and research centres correspond to the total of published documents, having a more realistic productivity scale.

For example, if three different research institutions collaborate in one research paper, then each of them will be granted 1/3 weight for their respective research paper. During this elaboration, the number of authors has not been considered, since the information that places the authors in relation to the participating countries or research institutions is not always available in WOS.

This indicator is calculated by processing the information field Addresses of WOS, identifying all research centres and participating countries for every research paper. Thus, the weighted number of papers for each country has been calculated, for a specific period (year, triennium or 15-year period) as:

$$N_P = \sum_{i=1}^N \frac{1}{N_{C,i}}$$

Where N_P is the total number of weighted research papers published in the country during said period and $N_{C,i}$ the number of participating countries for each research paper "i".

Equivalently, the weighted number of research papers for each Research centre has been calculated, for a specific period (year, triennium or 15-year period) as:

$$N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$$

Where N_P is the total number of research papers published by the Research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i".

c) Contribution to the world production (N_P (%))

Moreover, the contribution of each country or research centre to the world production has been calculated by:

$$N_P (\%) = \frac{N_P}{N_W}$$

Where N_P is the total number of research papers published by the country or research centre during said period, and N_W the total number of published research papers of "selected WOS category" at global level.

d) Year impact factor (YIF)

The impact factor of a journal is a quantitative tool to evaluate the relative importance of a journal. To assign an impact indicator to each individual research paper, journal IF has been assigned to each paper with respect to its publication year. This indicator has been called year impact factor (YIF). Through this YIF parameter, each research paper is separately analyzed. The average YIF for each country or research centre has been calculated, for a specific period (year, triennium, 15-year period) as:

$$YIF = (\sum_{i=1}^N YIF_i)/N$$

Where N is the total number of research papers of the country or research centre published during said period, and YIF_i is the IF to the journal of the year when each document "i" was published."

e) Number of citations (N_{CI})

Compilation of cited references helps to measure research influence and impact at the journal and category levels. The higher it is the number of citations, the higher the impact and international dissemination. The average number of citations for each country or Research centre has been calculated using field information "Citation Time" of WOS, referred to the time of downloading the data. Thus, the average number of citations for a specific period (year, triennium or period of 15 years) has been calculated as:

$$N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$$

Where N is the total number of research papers of the country or research centre published during said period, and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time (Citation Time field of WOS).

f) Collaborations indicators

Information has been processed from Addresses field of WOS, identifying the participating countries and research centres related to each research paper. Moreover, information has been processed with respect to "Author (s)" field, counting the number of authors of each research paper. With this information, an analysis of partnerships at different levels has been carried out:

Percentage of international collaborations Col (%). The percentage of international collaboration for a given period has been calculated as the ratio of the research papers published in collaboration with at least one centre of another country and the total documents published.

Collaborations matrix. After creating the matrix of counters with all existing combinations of countries, a research paper is added to each of the combinations of countries that share responsibility for each of the document. The result is a matrix with the number of research papers that have been co-authored by any two countries. Equivalent collaborations between research centres have been counted.

Average number of authors (N_A). After identifying the authors who elaborate each research paper, average of this indicator for each country or research center has been calculated as:

$$N_A = (\sum_{i=1}^N N_{A,i})/N$$

Where N is the total number of research papers of the country or research published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i".

Average number of research centers (N_{RI}). Average number of participating research centers per research paper. After identifying centers that share authorship on each research document, the average of this indicator for each county or research center has been calculated as:

$$N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$$

Where N is the total number of research papers of the country or research centre published during this said period, and $N_{Ri,j}$, the number of research centres (of any nationality) participants in each item "i".

f) Language

From language information field, it has been determined the percentage of articles published in each of the languages.

g) Journal internationalization (JI)

To establish the effectiveness of the diffusion and internationalization of the worldwide research journals of the field, two complementary indicators have been calculated:

Percentage of the total number of papers published by a journal due to researchers of a specific country (Jl_j (%)).

The indicator shows the influence of each country in the existing journals.

$$Jl_j(\%) = N_{PJ} / N_j$$

Where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_j is the total number of research papers published by this journal.

Percentage of the total number of weighted papers of one country published in a specific journal (Jl_c (%)).

The indicator shows the dissemination of the papers of each country in the different journals of the field

$$Jl_c(\%) = N_{PJ} / N_P$$

Where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_P is the total number of weighted research papers published by the country (in every journal). The resulting matrixes expose "inbreeding" publishing trends and preponderance of some countries in certain journals.

3.1.4. Output templates

To synthesize millions of information data sets and to visualize scientometric indicators in an understandable form, a series of below listed outputs have been designed.

3.1.4.1. To reveal the evolution of the most frequent research topics: Keyword Analysis

a) Compound keywords Analysis for 1 year interval

	1997-2011	1997	1998	1999	2000	2001	2002	..
Compound keywords	N_k	N_k	N_k	N_k	N_k	N_k	N_k	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Table 2: Output template, evaluation of compound keywords for 1-year interval.

Description: Sample of computer application output template for compound keywords, evolution of the most frequently used keywords (counts keywords as they have been defined by the authors, whether keywords are single words or compound words) published in "WOS" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years).

b) Individual Keywords Analysis for 1 year interval

	1997-2011	1997	1998	1999	2000	2001	2002	..
Individual Keywords	N_k	N_k	N_k	N_k	N_k	N_k	N_k	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Table 3: Output template, evaluation of Individual Keywords for 1-year interval.

Description: Sample of computer application output template for individual keywords, evolution of the most frequently used words which are constituents of the keywords (either on their own or as part of keywords) published in "WOS" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years).

c) Individual Plural Keywords Analysis for 1 year interval

	1997-2011	1997	1998	1999	2000	2001	2002	..
Individual Plural Keywords	N_k	N_k	N_k	N_k	N_k	N_k	N_k	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Table 4: Output template, evaluation of Individual Plural Keywords for 1-year interval.

Description: Sample of computer application output template for individual plural keywords, evolution of the most frequently used words which are constituents of the keywords (unifying terms in singular and plural forms) published in "WOS" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years).

d) Compound Plural Keywords Analysis for 1 year interval

	1997-2011	1997	1998	1999	2000	..
Compound Plural Keywords	N_k	N_k	N_k	N_k	N_k	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 5: Output template, evaluation of Compound Plural Keywords for 1-year interval.

Description: Sample of computer application output template for compound plural keywords, evolution of the most frequently used keywords (unifying terms in singular and plural forms) published in "WOS" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years).

e) Compound Plural Keywords Analysis for 3-year interval along with ranking information

	1997-2011	1997-1999	2000-2002	..
Compound Plural Keywords	N_k	N_k	Rank	N_k Rank ..
...	..	..	..	
...	..	..	..	

Table 6: Output template, evaluation of Compound Plural Keywords along with Rank info

Description: Sample of computer application output template for compound plural keywords, evolution of the most frequently used keywords (unifying terms in singular and plural forms) published in "WOS" category research papers during the period 1997–2011, where N_k = number of times each word appears; (Rank)Rk: position in the ranking drawn from the number of words used during said period (i.e. 3-year Interval of total 15 years).

f) Individual Plural Keywords Analysis for 3-year interval along with ranking information

	1997-2011	1997-1999	2000-2002	..
Individual Plural keywords	N_k	N_k	Rank	N_k Rank ..
..	..	..	..	
..	..	..	..	

Table 7: Output template, evaluation of Individual Plural Keywords along with Rank info.

Description: Sample of computer application output template for individual plural keywords, evolution of the most frequently used words which are constituents of the keywords (unifying terms in singular and plural forms) published in "WOS" category research papers during the period 1997–2011, where N_k = number of times each word appears; (Rank)Rk: position in the ranking drawn from the number of words used during said period (i.e. 3-year Interval of total 15 years).

g) Keywords Concentration Analysis for 15-year interval

Total keywords	
N° times keywords Appear	
%100 keywords	
%1000 keywords	
%5000 keywords	
%keywords >1 papers	
% keywords >10 paper	
% keywords >100 paper	
% keywords >1000 paper	

Table 8: Output template, evaluation of Keywords concentration for 15-year interval.

Description: Sample of computer application output template for keywords concentration, where N° = number of times each keyword appears to reveal the heterogeneity of research topics under study during the period 1997–2011.

h) Keywords evolution

Figure 23: Output template, change in the use of frequently used keywords (Compound Keywords) for 15-year Interval.

Description: Sample of computer application output template for N_k change in the use of the most frequently employed keywords (as they appeared in the selected papers) between time interval of 15-years.

3.1.4.2. To reveal the evolution of geographical distribution of publications, through productivity, impact and collaborations analysis

a) Sample output for 1 year interval to evaluate productivity

Total		..	..	..	..	..	..	..
		1997	1998	1999	2000	2001	2002	..
Country		N_P	N_P	N_P	N_P	N_P	N_P	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Table 9: Output template, evaluation of N_P per year.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{C,i}}$, where N_P is the total number of weighted research papers published in the country during said period and $N_{C,i}$ the number of participating countries for each research paper "i", total 15-year interval are divided in to 1 year interval.

Figure 24: Output template, evaluation of N_P per year (changes in the number of national and international research papers).

Description: Sample of computer application output to see the changes in weighted publications of national and international research papers, where N_P , total 15-year interval are divided in to 1 year interval.

b) Sample output for 1 year interval to evaluate impact.

Mean	..	..	..	..	..	..	..
County	1997 YIF	1998 YIF	1999 YIF	2000 YIF	2001 YIF	2002 YIF	..
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..

Table 10: Output template, evaluation of YIF per year.

Description: Sample of computer application output for $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the country published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 1 year interval.

Mean	..	..	..	..	..	..	..
County	1997 N_{CI}	1998 N_{CI}	1999 N_{CI}	2000 N_{CI}	2001 N_{CI}	2002 N_{CI}	..
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..

Table 11: Output template, evaluation of N_{CI} per year.

Description: Description: Sample of computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 1 year interval.

Figure 25: Output template, evaluation of YIF and N_{CI} for countries.

Description: Sample of computer application output to see evaluation of YIF and N_{CI} (changes in the number of national and international research papers) where $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the country published during said period, and YIF is the IF to the journal of the year when each document "i" was published", $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 1 year interval.

c) Sample output for 1 year interval to evaluate collaborations.

Total				..	..	..	..	..
				1997	1997	1998	1998	..
	N° Col	%Col	Country	N° International	N° National	N° International	N° National	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Table 12: Output template, evaluation of N°Col and Col (%) per year.

Description: Sample of computer application output for N°Col Number collaborations and Col(%) percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another country and the total documents published, total 15-year interval are divided in to 1 year interval.

	Country 1	Country 2	Country 3	..
Country 1	..	..	..	..
Country 2	..	..	..	..
Country 3	..	..	..	..
..	..	..	..	..

Table 13: Output template, collaborations matrix.

Description: After creating the matrix of counters with all existing combinations of countries, a research paper is added to each of the combinations of countries that share responsibility for each of the document. The result is a matrix with the number of research papers that have been co-authored by any two countries.

Mean	..	..	..	..	..	..	..
	1997	1998	1999	2000	2001	2002	..
Country	N _A	N _A	N _A	N _A	N _A	N _A	..
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..

Table 14: Output template, evaluation of N_A per year.

Description: Sample of computer application output for $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i", total 15-year interval are divided in to 1 year interval.

Mean	..	..	..	..	..	..	..
	1997	1998	1999	2000	2001	2002	..
Country	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	..
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..

Table 15: Output template, evaluation of N_{RI} per year.

Description: Sample of computer application output for $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval.

Figure 26: Output template, evaluation of N_A and N_{RI} for countries (changes in the number of national and international research papers).

Description: Sample of computer application output to see evaluation of N_A and N_{RI} (changes in the number of national and international research papers) where $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i", $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$ the number of research centers (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval.

d) Sample output for 3-year interval to evaluate productivity.

Total	..	..	..	..	..	..
	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011	..
Country	N _P	N _P	N _P	N _P	N _P	
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 16: Output template, evaluation of N_P triennial.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{C,i}}$, where N_P is the total number of weighted research papers published in the country during said period and $N_{C,i}$ the number of participating countries for each research paper "i", total 15-year interval are divided in to 3-year interval.

Figure 27: Sample output of N_P in the country for selected WOS category.

Description: Sample output for selected WOS category, $N_P = \sum_{i=1}^N \frac{1}{N_{C,i}}$, where N_P is the total number of weighted research papers published in the country during said period and $N_{C,i}$ the number of participating countries for each research paper "i", total 15-year interval are divided in to 3-year interval.

e) Sample output for 3-year interval to evaluate impact.

Mean	..	..	..	..	..	..
	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011	..
Country	YIF	YIF	YIF	YIF	YIF	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 17: Output template, evaluation of YIF triennial.

Description: Sample of computer application output for $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published.", total 15-year interval are divided in to 3-year interval.

Mean	..	..	..	..	..	..
	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011	..
Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 18: Output template, evaluation of N_{CI} triennial.

Description: Sample of computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval.

Figure 28: Output template of YIF in the country for selected WOS category.

Description: Sample output for selected WOS category, $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval.

Figure 29: Output template of N_{CI} in the country for selected WOS category.

Description: Sample output for selected WOS category, $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval.

f) Sample output for 15-year interval to evaluate geographical distribution of publications.

Country	N _P	N _P (%)	1997-2011				
			Col (%)	YIF	N _{CI}	N _A	N _{RI}
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..

Table 19: Output template, evaluation of N_P , $N_{P\%}$, $Col\%$, YIF , N_{CI} , N_A , N_{RI} for 15 years.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{CI,i}}$, where N_P is the total number of weighted research papers published in the country during said period and N_{CI} the number of participating countries for each research paper "i"; $N_P (\%) = \frac{N_P}{N_W}$ is the contribution of each country to the world production, where N_W is the total number of published research papers of "Selected WOS category" at global level; $Col (\%)$ is percentage of international collaboration for a given period has been calculated as the ratio of the research papers published in collaboration with at least one centre of another country and the total documents published; $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published; $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time; $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15 years' time.

g) Language Analysis

Language	Country1		Country 2		..		..	
	N°Papers	%	N°Papers	%	N°Papers	%	N°Papers	%
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Table 20: Output template, evaluation of N° of research papers published in each of the languages.

Description: Sample of computer application output, main production indicators of worldwide countries specific average values during the time of 1997–2011 from language information field it has been determined the % and N° of research papers published in each of the languages globally.

3.1.4.3. To reveal the evolution of institutional distribution of publications, through productivity, impact and collaborations analysis.

a) Sample output for 1 year interval to evaluate productivity.

Total	..	..	..	..	..	..
	1997	1998	1999	2000	2001	..
Research centre	N _P	N _P	N _P	N _P	N _P	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 21: Output template evaluation of N_P per year.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval is divided in to 1 year interval.

b) Sample output for 1 year interval to evaluate impact.

Mean	..	..	..	..	..	..
	1997	1998	1999	2000	2001	..
Research centre	YIF	YIF	YIF	YIF	YIF	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 22: Output template, evaluation of YIF per year.

Description: Sample of computer application output for $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 1 year interval.

Mean	..	..	..	..	..	..
	1997	1998	1999	2000	2001	..
Research centre	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 23: Output template, evaluation of N_{CI} per year.

Description: Sample of computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 1 year interval.

c) Sample output for 1 year interval to evaluate collaborations.

Total				1997	1997	1998	1998	..
	N°Col	%Col	Research centre	N°Col	%Col	N° Col	%Col	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Table 24: Output template, evaluation of N°Col and Col (%) for 1 year for selected WOS category.

Description: Sample of computer application output, N°Col of collaborations and Col (%) percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another research centre and the total documents published, total 15-year interval are divided in to 1 year interval.

Mean	..	..	..	..	..	..
	1997	1998	1999	2000	2001	..
Research centre	N _A	N _A	N _A	N _A	N _A	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 25: Output template, evaluation of N_A per year.

Description: Sample of computer application output for $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the research centre published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i", total 15-year interval are divided in to 1 year interval.

Mean	..	..	..	..	..	..
	1997	1998	1999	2000	2001	..
Research centre	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	..
..	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 26: Output template, evaluation of N_{RI} per year.

Description: Sample of computer application output for $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the research centre published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval.

f) Sample output for 3-year interval to evaluate productivity.

Total		1997-1999	2000-2002	2003-2005	..
Research centre	N _P	N _P	N _P	N _P	..
..	..	..	..	..	..
..	..	..	..	..	..

Table 27: Output template evaluation of N_P triennial.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval is divided in to 3-year interval.

Figure 30: Output template of N_P by the research centre for selected WOS category.

Description: Sample output for selected WOS category, $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval is divided in to 3-year interval.

g) Sample output for 3-year interval to evaluate impact.

Mean	..	..	..	..
	1997-1999	2000-2002	2003-2005	..
Research centre	YIF	YIF	YIF	..
..	..	..	..	..
..	..	..	..	..

Table 28: Output template, evaluation of YIF triennial.

Description: Sample of computer application output for $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval.

Mean	..	..	..	..
	1997-1999	2000-2002	2003-2005	..
Research centre	N_{CI}	N_{CI}	N_{CI}	..
..	..	..	..	..
..	..	..	..	..

Table 29: Output template, evaluation of N_{CI} triennial.

Description: Sample of computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i}) / N$ where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval.

Figure 31: Sample output of YIF for research centre for selected WOS category.

Description: Sample output for selected WOS category, $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval.

Figure 32: Sample output of YIF for research centre for selected WOS category.

Description: Sample output for selected WOS category, $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval.

h) Sample output for 15-year interval to evaluate geographical distribution of publications.

Research institution	1997-2011						
	N_P	N_P (%)	Col (%)	YIF	N_{CI}	N_A	N_{RI}
..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..

Table 30: Output template, evaluation of N_P , $N_{P\%}$, $Col\%$, YIF , N_{CI} , N_A , N_{RI} for 15 years.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i"; N_P (%) = $\frac{N_P}{N_W}$ is the contribution of each research centre to the world production, where N_W is the total number of published research papers of "Selected WOS category" at global level; Col (%) percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another research centre and the total documents published; $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published; $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time; $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the research centre published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the research centre published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15 years' time.

3.1.4.4. To establish the effectiveness of the diffusion and internationalization of the worldwide research journals of the field

To facilitate the identification of strong relationship cases between countries and research journals, a color code scheme has been automated, indicating a higher percentage with darker background of table cells.

Abbreviated Journal	Mean IF	N° papers				
		Country 1	Country 2	...	..	
Journal 1	..	..	..	..	..	
..	..	..	..	..	..	

Table 31: Output template, percentage of the total number of papers published by a journal due to researchers of a specific country (JI_j (%)).

Description: Sample computer application output, JI_j (%) = N_{PJ}/N_j shows the influence of each country in the existing journals, JI_j (%) = N_{PJ}/N_j , where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_j is the total number of research papers published by this journal, JI_j (%) is percentage of the total number of papers published by a journal due to researchers of a specific country (the sum of each row is 100%, representing the total number of papers published by each journal).

Abbreviated Journal	Mean IF	N° papers				
			Country 1	Country 2	...	..
Journal 1	..	..	..	..	..	..
..	..	..	..	..	..	..

Table 32: Output template, percentage of the total number of weighted papers of one country published in a specific journal ($Jl_c(\%)$).

Description: Sample computer application output, $Jl_c(\%) = N_{PJ} / N_P$ shows the dissemination of the papers of each country in the different journals of the field, where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_P is the total number of weighted research papers published by the country (in every journal), ($Jl_c(\%)$) is percentage of the total number of weighted papers of one country published in a specific journal (the sum of each column is 100%, representing the total number of papers published by each country).

3.2. DEVELOPMENT OF COMPUTER APPLICATION TO PERFORM THE SCIENTOMETRIC ANALYSIS

3.2.1. Introduction

A computer application is developed that allows to implement the defined analysis as per methodology design, like processing thousands of scientific publications, characterizing the keywords evolution used by researchers, productivity and research impact, geographic and institutional distribution, national and international collaborations and networks, etc.

Among its many capabilities, this scientometrics based computer application can analyze keyword evolution, estimate the impact of an article, determine the collaborations established at different scales, and calculate the collaboration-weighted productivity of countries and research centres.

Through this computer application, keyword analysis is allowed, which help the researcher to know the important and rapidly growing research topics, as well as areas of lesser interest, to be identified and tracked, plus it also help to know about the changes detected in productivity, collaboration and impact scores over time, which could be used to provide a framework for assessing research activity in a realistic context.

Moreover, this computer application also help to examine, geographic and institutional distributions of the studied publications, along with changes in collaboration-weighted productivity, the impact of the major research countries and research centres, and the journals in which their results were published.

Additionally, this application provides the detailed analysis of existing collaborations between countries and research centres and the results obtained can be used as desired by researchers to determine the direction of specific trends in their areas of interest. Computer Application performs different types of analysis with the most effective algorithms defined in the methodology. It uses different visualizations to explore and understand specific datasets.

3.2.2. Utilized hardware technologies to run computer application

System	
Processor:	Intel(R) Core(TM) i7-3630QM CPU @ 2.40GHz 2.40 GHz
Installed memory (RAM):	6.00 GB (5.89 GB usable)
System type:	64-bit Operating System, x64-based processor

Table 33: Utilized hardware technologies to run computer application.

3.2.3. Utilized software technologies to develop computer application

a) EndNote X7 Component:

EndNote is a commercial reference management software package, used to manage bibliographies and references. Information stored in EndNote7 is exported specifically designed *.txt files. In later stage, same is to be used Excel-Files which are stored in database server.

b) Excel Workbook (Import Wizard):

Excel workbook has been used as a data source and the worksheet (tables) have been used to retrieve the data. Import Wizard of Microsoft Excel has been used to import data from a text file into a worksheet. Internal inbuilt functionality of Text Import Wizard examines the text file that individual is importing and helps to ensure that the data is imported.

c) Visual Basic (VBA):

VBA has been used to develop the computer application. Visual Basic is a third-generation event-driven programming language and integrated development environment (IDE) from Microsoft. Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications, access to databases using Data Access Objects, Remote Data Objects, or ActiveX Data Objects, and creation of ActiveX controls and objects.

A researcher has created a computer application using the components provided by the Visual Basic program itself. A special form of Visual Basic, Visual Basic for Applications (VBA), is used as a macro or scripting language within several Microsoft applications, including Microsoft Office 2010, the same has been utilized by the researcher, Visual Basic for Applications (VBA) is included in many Microsoft applications (Microsoft Office). Visual Basic development ended with 6.0, but in 2010 Microsoft introduced VBA 7 to provide extended features and add 64-bit support.

d) Microsoft Excel10 (Database):

It has been used as a database for Macros based programming interface of VBA. Microsoft Excel is a spreadsheet developed by Microsoft for Microsoft Windows, Mac OS X, and iOS. It features calculation, graphing tools, pivot tables, and a macro programming language called Visual Basic for Applications. Programming with VBA has been utilized for the spreadsheet manipulation. Computer application code is written directly by using the Visual Basic Editor (VBE), which includes a window for writing code, debugging code, and code module organization environment. The researcher has programmed formulated methodology equations for the automation of defined functionalities and guided the calculation using any desired intermediate results reported back to the spreadsheet.

The interaction of VBA code with the spreadsheet is done through the Excel Object Model, a vocabulary identifying spreadsheet objects, and a set of supplied functions or methods that enable reading and writing to the spreadsheet and interaction with its users (for example, through custom toolbars or command bars and message boxes).

e) ADO / ODBC Database Connectivity:

This section explains about the network technology which has been used by computer application, which is used in between computer application interface and connected database (Microsoft Excel).

Technical details: ADO Stands for ActiveX Data Objects, is Microsoft's Client-Server technology to access the data between Client and Server. ADO cannot access the data source directly; it helps OLE DB Provider to communicate with the data source. Most of the times OLE DB providers are specific to a Data Source Type. However, we have an OLE DB provider for ODBC, it is a general-purpose provider with help of this ADO can access any Data source which can understand ODBC. Database (DB) is a collection of information organized in such a way that a computer program can easily understand and read the data. And the Database Management System (DBMS) are destined to understand and interact with other computer applications to perform the different operations on the data

In database part of computer application, the information stored in the data in the form of tables, and a table is designed with set of records (rows) and fields (columns). Microsoft Excel is used to store data, where an Excel workbook acts as a data source; worksheet is a table and the rows and the columns of the worksheet are records and the fields of the table. Following steps has been programmed for the connectivity with Data source (Microsoft Excel Workbook):

- Open the connection to the Data Source (Microsoft Excel) /add reference for Microsoft ActiveX Data Objects Library.
- Run the required SQL command.
- Copy the resulted record set into our worksheet.
- Close the record set and connection.

3.2.4. High Level Architectural Diagram

High-level design (HLD) explains the architecture that is used to develop computer application. The architecture diagram provides an overview of an entire system (Figure 33), identifying the main components that would be developed for the computer application and their interfaces. The HLD uses possibly non-technical to mildly technical terms that should be understandable.

A high-level design adds the necessary details to the current computer application description to represent a suitable model for coding. Architecture diagram includes a depicting the structure of the system, such as the database architecture, application architecture (layers), application flow (navigation and technology architecture).

Figure 33: Complete high level architecture of based computer application.

a) Web of Science Online Database and Import and Export Wizard Component:

Web of Science-Online Database: Web of Science Online Database, provides access to the most reliable, integrated, multidisciplinary research connected through linked content citation metrics from multiple sources within a single interface.

EndNoteX7<<Windows-OS>> Import Function End Note X7: Information stored in EndNoteX7 is exported in specifically designed *.txt files, in later stage same will be used as Excel files in database server.

Import Wizard Excel<<Import Function>>Importing text files into .xlsm using Text Import Wizard of Excel Package following (Figure 34) shows the modular high level diagram of above these components.

Figure 34: Access to web of science online database using EndNoteX7.

b) Windows Database Server <<Data Source>> Component:

Windows-Database Server<< Data Source >> is database which contains following major data files with millions of data sets inside

- Records_verify_WOS_info.xlsm
- Records_Keywords.xlsm
- Records_Pre_Category.xlsm

JCR_Citation_WOS.xlsm connection between VBA application code and Window Data server << Data Source >> is carried out by ODBC drivers, connection of Microsoft ActiveX Data Objects, allows treating Excel workbook as if it is database. ADO is used to connect to an Excel sheet data file either one of two OLE DB providers included in MDAC (Microsoft OLE DB Provider for ODBC drivers), where an Excel workbook used as a data source and worksheet as a database table and rows and columns of the worksheet are used as are records and fields of the table (Figure 35).

Figure 35: Windows database server <<Data Source>> Component.

c) Windows 8 – Computer application (VBA-Visual Basic):

Windows 8 operating system has been used to develop computer application using VBA.

VBA Visual basic editor is the tool used to create, modify and maintain Visual Basic for applications (VBA) procedure and modules in Microsoft office applications. Defined Computer application provides an automated calculation of following variables (Figure 36).

Internal library structure of VBA programming:

Visual Basic<<Windows-Application>>

<<Sceintometric_JCR_Analysis.vba>>

<<Scientometric_Pre_Prcessed_Category.vba>>

<<Scientometric_Countries_Analysis.vba>>

<<Scientometric_RI_Analysis.vba>>

<<Scientometric_Analysis_keywords.vba>>

<<Scientometric_Verify_WOS_info.vba>>

Figure 36: Windows 8 –computer application (VBA-Visual Basic).

d) Metrics and Report Generation Component:

<<Global -Analysis Reports -WOS Selected Category>> is a component to generate data analytical reports and graphical status reports for following variables as explained by Figure 37

- Keywords Number Analysis report for (N_k)
- Number of weighted published research papers by Country (N_P)
- Number of weighted published research papers by Research centre N_P
- Contribution to the world production ($N_P(\%)$)
- Year impact factor (YIF)
- Number of citations (N_{CI})
- Language.
- Journal internationalization (JI).

Figure 37: Metrics and report generation component.

3.2.5. Activity Diagram

Activity diagrams are graphical representations of workflows of stepwise activities and action with support for choice, iteration and concurrency. In the Unified Modelling Language, activity diagrams are intended to model both computational and organizational processes (i.e. workflows). Activity diagrams show the overall flow of control. Typical flowchart techniques lack constructs for expressing concurrency.

Activity diagrams are constructed from a limited number of shapes, connected with arrows. The most important shape types:

- Rounded rectangles represent actions.
- Diamonds represent decisions.
- Bars represent the start (split) or end (join) of concurrent activities.
- A black circle represents the start (initial state) of the workflow.
- An encircled black circle represents the end (final state).

Following Computer application activity diagrams is regarded as a form of flowchart. Activity diagrams are constructed from a limited number of shapes, connected with arrows. Complete activity diagram is connected network of multiple activities e.g. Access to WOS, EndNote query, Excel wizard, retrieve data of JCR analysis component, retrieve data proposed category component, verify web of science component, scientometric keywords analysis component, report and metrics generation component, trigger exit component (Figure 38).

- Activity Region-WOS<<< Web of Science >>>Access to WOS, following sub-activities have been performed (Figure 39):

- a) Access to Web of science Database
- b) Download Queried data in EndnotX7
- c) Conversion of predefined .txt to .xslm files, using import text wizard of Microsoft Excel 10
- d) Send .xslm files to Data Store

Figure 39: Activity Region-WOS<<< Web of Science >>>.

Figure 40: Activity Region Data server<<<Data Store>>>.

- Activity Region Data server <<<Data Store>>> following sub-activities have been performed (Figure 40):
 - a) Store all .xslm files and act as Excel data base, contains records_verify_WOS_info.xslm, records_Keywords.xslm, records_Pre_Category.xslm, JCR_Citation_WOS.xslm files respectively
 - b) Retrieve data from above quoted files using common function: Retrieve Data, <<Pre_Processed_Category_Function>>

Figure 41: Scientometric Report Generations<<<Report Generations>>> module part 1.

Figure 42: Scientometric Report Generations<<<Report Generations>>> module part 2.

3.3. APPLICATION OF THE DEFINED METHODOLOGY

3.3.1. Introduction

As principal purpose of the research is to develop a systematic, empirical methodology for scientometric analysis and correspondingly to analyze WOS categories like Hardware Architecture and Cybernetics. Through this methodology based automated scientometric analysis application, researcher seeks to quantify the research growth carried out in the field of Cybernetics and Hardware Architecture, to identify new areas of interest, to determine the research oriented countries and leading worldwide research centres, to quantify the internationalization and diffusion of the journals, and to establish benchmarks to evaluate, i.e. to identify the countries and research centres associated with research papers (Hardware Architecture and Cybernetics WOS categories), tracks the development of the most important research topics, and analyses changes in the geographic and institutional distribution of publications.

The literature review on scientometrics during the time from 1997-2011 has justified that, neither there is hardly any computer application for the scientometric analysis which has been used for scientometric analysis of "Hardware Architecture" and "Cybernetics" WOS categories, nor on it is under development over recent years.

A number of authors have analyzed scientific production in multiple disciplines of WOS categories like public hygiene (Parra Hidalgo et al., 1983), tsunami research (Chiu & Ho, 2007), tropical medicine (Falagas et al., 2006; Vergidis et al., 2005), bio-energy (Konur, 2011), renewable energy (Montoya et al., 2014), vaccines (Guzman et al., 1998), otorhinolaryngology (Mora et al., 2003), respiratory medicine (Michalopoulos & Falagas, 2005), cancer molecular epidemiology (Ugolini et al., 2007), geographic information system (GIS) (Tian et al., 2008), computer science (Rojas-Sola & Jorda-Albinana, 2009b), materials science, ceramics (Rojas-Sola et al., 2009), PubMed (Vioque et al., 2010), hydraulic engineering (Rojas-Sola & Jorda-Albinana, 2011), civil engineering (Canas-Guerrero et al., 2013b), collaborative networks (Franceschet & Costantini, 2011; Hou et al., 2008; Huamani et al., 2014; Melin & Persson, 1998; Toivanen & Ponomariov, 2011), competitiveness of universities (Abramo et al., 2008; Silaghi-Dumitrescu & Sabau, 2014), chemical engineering (Rojas-Sola & San-Antonio-Gomez, 2010b, 2010d), ecology (Rojas-Sola & Jorda-Albinana, 2010), etc. However, there is no precedent in the study of Cybernetics and Hardware Architecture.

The author (s), editor (s), title, source, addresses, citation time, keywords, language and WOS category are recorded for each article and it is further analyzed by using the inbuilt formulated methodology for scientometric analysis.

3.3.2. Cybernetics

In engineering, cybernetics refers to field which deals with the question of control engineering of mechatronic systems as well as chemical or biological systems. It is used to control and predict the behavior of such a system. Cybernetics is relevant to the study of systems, such as mechanical, physical, biological, cognitive, and social systems. Cybernetics is applicable when a system being analyzed incorporates a closed signaling loop; that is, where action by the system generates some change in its environment and that change is reflected in that system in some manner (feedback) that triggers a system change, originally referred to as a "circular causal" relationship.

This category includes the resources that focus on the control and information flows within and between artificial (machine) and biological systems. Resources in this category are drawn from the fields of artificial intelligence, automatic control and robotics.

3.3.3. Hardware Architecture

In engineering, hardware architecture refers to the identification of a system's physical components and their interrelationships. This description, often called a hardware design model, allows hardware designers to understand how their components fit into a system architecture and provides to software component designers important information needed for software development and integration. Clear definition of a hardware architecture allows the various traditional engineering disciplines (e.g., electrical and mechanical engineering) to work more effectively together to develop and manufacture new machines, devices and component (Rai & Kang, 2008).

This category covers resources on the physical components of computer systems: main and logic boards, internal buses and interfaces, static and dynamic memory, storage devices and storage media, power supplies, input and output devices, networking interfaces, and networking hardware such as routers and bridges. Resources in this category also cover the architecture of computing devices, such as SPARC, RISC, and CISC designs, as well as scalable, parallel, and multi-processor computing architectures.

4. RESULTS

4.1. EXAMPLES OF RESULTS TEMPLATES GENERATED BY COMPUTER APPLICATION

This section provides output examples (results templates) which have been generated by computer application:

4.1.1. To reveal the evolution of the most frequent research topics: Keyword Analysis

a) Compound keywords sample output per year

	1997-2011	1997	1998	1999	2000	2001	2002	..
Compound keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	..
DESIGN	2652	60	63	69	88	85	130	..
SYSTEMS	2092	80	95	81	79	79	94	..
NETWORKS	1907	68	90	76	98	85	124	..
ALGORITHMS	1873	66	65	65	82	89	105	..
PERFORMANCE	1859	59	51	78	64	70	84	..
ALGORITHM	1704	63	67	82	75	84	78	..
OPTIMIZATION	1236	42	49	65	62	71	72	..
MODEL	954	30	38	41	41	50	37	..
CIRCUITS	876	37	40	47	57	45	55	..
..	..	..	..	..	..	..	..	..

Table 34: Sample output, evaluation of Compound Keywords 1-year interval for selected WOS category.

b) Individual Keywords sample output per year

	1997-2011	1997	1998	1999	2000	2001	2002	..
Individual Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	..
NETWORKS	8061	314	328	338	347	371	447	..
SYSTEMS	5729	260	274	250	262	259	249	..
DESIGN	5463	156	173	209	229	250	326	..
NETWORK	4582	185	155	185	200	192	226	..
PERFORMANCE	3704	121	149	181	171	168	202	..
ALGORITHM	3676	135	169	172	186	181	186	..
SYSTEM	3611	141	170	173	190	229	191	..
POWER	3280	75	91	95	98	163	231	..
TIME	3278	158	154	166	168	167	213	..
..	..	..	..	..	..	..	..	..

Table 35: Sample output, evaluation of Individual Keywords 1-year interval for selected WOS category.

c) Individual Plural Keywords sample output per year

	1997-2011	1997	1998	1999	2000	2001	2002	..
Individual Plural Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	..
NETWORK/NETWORKS	12643	499	483	523	547	563	673	..
SYSTEM/SYSTEMS	9340	401	444	423	452	488	440	..
ALGORITHM/ALGORITHMS	6875	268	293	312	343	333	376	..
DESIGN/DESIGNS	5575	157	183	216	238	256	329	..
MODEL/MODELS	4171	140	162	159	216	225	207	..
CIRCUIT/CIRCUITS	3935	187	205	227	270	190	262	..
PERFORMANCE/PERFORMANCES	3711	121	149	181	171	169	202	..
TIME/TIMES	3365	161	159	172	172	172	219	..
POWER/POWERS	3288	75	92	95	99	165	233	..
..	..	..	..	..	..	..	..	..

Table 36: Sample output, evaluation of Individual Plural Keywords 1-year interval for selected WOS category.

d) Compound Plural Keywords sample output per year

	1997-2011	1997	1998	1999	2000	..
Compound Plural Keywords	N _k	N _k	N _k	N _k	N _k	..
ALGORITHM/ALGORITHMS	3577	129	132	147	157	..
SYSTEM/SYSTEMS	2908	112	129	117	119	..
DESIGN/DESIGNS	2702	60	68	74	92	..
NETWORK/NETWORKS	2478	91	111	105	132	..
PERFORMANCE/PERFORMANCES	1865	59	51	78	64	..
MODEL/MODELS	1403	48	64	53	65	..
OPTIMIZATION/OPTIMIZATIONS	1252	42	49	66	62	..
CIRCUIT/CIRCUITS	1066	42	48	55	72	..
NEURAL NETWORK/NEURAL NETWORKS	1001	79	83	74	79	..
..	..	..	..	..	..	..

Table 37: Sample output, evaluation of Compound Plural Keywords 1-year interval for selected WOS category.

e) Compound Plural Keywords sample output triennial

	1997-2011	1997-1999		2000-2002		..
Compound Plural Keywords	N _k	N _k	Rank	N _k	Rank	..
ALGORITHM/ALGORITHMS	3577	408	1	513	1	..
SYSTEM/SYSTEMS	2908	358	2	379	3	..
DESIGN/DESIGNS	2702	202	5	310	4	..
NETWORK/NETWORKS	2478	307	3	396	2	..
PERFORMANCE/PERFORMANCES	1865	188	6	218	5	..
MODEL/MODELS	1403	165	7	200	8	..
OPTIMIZATION/OPTIMIZATIONS	1252	157	8	206	6	..
..	..	..	..	..	..	..

Table 38: Sample output, evaluation of Compound Plural Keywords along with Rank info 3-years interval for selected WOS category.

f) Individual Plural Keywords sample output triennial

	1997-2011	1997-1999		2000-2002		..
Individual Plural keywords	N _k	N _k	Rank	N _k	Rank	..
NETWORK/NETWORKS	12643	1505	1	1783	1	..
SYSTEM/SYSTEMS	9340	1268	2	1380	2	..
ALGORITHM/ALGORITHMS	6875	873	3	1052	3	..
DESIGN/DESIGNS	5575	556	5	823	4	..
MODEL/MODELS	4171	461	8	648	6	..
CIRCUIT/CIRCUITS	3935	619	4	722	5	..
PERFORMANCE/PERFORMANCES	3711	451	9	542	8	..
..	..	..	..	..	..	..

Table 39: Sample output, evaluation of Individual Plural Keywords along with Rank info 3-year interval for selected WOS category.

g) Keywords Concentration sample output of 15 Years

Total keywords	77069
N° times keywords Appear	264657
%100 keywords	18%
%1000 keywords	41%
%5000 keywords	61%
%keywords >1 papers	28%
% keywords >10 paper	4%
....	

Table 40: Sample output, evaluation of Total Keywords for 15-year interval for selected WOS category.

4.1.2. To reveal the evolution of geographical distribution of publications, trough productivity, impact and collaborations analysis

a) Sample Output for 1-year interval to evaluate productivity.

Total		3159	2983	2719	2826	2770	2817	..
		1997	1998	1999	2000	2001	2002	..
	Country	N _p	N _p	N _p	N _p	N _p	N _p	..
16742,68	USA	1158,57	1099,95	1090,22	1026,93	1012,54	1021,98	..
5169,38	JAPAN	312,99	327,53	353,32	357,17	336,48	319,76	..
3474,48	PEOPLES R CHINA	54,73	42,5	52,03	129,98	121,63	149,18	..
2527,4	TAIWAN	89,17	99,25	101,33	127,33	113,67	135,53	..
2179,19	SOUTH KOREA	64,67	55,5	61,92	81,67	81,3	85,95	..
2073,27	UNITED KINGDOM	119,66	142,56	114,28	149,97	138,39	127,18	..
2035,01	CANADA	94,39	108,82	108,92	101,05	88,13	115,49	..
1782,51	ITALY	68,49	101,23	97,22	104,72	147,22	110,25	..
..	..	..	..	..	..	..	..	..

Table 41: Sample output, evaluation of N_p for 1-year interval for selected WOS category.

Figure 43: Sample output, evaluation of N_P per year for selected WOS category.

b) Sample output for 1-year interval to evaluate impact.

Mean		14	13	19	17	16	18	..
		1997	1998	1999	2000	2001	2002	..
	County	N_{CI}	N_{CI}	N_{CI}	N_{CI}	N_{CI}	N_{CI}	..
16	USA	24	21	28	26	25	26	..
4	JAPAN	5	6	6	6	8	6	..
7	PEOPLES R CHINA	15	31	11	9	11	11	..
7	TAIWAN	11	10	10	12	9	24	..
4	SOUTH KOREA	5	7	4	5	8	9	..
10	UNITED KINGDOM	14	11	17	12	14	16	..
9	CANADA	14	12	16	14	15	17	..
10	ITALY	17	10	16	20	10	18	..
..	..	..	..	..	..	..	..	..

Table 42: Sample output, evaluation of N_{CI} for 1-year interval for selected WOS category.

Mean		0.51	0.53	0.70	0.68	0.88	0.83	..
		YIF	YIF	YIF	YIF	YIF	YIF	..
	Country	1997	1998	1999	2000	2001	2002	..
1.22	USA	0.69	0.75	0.89	0.88	1.12	1.10	..
0.48	JAPAN	0.30	0.34	0.39	0.37	0.42	0.45	..
1.03	PEOPLES R CHINA	0.69	0.68	0.71	0.64	1.00	0.50	..
0.84	TAIWAN	0.52	0.42	0.49	0.57	0.59	0.70	..
0.72	SOUTH KOREA	0.41	0.37	0.42	0.44	0.65	0.55	..
1.06	UNITED KINGDOM	0.53	0.47	0.65	0.59	0.76	0.78	..
1.04	CANADA	0.63	0.52	0.72	0.63	0.84	0.90	..
1.04	ITALY	0.71	0.59	0.78	0.68	0.73	0.88	..
..	..	..	..	..	..	..	..	..

Table 43: Sample output, evaluation of YIF for 1- year interval for selected WOS category.

Figure 44: Sample output, evaluation of YIF and N_{CI} for countries for selected WOS category.

c) Sample Output for 1 year interval to evaluate collaborations.

Total				314	2845	380	2603	..
				1997	1997	1998	1998	..
	N° Col	%Col	Country	N° International	N° National	N° International	N° National	..
16743	2492	15%	USA	108	1051	113	987	..
5169	373	7%	JAPAN	12	301	26	302	..
3474	740	21%	PEOPLES R CHINA	13	42	13	30	..
2527	194	8%	TAIWAN	10	79	8	91	..
2179	312	14%	SOUTH KOREA	8	57	7	49	..
2073	492	24%	UNITED KINGDOM	14	106	20	123	..
2035	554	27%	CANADA	21	73	27	82	..
..	..	..	..	..	..	..	..	..

Table 44: Sample output, evaluation of $N^{\circ}Col$ and Col (%) for 1- year interval for selected WOS category.

Coll matrix	USA	JAPAN	PEOPLES R CHINA	TAIWAN	SOUTH KOREA	UNITED KINGDOM	..
USA		301	776	293	445	342	..
JAPAN	301		150	16	68	46	..
PEOPLES R CHINA	776	150		77	53	169	..
TAIWAN	293	16	77		23	17	..
SOUTH KOREA	445	68	53	23		14	..
UNITED KINGDOM	342	46	169	17	14		..
CANADA	588	53	182	17	29	79	..
ITALY	361	20	12	1	4	75	..
GERMANY	399	40	27	10	15	114	..
SPAIN	198	25	9		11	69	..
FRANCE	263	28	35	5	11	85	..
INDIA	219	16	11	1	11	15	..
..	..	..	..	..	..	..	..

Table 45: Sample output, collaborations matrix between countries for selected WOS category.

Mean		2,3	2,5	2,7	2,8	2,7	2,8	..
		1997	1998	1999	2000	2001	2002	..
	Country	N _A	N _A	N _A	N _A	N _A	N _A	..
3,1	USA	2,4	2,6	2,8	2,8	2,9	3	..
3,2	JAPAN	2,9	3	3	3,1	2,8	3	..
3,4	PEOPLES R CHINA	2,7	2,5	2,9	3	2,9	3	..
2,8	TAIWAN	2,3	2,3	2,4	2,6	2,6	2,6	..
3,2	SOUTH KOREA	2,7	2,9	3	2,7	3	3	..
3,1	UNITED KINGDOM	2,7	2,7	2,8	2,6	2,8	2,8	..
3	CANADA	2,5	2,7	2,6	2,7	2,7	2,8	..
3,5	ITALY	3,3	3,2	3,2	3,2	3,3	3,3	..
..	..	..	..	..	..	..	..	..

Table 46: Sample output, evaluation of N_A for 1- year interval for selected WOS category.

Mean		1,5	1,6	1,6	1,6	1,6	1,6	..
		1997	1998	1999	2000	2001	2002	..
	Country	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	..
1,9	USA	1,6	1,7	1,8	1,8	1,9	1,9	..
1,6	JAPAN	1,3	1,6	1,6	1,6	1,5	1,7	..
1,9	PEOPLES R CHINA	1,7	1,8	1,9	1,7	1,7	1,7	..
1,7	TAIWAN	1,5	1,5	1,5	1,6	1,7	1,6	..
1,8	SOUTH KOREA	1,5	1,8	1,8	1,6	1,7	1,7	..
1,9	UNITED KINGDOM	1,5	1,6	1,6	1,6	1,6	1,8	..
1,9	CANADA	1,9	1,9	1,9	1,9	1,9	2	..
1,9	ITALY	1,9	2	1,9	2	1,8	2	..
..	..	..	..	..	..	..	..	..

Table 47: Sample output, evaluation of N_{RI} for 1 year interval for selected WOS category.

Figure 45: Sample output, evaluation of N_A and N_{RI} per year for selected WOS category.

d) Sample output for 3-year interval to evaluate productivity.

Total		8861,00	8413,00	11506,00	11101,00	11588,00	..
		1997-1999	2000-2002	2003-2005	2006-2008	2009-2011	..
	Country	N _P	N _P	N _P	N _P	N _P	
16742,68	USA	3348,73	3061,46	3779,81	3474,67	3078,02	..
5169,38	JAPAN	993,84	1013,40	1109,17	1104,26	948,70	..
3474,48	PEOPLES R CHINA	149,27	400,79	791,77	910,83	1221,82	..
2527,40	TAIWAN	289,75	376,53	498,41	637,38	725,32	..
2179,19	SOUTH KOREA	182,08	248,92	560,78	598,00	589,41	..
2073,27	UNITED KINGDOM	376,50	415,54	435,68	395,68	449,87	..
2035,01	CANADA	312,13	304,68	404,06	516,55	497,60	..
1782,51	ITALY	266,94	362,19	401,79	341,78	409,81	..
..	..	..	..	..	..	..	..

Table 48: Sample output evaluation of N_P for 3-years interval for selected WOS category. Figure 46: Sample graph of N_P for 3-year's interval for selected WOS category.

e) Sample output templates for 3-year interval to evaluate impact.

Mean		0,58	0,80	0,95	1,16	1,21	..
		1997-1999	2000-2002	2003-2005	2006-2008	2009-2011	..
	Country	YIF	YIF	YIF	YIF	YIF	..
1,22	USA	0,77	1,03	1,29	1,44	1,51	..
0,48	JAPAN	0,35	0,41	0,50	0,55	0,59	..
1,03	PEOPLES R CHINA	0,69	0,66	0,74	1,15	1,24	..
0,84	TAIWAN	0,47	0,62	0,75	1,00	1,03	..
0,72	SOUTH KOREA	0,40	0,55	0,59	0,84	0,88	..
1,06	UNITED KINGDOM	0,55	0,71	0,98	1,43	1,40	..
1,04	CANADA	0,62	0,80	0,99	1,18	1,31	..
1,04	ITALY	0,69	0,76	1,02	1,27	1,30	..
..	..	..	..	..	..	..	..

Table 49: Sample output, evaluation of YIF for 3-years interval for selected WOS category.

Mean		15	17	11	7	3	..
		1997-1999	2000-2002	2003-2005	2006-2008	2009-2011	..
	Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	..
16	USA	24	26	17	10	3	..
4	JAPAN	6	7	5	3	1	..
7	PEOPLES R CHINA	19	10	8	7	3	..
7	TAIWAN	10	15	9	6	2	..
4	SOUTH KOREA	5	7	6	4	2	..
10	UNITED KINGDOM	14	14	13	9	3	..
9	CANADA	14	15	12	7	3	..
10	ITALY	14	15	10	8	3	..
..	..	..	..	..	..	..	..

Table 50: Sample output evaluation of N_{CI} for 3-years interval for selected WOS category.

Figure 47: Sample status graph of YIF for 3-years interval for selected WOS category.

Figure 48: Sample status graph of N_{Ci} for 3-years interval for selected WOS category.

f) Samples Output for 15-year interval to evaluate geographical distribution of publications.

Country	N_P	N_P (%)	1997-2011		N_{Ci}	N_A	N_{Ri}
			Col (%)	YIF			
USA	16743	32,50%	26,00%	1,22	16	3,1	1,9
JAPAN	5169	10,00%	14,10%	0,48	4	3,2	1,6
PEOPLES R CHINA	3474	6,80%	36,20%	1,03	7	3,4	1,9
TAIWAN	2527	4,90%	14,60%	0,84	7	2,8	1,7
SOUTH KOREA	2179	4,20%	25,60%	0,72	4	3,2	1,8
UNITED KINGDOM	2073	4,00%	41,90%	1,06	10	3,1	1,9
CANADA	2035	4,00%	45,70%	1,04	9	3	1,9
ITALY	1783	3,50%	35,90%	1,04	10	3,5	1,9
..	..	..	..	..	..	..	..

Table 51: Sample output, evaluation of N_P , $N_{P\%}$, $Col\%$, YIF , N_{Ci} , N_A , N_{Ri} for 15-years interval for selected WOS category.

g) Language Analysis

Country	ALGERIA		ARGENTINA		ARMENIA		AUSTRALIA	
Language	N°Papers	%	N°Papers	%	N°Papers	%	N°Papers	..
	36	100,00%	43	100,00%	4	100,00%	1053	..
English	32	88,90%	43	100,00%	4	100,00%	1053	..
French	4	11,10%	0	0,00%	0	0,00%	0	..
Japanese	0	0,00%	0	0,00%	0	0,00%	0	..
Welsh	0	0,00%	0	0,00%	0	0,00%	0	..

Table 52: Sample output, evaluation of N° of research papers published in each of the languages for selected WOS category globally.

4.1.3. To determine the institutional distribution of publications, through productivity, impact and collaborations analysis.

a) Sample of Output for 1 year interval to evaluate productivity.

Total			3159	2983	2719	2826	2770	..
			1997	1998	1999	2000	2001	..
	Research centre	Country	N _P	N _P	N _P	N _P	N _P	..
632,82	IBM CORP	USA	53,1	69,1	55,22	40,7	47,08	..
388,36	UNIV ILLINOIS	USA	24,68	29,58	24,35	17,06	20,5	..
346,03	UNIV TEXAS	USA	32,25	26,38	29,58	22,58	22,83	..
337,74	NANYANG TECHNOL UNIV	SINGAPORE	14	15,33	19,95	15,33	18,5	..
323,2	TOKYO INST TECHNOL	JAPAN	28,42	22,67	20	16,08	22,67	..
310,27	NATL CHIAO TUNG UNIV	TAIWAN	22	19,83	26	18,33	17,83	..
288,62	INTEL CORP	USA	10,05	16,9	10	21,42	13,33	..
..	..	..	..	..	..	..	..	..

Table 53: Sample output, evaluation of N_P 1-year interval for selected WOS category.

b) Sample output for 1 year interval to evaluate impact.

Mean			0,51	0,53	0,7	0,68	0,88	..
			1997	1998	1999	2000	2001	..
	Research centre	Country	YIF	YIF	YIF	YIF	YIF	..
1,55	IBM CORP	USA	0,93	0,9	1,1	1,05	1,51	..
1,26	UNIV ILLINOIS	USA	0,72	0,53	0,92	0,73	1,09	..
1,09	UNIV TEXAS	USA	0,71	0,76	0,87	0,86	1,07	..
1,02	NANYANG TECHNOL UNIV	SINGAPORE	0,15	0,27	0,56	0,54	0,32	..
0,45	TOKYO INST TECHNOL	JAPAN	0,2	0,32	0,3	0,32	0,42	..
0,9	NATL CHIAO TUNG UNIV	TAIWAN	0,74	0,61	0,58	0,78	0,64	..
1,08	INTEL CORP	USA	0,61	0,85	0,59	0,84	0,99	..
..	..	..	..	..	..	..	..	..

Table 54: Sample output, evaluation of YIF1-year interval for selected WOS category.

Mean			14 1997	13 1998	19 1999	17 2000	16 2001	..
	Research centre	Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	..
22	IBM CORP	USA	22	25	34	33	42	..
17	UNIV ILLINOIS	USA	25	22	35	27	16	..
15	UNIV TEXAS	USA	17	18	22	23	15	..
10	NANYANG TECHNOL UNIV	SINGAPORE	5	8	18	24	3	..
3	TOKYO INST TECHNOL	JAPAN	2	8	3	5	3	..
9	NATL CHIAO TUNG UNIV	TAIWAN	15	10	12	10	11	..
13	INTEL CORP	USA	19	21	31	17	9	..
..	..	..	..	..	..	..	..	..

Table 55: Sample output, evaluation of N_{CI} for 1 year for selected WOS category.

c) Sample output for 1 year interval to evaluate collaborations.

Total				314 1997	10% 1997	380 1998	13% 1998	..
	N°ColTotal	%ColTotal	Research centre	N°Col	%Col	N° Col	%Col	..
633	90	14%	IBM CORP	3,61	7%	9,4	14%	..
388	58	15%	UNIV ILLINOIS	1,68	7%	2,66	9%	..
346	45	13%	UNIV TEXAS	3,41	11%	2,16	8%	..
338	56	16%	NANYANG TECHNOL UNIV	1	7%	0,33	2%	..
323	16	5%	TOKYO INST TECHNOL	0	0%	3,16	14%	..
310	23	7%	NATL CHIAO TUNG UNIV	3,66	17%	1,5	8%	..
..	..	..	..	..	..	..	..	..

Table 56: Sample output, evaluation of $N^{\circ}Col$ and Col (%) for 1 year for selected WOS category.

d) Sample output for 3-year interval to evaluate productivity.

Total			8861 1997-1999	8413 2000-2002	11506 2003-2005	..
	Research centre	Country	N _P	N _P	N _P	..
632,82	IBM CORP	USA	177,42	150,72	134,78	..
388,36	UNIV ILLINOIS	USA	78,62	60,13	88,2	..
346,03	UNIV TEXAS	USA	88,21	70,71	115,22	..
337,74	NANYANG TECHNOL UNIV	SINGAPORE	49,28	62,67	73,17	..
323,2	TOKYO INST TECHNOL	JAPAN	71,08	55	63	..
310,27	NATL CHIAO TUNG UNIV	TAIWAN	67,83	57,33	63,28	..
288,62	INTEL CORP	USA	36,95	49,86	83,78	..
287,22	MIT	USA	55,72	70,47	70,41	..
..	..	..	..	..	..	..

Table 57: Sample output, evaluation of N_P for 3 years for selected WOS category.

Figure 49: Sample of status graph of N_p by the research centre for selected WOS category.

e) Sample output templates for 3-year interval to evaluate impact.

Mean			0,58	0,80	0,95	..
			1997-1999	2000-2002	2003-2005	..
	Research centre	Country	YIF	YIF	YIF	..
1,55	IBM CORP	USA	0,97	1,73	1,50	..
1,26	UNIV ILLINOIS	USA	0,72	0,94	1,40	..
1,09	UNIV TEXAS	USA	0,78	1,01	1,28	..
1,02	NANYANG TECHNOL UNIV	SINGAPORE	0,36	0,50	0,86	..
0,45	TOKYO INST TECHNOL	JAPAN	0,27	0,37	0,47	..
0,90	NATL CHIAO TUNG UNIV	TAIWAN	0,64	0,77	0,91	..
1,08	INTEL CORP	USA	0,70	0,91	1,10	..
1,42	MIT	USA	1,04	1,20	1,54	..
..	..	..	..	..	..	..

Table 58: Sample output, evaluation of YIF for 3 years for selected WOS category.

Figure 50: Sample of status graph of YIF by the research centre for selected WOS category.

Mean			15	17	11	..
			1997-1999	2000-2002	2003-2005	..
	Research centre	Country	N _{ci}	N _{ci}	N _{ci}	..
22	IBM CORP	USA	27	34	19	..
17	UNIV ILLINOIS	USA	27	25	21	..
15	UNIV TEXAS	USA	19	19	14	..
10	NANYANG TECHNOL UNIV	SINGAPORE	12	14	12	..
3	TOKYO INST TECHNOL	JAPAN	4	4	4	..
9	NATL CHIAO TUNG UNIV	TAIWAN	12	14	11	..
13	INTEL CORP	USA	23	14	20	..
35	MIT	USA	47	47	43	..
..	..	..	..	..	..	..

Table 59: Sample output, evaluation of N_{ci} for 3 years for selected WOS category.

Figure 51: Sample of status graph of N_{Ci} by the research centre for selected WOS category.

f) Sample output for 15-year interval to evaluate geographical distribution of publications.

Research institution	Country	1997-2011						
		N _P	N _P (%)	Col (%)	YIF	N _{CI}	N _A	N _{RI}
IBM CORP	USA	633	1,2%	22,6%	1,55	22	4,7	2,1
UNIV ILLINOIS	USA	388	0,8%	22,4%	1,26	17	3,4	2,3
UNIV TEXAS	USA	346	0,7%	19,5%	1,09	15	3,1	2,0
NANYANG TECHNOL UNIV	SINGAPORE	338	0,7%	29,8%	1,02	10	2,9	1,6
TOKYO INST TECHNOL	JAPAN	323	0,6%	8,9%	0,45	3	3,0	1,6
NATL CHIAO TUNG UNIV	TAIWAN	310	0,6%	13,0%	0,90	9	2,9	1,8
INTEL CORP	USA	289	0,6%	21,5%	1,08	13	3,6	2,4
MIT	USA	287	0,6%	21,6%	1,42	35	3,3	2,2
„	„	„	„	„	„	„	„	„

Table 60: Sample output, evaluation of N_P , $N_{P\%}$, Col%, YIF, N_{Ci} , N_A , N_{RI} for 15 years for selected WOS category.

4.1.4. To establish the effectiveness of the diffusion and internationalization of the worldwide research journals of the field

An analysis has been carried out to verify the influence of each country related to the publication of total number of research papers in each journal.

Abbreviated Journal	Mean IF	N° papers	5315	1656	1793	..
			USA	JAPAN	PEOPLES R CHINA	..
VLDB J	3,83	222	40	1	11	..
IBM J RES DEV	3,02	301	64	2	4	..
IEEE T NEURAL NETWORK	2,99	883	17	3	28	..
J ACM	2,78	150	49	1	1	..
IEEE WIREL COMMUN	2,39	310	28	2	8	..
IEEE MICRO	2,36	204	66	5	3	..
IEEE NETWORK	2,2	190	30	1	6	..
COMMUN ACM	2,17	741	63	1	2	..
IEEE ACM T NETWORK	2,16	679	61	1	5	..
..	..	..	..	..	..	..

Table 61: Sample of percentage of the total number of papers published by a journal due to researchers of a specific country ($JI_j(\%)$). The sum of each row is 100%.

Abbreviated Journal	Mean IF	N° papers	5315	1656	1793	..
			USA	JAPAN	PEOPLES R CHINA	..
VLDB J	3,83	222	1,7	0,1	1,4	..
IBM J RES DEV	3,02	301	3,6	0,4	0,6	..
IEEE T NEURAL NETWORK	2,99	883	2,8	1,6	13,9	..
J ACM	2,78	150	1,4	0,1	0,1	..
IEEE WIREL COMMUN	2,39	310	1,6	0,4	1,4	..
IEEE MICRO	2,36	204	2,5	0,6	0,4	..
IEEE NETWORK	2,20	190	1,1	0,1	0,7	..
COMMUN ACM	2,17	741	8,7	0,5	0,8	..
IEEE ACM T NETWORK	2,16	679	7,8	0,3	2,0	..
..	..	..	..	..	..	..

Table 62: Percentage of the total number of weighted papers of one country published in a specific journal ($JI_c(\%)$). The sum of each column is 100%.

4.2. APPLICATION OF THE METHODOLOGY FOR THE CHARACTERIZATION OF RESEARCH FIELD IN CYBERNETICS

4.2.1. Summary of the most outstanding results

This chapter summarizes the most outstanding results. The details, figures and tables of the study can be consulted in the Annexes.

Application of methodology for the characterization of the research field in cybernetics has been investigated through the computer application, with Cybernetics WOS category data. Application of this methodology provides a characterization of global overview of the research activity carried out in the field of cybernetics for the 15-year interval (1997–2011).

As through automated computer analysis for scientometric analysis states that, scientific publications in the field of cybernetics have experienced very little growth in recent years (from 1,004 research papers published in 1997 to 1,126 in 2011), quite low as compared to general trend of growth in other disciplines. However, the research impact has experienced tremendous growth (from 0.35 YIF in 1997 to 1.31 in 2011). Moreover, there has been an increment in collaborations at all levels (Internationals dispersal, number of research centres and number of authors per research paper) which reflects big complex structural framework of research networks.

The keywords analysis reflects a great diversity in research topics (73% of keywords only appears in one research paper). Nevertheless, there is a core of common terminologies which is an important part of conducted research (100 most used words account for 37% of the total). The analysis of increments and decrements in the use of keywords can help researchers to identify research areas that are gaining strength and the research topics which are relegated into disuse.

Scientific production in this field is closely linked to the degree of industrialization and the research resources. The first 30 countries are responsible for 90.3% of worldwide production. The first 10 positions are taken over by G8 countries, along with the new emerging countries such as People's Republic of China and Taiwan. However, there are major differences in the impact levels and diffusion across different countries and research centres; it is a consequence of the diverse publishing trends.

The high number of research papers published by the journals "IEEE Transactions On Systems Man And Cybernetics" (A, B and C) and journal of "Biological Cybernetics" influence the big number of impact indicators in countries such as USA, UK or People's Republic of China and their corresponding research centres. USA leads all the consecutive periods studied with an overwhelming advantage over the rest of the countries (20.1% of world production); carry 27 out of 100 most productive worldwide research centres; outstanding research centres among them are "MIT" and "Stanford University" for their high level of impact rates.

Generally, USA combines its productivity with high research impacts and researches diffusion, being the country with the highest number of international collaborations (1,132 research papers). Through collaborations of USA, important percentage of production has been observed in countries such as Canada, People's Republic of China, Japan, Taiwan, South Korea, India and Israel.

People's Republic of China has experienced a spectacular growth, quadrupled its production in few years and reached at the second place in world ranking. Total increment in R&D investments seems to have a clear impact on the production and research publications in the field of cybernetics. Some of the Chinese research centres have achieved top ranking both in production and impact, such as "Chinese Academy of Sciences" and "City University of Hong Kong".

Since 1997, Russia has been affected by a steady decline of research publications, despite the increase in the gross domestic investment in Engineering and Technology. Moreover, the impact of their research is very low due to a high concentration of low impact research publications; the same episode has been repeated in other Eastern European countries. The "Russian Academy of Sciences" is not only the research centre with the highest number of research papers, but also one of the lowest impact indicators and lowest in International collaboration.

4.2.2. Global evolution of publications under the "Computer Science, Cybernetics" category

The computer application identifies the countries and research centres involved in the publication of each research paper (in this step a 2.5% did not contain information of the origin of the research paper in the field Addresses of WOS).

The research papers published in the category of "Computer Science, Cybernetics" have experienced a slight increment between the time span of 15 years (1997–2011), presenting some ups and downs throughout the said time. In this category, the research publications have had a considerable diffusion, with 1,004 research papers published in 1997 year which increased to 1,126 research papers published in 2011. Over the past years, there has been a notable growth trend in the publications of research papers along with participation of countries and worldwide research centres.

Research collaborative papers have shifted from the national interinstitutional to the international collaboration: The percentage of research papers published through international collaboration has nearly doubled, from 11% in 1997 to 23% in 2011.

Moreover, the category of "Computer Science and Cybernetics" has experienced an increment in number of authors and institutional collaboration in the publication of research papers. Regarding the number of authors per research paper, it has gradually increased from the 2.1 authors in 1997 to 3.0 in 2011 (a growth of 43 %). Regarding the research centres, the numbers have gone up from 1.4 in 1997 to 1.8 in 2011 (a growth of 28 %, category this indicates the increasingly global character of the research activity and increased complexity of research networks.

The YIF also reflects the growth of "Computer Science, Cybernetics" category along the span of 15 years, from 0.35 in 1997 to 1.31 in 2011 (a growth of 274 %). The average number of citations received by research papers published in a year has a large variation over the years, and it decreased from 11 citations in 1997 to only 1 citation in 2011 category: This is due to factors such as the overall increment in the number of journals and

research papers, the available time for them to be cited, until December 2012 (time of download), the tendency to forget older research papers. The research papers published in the first years of the study receive a higher number of citations since they have more margins to be studied and they are used in new research. As the time of study passes by, the number of citations decreases. However, these values provide a benchmark to compare the impact of a country or research centre specifically with respect to the impact of all publications of each specific period.

The percentage of other languages is negligible, as 99.98% of English is used in the research and development activity of this category (*Table 82*).

4.2.3. Evolution of the important research topics

The analysis of keywords might be important to monitor the development and directions of science and research activity. In the category of "Computer Science, Cybernetics", more than 31,000 keywords have been detected with 92,294 times of appearance (*Table 69*). There are a handful of topics that appear quite frequently as compared to most of the keywords that appear in small number of research papers. Thus, 27% appear in more than one research paper, 4% appear in more than ten research papers and less than 1% of the keywords appear in more than 100 research papers. The existence of a small group of commonly used keywords count occurrence of the 100 most used keywords accounts for 21% of the total permits to characterize the content of the research in the field of cybernetics in more detail. By analyzing only, the words that comprise of keywords, the count occurrence of the 100 most used words raise up to 37%.

It is noteworthy that some general terms used in the definition of the category of WOS such as "systems", "cybernetics" or "models" are widely used by researchers, occupying leading positions, while others such as "artificial", "intelligence", "automatic" or "robotics" are not included in the 100 most frequently used words (analysis of the words that make up the keyword). The evolution in the use of the most prominent words is shown in *Table 65*.

The first positions throughout the time period have been taken over by general terminologies words, used in multiple combinations such as "system" (systems theory, nonlinear system, control system, multi-agent system, information system, etc.), "model" (technology acceptance model, hidden mark of model, internal model, etc.), "control" (optimal control, control system, adaptive control, infinity control, etc.), "network" (neural network, sensor network, social network, Bayesian network, etc.), "design" (interaction design, inclusive design, interface design, etc.), "algorithm" (genetic algorithm, evolutionary algorithm, mimetic algorithm, etc.).

The most prominent actions within the field cybernetics are related to different types of "control", "design", "analysis" (stability analysis, systems analysis, sensitivity analysis, etc.), "recognition" (pattern recognition, face recognition, object recognition, etc.), "optimization" (global optimization, multi-objective optimization, combinatorial optimization, etc.), "learning" (machine learning, reinforcement learning, learning algorithm, etc.), "management" (supply chain management, uncertainty management, risk management, etc.), "interaction" (human computer interaction, human robot interaction, interaction design, etc.), "movement" (eye movement, arm

movement, human movement, etc.), "tracking" (tracking control, visual tracking, target tracking, etc.), "classification" (pattern classification, image classification, texture classification, etc.), "motion" (human motion, motion estimation, motion planning, etc.), "modelling" (user modelling, fuzzy modelling, cognitive modelling, etc.), "detection" (edge detection, face detection, fault detection, etc.), "communication" (computer mediated communication, communication technology, haptic communication, etc.), "programming" (dynamic programming, linear programming, stochastic programming, etc.), "perception" (visual perception, haptic perception, depth perception, etc.), "search" (visual search, tabu search, local search, etc.).

Other topics of great use are related to "information" (information technology, information system, information retrieval, etc.), "fuzzy" (fuzzy logic, fuzzy set, fuzzy control, etc.), "neural" (neural network, artificial neural network, recurrent neural network, etc.), "time" (time series, time delay, real time, etc.), "computer" (human computer interaction, computer vision, computer mediated communication, etc.), "user" (user interface, user acceptance, user modelling, etc.), "human" (human computer interaction, human factor human robot interaction, etc.), "theory" (systems theory, game theory, set theory, etc.).

The analysis of increments and detriments in the use of keywords can help researchers to identify research areas that are gaining strength and the research topics which are relegated into disuse. It also highlights the use of synonyms or terminologies which can characterize the same research lines. The terminologies with the highest growth in absolute terms are usually those in the top positions of the ranking for the entire period however, certain terminologies have experienced a large relative growth in recent years, winning many positions in the ranking. For example, a notable increase in terms such as "theory", "user", "technology", "management", "tracking", "web", "detection", "social", "delay", "usability" or "perception". Certain terms minor years have reached the top 100 in the last period, "accessibility" (61th), "haptic" (72th), "service" (74th), "game" (79th), "quality" (82th), "cognitive" (83th), "field" (85th), "uncertainty" (90th), "framework" (96th), "sensor" (97th).

While on the contrary, other terminologies have experienced limited growth, its relative importance decreasing and losing many positions in the ranking. Even some terms have suffered a decline in its use despite overall increase in research papers and keywords. The biggest drops in the rankings correspond to "controller", "rule", "cell", "distributed", "genetic", "neuron", "cortex", "space", "representation", "logic", "self", "structure", "robot", "motion", "memory", "language". Among the terms, most used words highlight the moderate growth of "fuzzy", "neural", "computer", "dynamic", "decision" and "knowledge".

Analyzing the keywords as they are defined by the authors, both simple and composite, highlights the growth of compound terminologies such as "systems theory", "information technology", "face recognition", "decision making", "human computer interaction", "user acceptance". Conversely, there are some keywords which have not shown high growth with respect to their appearance in number of research papers, having lost their relative importance among other keywords. Among these keywords is "neural network", "genetic algorithm", "fuzzy logic", "Petri net", "logic controller", "artificial intelligence", "expert system".

4.2.4. Evolution of research activity by country

Using automated methodology based scientometric analysis, computer application has ranked the most productive countries in the span of 15 years (1997–2011). Thus, indicators have been used such as productivity indicator (number of weighted research papers), impact and research diffusion indicators (YIF, number of citations) and collaboration indicators (international collaboration percentage, number of authors/research paper and number of centres/research paper).

The ten most productive countries are responsible for 65.7% and first 30 countries are responsible for 90.3% of worldwide production of considered research papers. The first 10 positions are taken over by the G8 countries, along with the new emerging countries such as People's Republic of China and Taiwan (Table 81). It demonstrates clear relationship between the countries' degree of industrialization and the resources used in cybernetics research.

USA is with the largest expenditure on R&D (from 212,709 to 415,193 million dollars in the studied period (*Source: OECD*, <http://www.oecd.org>) at first position with 20.1% of world production (weighted 3,302 research papers). However, the overall numbers of R&D corroborate the results in the field of cybernetics have specific constraints in the technology sector; the production of scientific publications in cybernetics field remains relatively stable over the entire time period (Figure 59), although R&D investments have been doubled (*Source: OECD*, <http://www.oecd.org>). The high production does not affect the overall impact and diffusion research, while reaching at high values of YIF and high number of citations per research paper (N_{CI}) with respect to a global average value.

There is great difference when it comes to production levels of UK (9.3% of total production) and Russia (9.1%). These production levels are quite high while taking in to account of their R&D investments, which is between 39,627 million dollars and 33,721 million dollars in 2011 (*Source: OECD*, <http://www.oecd.org>) much lower than that of USA. Despite their high number of research papers, UK and Russia have failed to increase their production level in recent years. Moreover, the number of weighted research papers of Russia has suffered a steady decline since 1997, despite an increase in total gross domestic expenditure in R&D from 8,797 million dollar in 1997 to 33,721 million dollar in 2011 and the gross domestic expenditure in Engineering and Technology from 6,457 million dollar in 1997 to 23,116 million dollar in 2010. Besides this, Russia has very low levels of impact factor and low number of citations of their publications, because of the high concentration of their research papers in the low impact national journals.

People's Republic of China has experienced a spectacular growth; the number of weighted research papers has quadrupled in the last few years. In this way, People's Republic of China has been located at the second place of the ranking table, which is far ahead of the UK and Russia. Unlike the above, the large increase in total expenditure in R&D from 14,733 million dollars in 1997 to 208,172 million dollars in 2011 and the number of researchers from 588,700 to 1,318,086 (*Source: OECD*, <http://www.oecd.org>) seems to be a clear reflection in production and impact of their publications in cybernetics field. This increase is accompanied by an outstanding

impact and their work dissemination, with YIF values like USA and UK, and with number of citations per research paper (N_{CI}) that is more than that of both in last few years.

None of the other countries have been reached at 5% of the total production. Countries such as Canada, Taiwan, Spain and South Korea have experienced significant growth in last few years. Conversely, Ukraine has experienced a sharp decline in their scientific production, being almost negligible in recent years. Also, Japan has experienced a decline in its production, although it is less severe compared to Ukraine (Table 79). There are great differences in the impact levels and diffusion between one country and another. Most of the top-ranking countries with greater production level stand out due to their ability to maintain an increased production level as well as an increased impact factor (YIF) and number of citations (N_{CI}) of their research publications. Eastern European countries such as Russia, Ukraine, Slovakia, Czech Republic and Poland have lower YIF and N_{CI} values) (Table 80).

In rest of the countries, YIF and N_{CI} values have marked their influence on the said time. This is due to the general change in averages values which has been previously analyzed. There is big difference of YIF and N_{CI} values between one country and another due to publishing preferences in journals highly variable in impact. Among countries of small scale production, Singapore is the only country with greater YIF values and with large number of citations.

If we analyze the worldwide research collaboration level in this category, a great difference can be found between one country and another. These differences are not due to expenditure on R&D or the number of researchers of the country, they must be due to other causes, such as geopolitical factors and language. Countries with maximum range value of international research collaboration are France (43.1%), Canada (43.1%), Australia (42.2%), Singapore (44.6%), Switzerland (40.3%) and Austria (44.8%) (Table 81).

Although most of the countries with high percentage of collaboration have greater YIF values and increased number of citations, there is no direct relationship between collaboration percentage and impact factor and dissemination of research work. Generally, countries such as Russia or Ukraine, with limited international collaboration, have low impact indices, while on the other hand Taiwan represents increased index values.

In absolute terms, USA is the country with the largest number of international documents (1,132 research papers are with shared authorship) (Table 73), being the country of major collaborations or the country where majority of other countries collaborate USA and People's Republic of China are the countries where majority of the research papers (542), are developed through mutual understanding and collaboration. This means that 60% of the total international research papers of China (24% of total research papers) have been made through collaboration of USA, compared to 29% of total USA international research papers. Also, there is a high level of collaborations between USA and other English-speaking countries such as Canada (724 research papers, 43% of the total are through collaborations) and UK (566 research papers, 31% of total are through collaborations).

International importance of USA has been reflected through a high percentage of research collaborations with other countries, such as Japan (26% of the international research papers are developed through USA collaboration), Taiwan (12 %), South Korea (32%), India (29%) and Israel (33%) (Table 74).

Through the further study of collaboration levels, the data have been analyzed through mythology based computer application with respect to the number of authors per research paper and the number of research institutions per research paper. Low collaboration levels have been found in Eastern European countries, in case of authors collaborations (there is less than two authors per research paper) and in case of research centres collaboration (there is less than 1.6 research centres per research paper). Conversely, countries with greater YIF values and higher research impact values have numerous and complex research networks, with an average of more than 3 authors and more than 2 research centres per research paper (*Table 81*).

4.2.5. Evolution of research activity by worldwide research centres

The 10 most productive worldwide research centres are responsible for 7.2%, first 30 for 14.4%, first 50 for 19.6%, first 100 for 29.1%, and first 1,000 worldwide research centres are responsible for 72.9% of worldwide production. This indicates that a big number of worldwide research centres is working globally in the field of cybernetics. The country with the highest number of productive research centres is USA. Out of the 100 most productive worldwide research centres, 27 are from USA, 16 are from UK, 9 are from China, 5 each from Russia and Canada, 4 from Netherlands, 3 each from Taiwan, Poland, Israel and Czech Republic, 2 each from Spain, South Korea, Singapore, Japan, India, France, Australia and 1 each from Ukraine, Sweden, Slovenia, Norway, Italy, Germany, Denmark. "Russian Academy of Sciences", is the research centre with the highest number of weighted research papers (464 research papers, 2.8% of total) (*Table 91*).

Nevertheless, it has also one of the lowest YIF values (0.12), one of the lowest numbers of citation per research paper (1) and one of the lowest percentages of international collaboration (6.5%). This high production with low YIF values and low number of citations is since high number of research papers is published without other research centre collaboration in low impact factor journals; with low international diffusion. The rest of research centres has shown lower production levels. Depending on the year, there is major change in their rankings with respect to production levels (*Table 90*).

While emphasizing on production level of research centres such as "Tsinghua University" of China, "Nanyang Technological University" of Singapore, "Chinese Academy of Sciences", who have raised their ranking positions to 2nd, 4th, 5th rank in the time 2009–2011, achieving high values of impact and diffusion. Conversely, there are some examples of significant falls in the ranking positions, for example "MIT" of USA and "University of Paris" of France, which have experienced a fall of more than 40 positions in their rankings while leaving top 5 positions of ranking order.

In contrast to the number of weighted research papers, there is a big difference between impact and number of citations received by the research work of different research centres. In this time period (1997–2011), the top research centres with high values of YIF and high average values of citations are "MIT" with 1.23 YIF and 22 citations per research paper, "Chinese Academy of Sciences" with 1.51 YIF and 19 citations, "Nanyang Technological University" with 1.39 YIF and 17 citations, "City University of Hong Kong" with 1.35 YIF and 21

citations, "Stanford University" with 1.44 YIF and 23 citations and "Delft University of Technology" with 1.25 YIF and 20 citations (Table 92).

On the contrary, Eastern European research centres generally exhibit lower impact values throughout the entire time, lower than world average value (Table 92). Particularly, centres with lower impact are "Russian Academy of Sciences", "Academy of Sciences of the Czech Republic", "and National Academy of Sciences of Ukraine", "Charles University Prague and Technical University" of Russia.

If we focus on worldwide research centres collaboration, generally the research centres which belong to the countries of high collaboration always present high ratios. Thus, among first thirty research centres stand more than 50% of the collaboration such as "University of Paris 06", France, "Nanyang Technological University", Singapore, "Tsinghua University", People's Republic of China and "Chinese Academy of Sciences". On the other hand, research centres with low percentage of international collaboration are "Russian Academy of Sciences" (6.5%), "Technical University" of Russia (1.4%), "National Academy of Sciences" of Ukraine (7.0%) and "National Chiao Tung University" of Taiwan.

Despite the high percentage of international collaboration of some research centres, some research centres, there is great number of research centres where they do not have strong linkage with most productive centres. Usually, many collaborations are held between the national research centres, for example "Academy of Sciences of the Czech Republic" and "Charles University Prague". However, the largest number of collaboration from all research centres is performed between "Tsinghua University" of People's Republic of China and the "Purdue University" of USA, which shows strong relationship between these two countries in the field of cybernetics.

Generally, research centres with greater research impact and diffusion have high percentage of international collaboration and/or high number of research centres and authors per research paper (Table 94), that appears to be indicative of more complex and numerous research networks. Reciprocally, the centres with low level of international collaboration are represented by smaller research groups, with few authors and few research centres. Exceptionally, some research centres such as "National Chiao Tung University" of Taiwan has low level of international collaboration but high level of complex national network.

Regarding research papers related to biological aspects, there is no research centre whose production stands out from the rest. The production of the 10 most productive centres does not reach 10% of the total: University of Maryland (1.1%), Bielefeld University (1.0 %), Pennsylvania State University (0.9 %), Technion-Israel Institute of Technology (0.9 %), MIT (0.9 %), Osaka University (0.9 %), Technical University of Munich (0.9 %), Riken (0.8 %), Tel Aviv University (0.8%) and University of Southern California (0.8 %).

4.2.6. Internationalization and diffusion of journals Cybernetics

In this section, research journals research papers related to the category of "Computer Science, Cybernetics" have been studied in the last years (time 2007–2011). An analysis has been carried out to verify the influence of each country related to the publication of total number of research papers in each journal. It is noted

that journals with higher IF (2011 data) tend also to have high levels of international diffusion, with large number of participating countries, especially those of higher level of production) (Table 95).

Journals such as "IEEE Transactions on Systems Man and Cybernetics" (A, B and C) and the "Biological Cybernetics" have contributions from more than 25 countries out those 30 are of high production levels. On the other hand, the journals with the least impact generally have less international diffusion, with an increased percentage of research papers coming from less productive countries, and they have participation from very few countries.

There is a direct relationship between previously obtained country's YIF and journal's IF where they have most of their publications. Recurrently, journals such as "IEEE Transactions on Systems Man and Cybernetics" (A, B and C) and "Biological Cybernetics" have a relevant influence, because of the high number of research papers published in these journals and the high values of IF, which influence the impact indicators of countries such as USA (where 46% of research papers are published in these journals), UK (29 %), People's Republic of China (52 %) (Table 96).

Similarly, research centres with high level of impact indicators usually publish their high percentage of research publications in said journals, for example 56% of "MIT", 88% of "Chinese Academy of Sciences", 75% of "Nanyang Technological University", 85% of "City University of Hong Kong". Ukraine, and Slovakia publish few research papers in journals with high impact factor and bigger internationalization; majority of their research papers are published in journals with low impact factor.

This phenomenon results in a lower level of international dissemination of their research work, with a consistent number of citations for their research papers. Also, this could result in a lower percentage of collaboration with research centres of other countries. Particularly, this is significant in the case of "Journal of Computer and Systems Sciences International", which concentrates 95% of Russian production and 77% of Ukrainian production during the last years. The concentration of most the research papers of Eastern European research centres is found in few journals, and this causes a negative impact on their international diffusion. Thus, research centres such as "Russian Academy of Sciences" concentrates 94% of its production in "Journal of Computer and Systems Sciences International" and the "Academy of Sciences of the Czech Republic" concentrates 94% of its production in "Kybernetika."

4.3. APPLICATION OF THE METHODOLOGY FOR THE CHARACTERIZATION OF RESEARCH FIELD IN HARDWARE ARCHITECTURE

4.3.1. Summary of the most outstanding results

This chapter summarizes the most outstanding results. The details, figures and tables of the study can be consulted in the Annexes.

Application of methodology for the characterization of the research field in Hardware Architecture has been investigated through the computer application, with Hardware Architecture WOS category data. Automated computer application analysis provides an overview of the research activity in the field of hardware architecture from 1997 to 2011. Over 51,000 articles were analyzed using specially developed computer application. Among its many capabilities, this computer application can analyze keyword evolution, compute weighted productivity with respect to the number of research centres per article, estimate the impact of each article, and determine the collaborations established at different scales.

The keyword analysis showed that topics of interest evolve. Most of the technical terms used in the definition of the category "Computer Science, Hardware Architecture", such as Board, Bridge, SPARC, RISC, CISC, Bus or Router Interface, were hardly employed by researchers. Over recent years there has been a remarkable increase in the amount of research undertaken in the field of networks and sensors (wireless sensor network, ad hoc networks, etc.). Topics such as Security, Stability, Energy, Chips, Optical and Reduction have also shown a notable increase. The study also identifies keywords of lesser interest (neural networks, ATM, VLSI, etc.).

Scientific production and the impact of this research have grown unevenly. Scientific production is also concentrated, with the 30 most productive countries responsible for 93% of world production. The USA dominates this field of study, combining a huge production (32.5% of the total collaboration-weighted production) with a high research impact (much higher than that of most other countries). Forty four of the 100 most productive research centres were found to be in the USA. Although many US centres have failed to maintain their growth of production, their research work has a greater scientific impact. Japan, the UK, Italy and Germany all returned relatively constant levels of output. The results also showed the People's Republic of China to be a growing force. The impact of research by these countries and their research centres, however, showed differences due to the internationalization and impact of the journals in which they publish.

This computer application provides detailed information on existing collaborations between countries and research centres. Collaboration levels have increased at all scales, indicating more complex research networks. The conditions of each country influence the amount of international collaboration in which it is engaged. US research centres are those that collaborate most with the rest of the world.

4.3.2. Global evolution of publications under the “Computer Science, Hardware Architecture” category

Through computer application for scientometric analysis provides an overview of the research undertaken in the field of hardware architecture between 1997 and 2011. Over 51,000 journal articles (conference articles excluded) were analyzed using specially developed computer application. This computer application identifies the countries and research centres associated with research papers (3.4% contained no information on origin in the WOS field “Addresses”), tracks the development of the most important research topics, and analyses the changes in the geographic and institutional distribution of publications.

The geographic and institutional distribution of publications was examined by determining the number of collaboration-weighted articles (N_P) produced by each country and research centre. This indicator ensures that the sum of research papers published by the total number of countries and research centres correspond to the total of published papers, having a more realistic productivity scale. For any specific period, this indicator N_P has been calculated. For example, for 15 years, 3 years and for 1 year respectively (Table 104).

To analyze the complexity of the research network structures, the computer application has examined the degree of international collaboration involved in each article, as well as the number of research centres and authors involved. This was achieved by its recording the connections between the participating countries and research centres, and generating corresponding matrices that reflected them. The percentage of international collaboration -Col (%) - for the different countries and centres was then calculated as the number of research papers published in collaboration with at least one centre of another country over their total production. The average number of authors per article from each country or research centre N_A can be calculated accordingly (Figure 67). The average number of research institutions (N_{RI}) participating in each paper is also possible to calculate for each country and research centre.

To determine the impact of a piece of research, the IF and the number of citations per article were examined. An impact indicator, i.e., the Year Impact Factor (YIF the IF of the journal for the year in which the article was published) was first assigned to each paper. The average YIF for each country and research centre can be calculated. The average number of citations for each country and research institution (N_{CI}) can be calculated for related category of WOS (Figure 68). The percentage of other languages is negligible, as 98.85% of English is used in the research and development activity of this category (Table 116).

4.3.3. Evolution of the important research topics

The statistical analysis of author keywords might be aimed at discovering directions of science, and proved important for monitoring development of science and programs. The keywords are provided by the authors of a paper and further keywords or keywords plus are generated by the ISI. The program obtained an annual count of the number of research papers (N_K) in which each detected keyword appeared (the computer application can identify singular and plural forms to provide an overall picture). In an additional analysis, compound keywords

were analyzed. These analyses were then combined to provide a more realistic and representative account of the research topics that had been studied.

More than 77,000 different keywords were detected in the category "Computer Science, Hardware Architecture"; in total, these 77,000 different keywords appeared 265,000 times. Some 28% were used in more than one research article but only 4% in more than 10. The 100 most used keywords accounted for 18% of the total, and the 5000 most used keywords accounted for 61%. This reveals the heterogeneity of research topics in this field of study.

Curiously, few of the terms used in the definition of the category "Computer Hardware Architecture" were used as keywords. Even when all the occurrences (i.e., as a single keyword or as part of compound keyword) of the terms Board, Bridge, SPARC, RISC or CISC were considered, their use was very limited (<100 articles each).

Other terms, such as Bus, Interface, Storage, Router or Scalable were found in 100-400 papers. Hardware was mentioned in just over 700 articles. Some keywords, however, were greatly used, e.g., Network (12,643), Power (3288), Memory (1798), Processor (1236) or Parallel (1460). The keywords that occupied the top positions were relatively general, such as Algorithm, System, Design, Network, Performance, Model, Optimization, Circuit and Architecture (Table 101).

Among the 50 most common keywords the growth in the use of some has stagnated or declined over recent years, e.g., Neural Network, Simulation, Scheduling, Routing, Fault tolerance, VLSI, Internet, Performance Evaluation, Cryptography, Interconnection Network and Quality of Service. Strong declines were also seen in the use of ATM, Distributed System, Low Power Design, High Level Synthesis, Parallel, Petri Net, Hypercube, Multiprocessor, Multimedia, Learning, Logic Synthesis, Partitioning and Boolean function.

When the words used in compound keywords were analyzed separately, the term "Network" was the most often used indeed, it showed impressive growth over recent years, much more so than other terms. Next in importance were general terms common to many investigations, such as System (in Embedded System, Distributed System, Real-Time System, etc.), Algorithm (in Genetic Algorithm, Approximation Algorithm, Parallel Algorithm, etc.), Design (in Low Power Design, Design Automation, Physical Designed.), Model (in Model Checking, Analytical Model, etc.), Circuit (in Integrated Circuit, Circuit Simulation, Sequential Circuit, etc.), Performance (in Performance Evaluation, Performance Analysis, High Performance, etc.), Time (in Real Time, Time Delay, Continuous Time Filter, etc.), Power (in Low Power, Power Control, Power Management, etc.), and Analysis (in Independent Component Analysis, Power Analysis Attack, etc.).

Most of this general terminology experienced significant growth. It also highlights the growth of terms such as Wireless, Sensor, Optical, Chip, Security, Stability, Energy and Reduction. In contrast, the use of terms such as Circuit, Neural (mostly related to Neural Network), Fault, Simulation, Logic, Parallel, Array, Processing, Synthesis and VLSI appeared to have stalled, showing zero or even negative growth (*Table 97*).

4.3.4. Evolution of research activity by country

The number of research papers published in the category “Computer Science, Hardware Architecture”, experienced an irregular increment over the 15-year study period. Article production in this category experienced a decline over the first four of these years, from 3159 publications in 1997 to 2770 publications in 2001. Production between 2003 and 2011 was then maintained between 3500 and 4000 papers per year. The total increase in production over the study period was around 30%. It would appear to be an area of irregularly increasing research.

The percentage of papers involving international collaboration more than doubled from 10% in 1997 to 26% in 2011 (Figure 66). The number of authors per article also gradually increased from 2.3 authors in 1997 to 3.3 in 2011 (a growth of 43 %). The average number of research centres involved per paper also went up from 1.5 in 1997 to 1.8 in 2011 (a growth of 23%) (Figure 67). This indicates the increasingly global nature of scientific research.

Modest growth was also seen in the YIF value, which rose from 0.51 in 1997 to 1.10 in 2011 (Figure 68). The number of citations per article, however, gradually decreased (Figure 68) newer articles naturally receive fewer citations within a set period since less time elapses over which other authors can cite them. This should be considered when assessing the merits of researchers.

The 10 most productive countries were responsible for 76% of scientific production in the studied category; the 30 most productive countries were responsible for 93%. The USA alone was responsible for 32.5% of production, followed by several Asian countries (between 4% and 10%). Of these 30 most productive countries, Denmark and Norway surprisingly lagged far behind with just 0.3% of the total production each (Table 113).

The change in the number of collaboration-weighted articles (N_P) produced by different countries differed strongly. When the 15-year study period was divided into consecutive three year slots, (1997-1999, 2000-2002, 2003-2005, 2006-2008 and 2009-2011), UK, Italy and Germany showed rather constant N_P values (Table 112).

In contrast, some countries experienced tremendous growth. For example, People's Republic of China, N_P multiplied 8 times, raising the country from 11th to 2nd position in the ranking. China's increase in total expenditure on R&D (from \$14,733 million in 1997 to \$208,172 dollars in 2011 (*Source: OECD*, <http://www.oecd.org>) seems to have had a clear influence on its production and impact in this field. N_P also grew in Taiwan and South Korea, which now rank among the five top producers. Other countries that have increased their N_P in this field in recent years include Canada, Spain and Iran.

The complexity and size of research networks were examined by analyzing the indicators of research collaboration at all scales. The number of authors per article varied significantly depending on the country. In general, European countries had higher number of authors per article (N_A), with the highest in Spain (4.0), Belgium (3.8) and Switzerland (3.8). Other countries averaged less than 3 authors per article, such as Taiwan, Australia, Turkey and Iran. Moreover, average number of research institutions per article (N_{RI}) was similar in most countries, close to 2.

The conditions of each country influence the amount of international collaboration in which it is engaged. The countries with the most international research collaboration Col (%) were Switzerland (58.0%), Denmark (50.9%), France (50.6%), Israel (49.9%) and Sweden (44.6%). Some countries, such as Japan and Taiwan did not reach 20% category. The USA had the largest number of collaborations, producing a very large total output (Table 115).

Substantial differences were seen between countries in terms of the mean YIF value and number of citations received (N_{CI}). The USA's huge production also had a high impact; indeed, it is one of the countries with the highest average YIF (1.22) and N_{CI} (16), well above the values recorded for other most productive countries. Israel and Switzerland also managed reasonable (Table 115).

Over time, the YIF values of the countries improved (Figure 70), but rates differed. The YIFs of the People's Republic of China, Singapore, Netherlands, Israel and Switzerland grew more strongly, exceeding the world average. In contrast, Japan and Iran had below average YIFs over the entire period, and experienced only very limited growth in recent years. The average number of citations (N_{CI}) decreased over time for all countries (Figure 71) high citation values of Finland and Ireland are explained by their Production of a small number of high impact articles.

4.3.5. Evolution of research activity by worldwide research centres

The dominance of the USA and Asian countries was reflected in the ranking of the most productive research centres (Table 128). The production of the first 30 centres ranged from 0.4% to 1.2% of all articles. Among the top 100 centres, 44 were from the USA, 11 each from China and Japan, 8 from Taiwan, 6 from Canada, 5 from South Korea, 4 from Italy, 2 from Singapore, Israel and Greece, and one from the UK, Switzerland, the Netherlands, India and Belgium. Curiously, countries that achieved a high ranking, such as Germany Spain and France, had no outstanding, highly productive centres. Rather, their output was the sum of that of many centres.

As expected, developments at national level were reflected at the level of national research centres. Thus, the Tsinghua University (People's Republic of China) achieved 1st place in the N_P ranking in the last three-year period, the Chinese Academy of Sciences the 3rd, and the National Tsing Hua University, the National Cheng Kung University, the National Chiao Tung University and the National Taiwan University (all of them from Taiwan) the 4th, 8th, 9th and 10th positions respectively. On a smaller scale, an increase in ranking was seen for South Korea's Seoul National University, the Korean Advanced Institute of Science & Technology, and Korea University, all of which entered the top 20 in more recent years.

The most prominent positions belonged to American research centres such as the University of Texas (2nd), the University of Illinois (6th), Purdue University (7th), and the Georgia Institute of Technology (14th). Singapore's Nanyang Technological University was 5th, the UK's Imperial College of Science, Technology and Medicine 11th, Japan's Tokyo Institute of Technology 13th and Waseda University 17th, Canada's University of Waterloo 16th, and Italy's Politecnico di Torino 19th. A significant fall was seen in the N_P of the IBM Corporation; the company slid out of the top ten rank spots in more recent years, largely because of its division into specific

research centres such as IBM SYST & TECHNOL GRP, and the IBM TJ Watson Research Center, etc. A striking fall was also seen for the INTEL Corporation (USA), MIT (USA), the University of California Berkeley (USA), Carnegie Mellon University (USA), Stanford University (USA), the Indian Institute of Technology (India), and the University of Maryland (USA), none of which are now in the top 20.

Most the most productive centres had between 3 and 4 authors per article (N_A), and between 1.5 and 2.5 research institutions per article (N_{RI}) (Table 128). The American and Chinese centres often returned the highest collaboration values. In absolute terms, the highest number of collaborations were established between some of the major American research centres (note the collaboration between IBM and Intel and some of the major American universities) the strongest relationship was between Purdue University and the University of Iowa, which together produced 90 articles. Papers involving the IBM Corporation had a high average number of authors but a low mean number of participating research centres, indicating that many company researchers were involved in these articles.

International collaboration Col (%) accounted for some 50% of the total of research papers produced by some centres (e.g., the University of Waterloo or National University of Singapore) but under 10% of the production of others (e.g., Tokyo Institute of Technology and Osaka University) (Table 128).

Although many of the USA's research centres failed to maintain their growth in production and lost positions in the productivity ranking, their research works still had the greatest scientific impact. The high YIF values and N_{CI} of the IBM Corporation, MIT, Stanford University, Carnegie Mellon University, the University of California Berkeley, the Georgia Institute of Technology, the University of Southern California and the University of California Los Angeles are noteworthy. The National University of Singapore also had a high YIF and N_{CI} . Conversely, the lowest values were returned by research centres in Japan and South Korea.

4.3.6. Internationalization and diffusion of journals

In this section, research journals research papers related to the category of "Computer Science, Hardware Architecture" have been studied in the last years (time 2007–2011). An analysis has been carried out to verify the influence of each country related to the publication of total number of research papers in each journal. It is noted that journals with higher IF (2011 data) tend also to have high levels of international diffusion, with large number of participating countries, especially those of higher level of production (Table 129).

The difference in the impact of research might be explained by the preferences of the journals publishing in the category. In the last 5 years of the study period, the USA was the main contributor to 75% of the journals in the category, and many more articles were published in major impact journals than in low-impact journals, thus explaining the high values of the country's quality indicators. The high impact values achieved by some other countries over the same period can be explained in the same way (Table 130).

The low impact values of Japan, South Korea, Turkey or Iran are explained by a significant percentage of their articles being published in low impact journals.

5. CONCLUSIONS

The present thesis develops a methodology to carry out scientometric analysis of a global character, by combining different complementary approaches which permits to characterize the worldwide research of a study field in an integral and comprehensive form.

Among its many capabilities, the methodology can reveal the evolution of the most frequent research topics in a category or scientific area through the processing of keywords; reveal the evolution of geographical and institutional distribution of publications, through productivity, impact and collaborations analysis; establish the effectiveness of the diffusion and internationalization of the worldwide research journals of the field.

The methodology for scientometric analysis overcomes some of the limitations of actual existing tools, like inability to analyze simultaneously the keywords defined by the authors as well as the words that make up those keywords; grouping terms of keywords like singular and plural forms; weighting of scientific production with respect to participating research centres or countries; production based qualitative classification of countries and research centres through the impact factor of their publications; determine the collaborations established at different scales, etc.

The analysis of keywords might be important for monitoring development and directions of science and research activity, helping researchers to identify research areas that are gaining strength and the research topics which are relegated into disuse. Moreover, the changes in distributions of the publications, along with changes in collaborations, could help worldwide research institutions to evaluate research plans or investment strategies and to make decisions related to old or new research collaborations, based on worldwide rankings of leading research centres.

To implement the methodology in research fields with thousands of published works, a computer application has been developed. The computer application performs different types of analysis with the most effective algorithms and use different visualizations to explore and understand specific datasets. To determine the validity of the developed methodology, it has been applied to the characterization of two specific research fields: hardware architecture and cybernetics; which are in the confluence of author technical education, the doctoral program and the unit where the final thesis is developed.

Among the many results obtained in the field of cybernetics, it stands out that the publications have experienced very little growth in recent years quite low as compared to general trend of growth in other disciplines. However, the research impact has experienced tremendous growth (from 0.35 YIF in 1997 to 1.31 in 2011). Moreover, there has been an increment in collaborations at all levels (Internationals dispersal, number of research centres and number of authors per research paper) which reflects big complex structural framework of research networks.

The keywords analysis reflects a great diversity in research topics (73% of keywords only appears in one research paper). Nevertheless, there is a core of common terminologies which is an important part of conducted research (100 most used words account for 37% of the total).

The scientific production in this field is closely linked to the degree of industrialization and the research resources. The first 10 positions are taken over by the G8 countries, along with the new emerging countries such

as People's Republic of China and Taiwan. However, there are major differences in the impact levels and diffusion across different countries and research centres; it is a consequence of the diverse publishing trends.

USA leads all the consecutive periods studied with an overwhelming advantage over the rest of the countries (20.1% of world production), carry 27 out of 100 most productive worldwide research centres; outstanding research centres among them are "MIT" and "Stanford University" for their high level of impact rates.

Generally, USA combines its productivity with high research impacts and researches diffusion, being the country with the highest number of international collaborations (1,132 research papers). Through collaborations of USA, important percentage of production has been observed in countries such as Canada, People's Republic of China, Japan, Taiwan, South Korea, India and Israel.

People's Republic of China has experienced a spectacular growth, quadrupled its production in few years and reached at the second place in world ranking. Total increment in R&D investments seems to have a clear impact on the production and research publications in the field of cybernetics. Some of the Chinese research centres have achieved top ranking both in production and impact, such as "Chinese Academy of Sciences" and "City University of Hong Kong.

Among the many results obtained in the field of Hardware Architecture, it stands out that over recent years there has been a remarkable increase in the amount of research undertaken in the field of networks and sensors (wireless sensor network, ad hoc networks, etc.). Topics such as Security, Stability, Energy, Chips, Optical and Reduction have also shown a notable increase. The study also identifies keywords of lesser interest (neural networks, ATM, VLSI, etc.).

Scientific production is also concentrated, with the 30 most productive countries responsible for 93% of world production. The USA dominates this field of study, combining a huge production (32.5% of the total collaboration-weighted production) with a high research impact (much higher than that of most other countries). Forty four of the 100 most productive research centres were found to be in the USA.

Although many USA centres have failed to maintain their growth of production, their research work has a greater scientific impact. Japan, UK, Italy and Germany all returned relatively constant levels of output. The results also showed the People's Republic of China to be a growing force.

The impact of research by these countries and their research centres, however, showed differences due to the internationalization and impact of the journals in which they publish. Collaboration levels have increased at all scales, indicating more complex research networks. USA research centres are those that collaborate most with the rest of the world.

Through defined scientometrics methodology and its computer application, researcher has shown the way to identify new trends and practices of greater interest in selected research fields; to help worldwide research institutions to take decisions related to old or new research collaborations and to establish the effectiveness of the diffusion; to help internationalization of research publications; to help the strategic decisions in research and development (R&D).

6. BIBLIOGRAPHY

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7. ANNEXES

7.1. ANNEX 1. PUBLICATIONS RESULTING FROM THE THESIS

7.1.1. Publication in Biological Cybernetics Journal

Biological Cybernetics (BiolCybern).

Publisher: Springer.

Journal description: Biological Cybernetics is an interdisciplinary medium for theoretical and application-oriented aspects of information processing in organisms, including sensory, motor, cognitive, and ecological phenomena. Topics covered include: mathematical modeling of biological systems; computational, theoretical or engineering studies with relevance for understanding biological information processing; and artificial implementation of biological information processing and self-organizing principles. Under the main aspects of performance and function of systems, emphasis is laid on communication between life sciences and technical/theoretical disciplines.

Ranking: 8/24 in 2014 in "Computer Science, Cybernetics" category.

Original Paper
Biological Cybernetics
December 2014, Volume 108, Issue 6, pp 757-776
First online: 10 July 2014

Analysis of worldwide research in the field of cybernetics during 1997–2011

Virender Singh, Alicia Perdigones, José Luis García, Ignacio Cañas-Guerrero, Fernando R. Mazarrón

The study provides an overview of the research activity carried out in the field of cybernetics. To do so, all research papers from 1997 to 2011 (16,445 research papers) under the category of "Computer Science, Cybernetics" of Web of Science have been processed using our in-house software which is developed specifically for this purpose. Among its multiple capabilities, this software analyses individual and compound keywords, quantifies productivity taking into account the work distribution, estimates the impact of each article and determines the collaborations established at different scales. Keywords analysis identifies the evolution of the most important research topics in the field of cybernetics and their specificity in biological aspects, as well as the research topics with lesser interest. The analysis of productivity, impact and collaborations provides a framework to assess research activity in a specific and realistic context. The geographical and institutional distribution of publications reveals the leading countries and research centres, analysing their relation to main research journals. Moreover, collaborations analysis reveals great differences in terms of internationalization and complexity of research networks. The results of this study may be very useful for the characterization and the decisions made by research in the field of cybernetics.

Figure 52: Screen shot cybernetics publication.

Biol Cybern (2014) 108:757–776
DOI 10.1007/s00422-014-0617-3

ORIGINAL PAPER

Biological
Cybernetics

Analysis of worldwide research in the field of cybernetics during 1997–2011

Virender Singh · Alicia Perdígones ·
José Luis García · Ignacio Cañas-Guerrero ·
Fernando R. Mazarrón

Received: 26 September 2013 / Accepted: 17 June 2014 / Published online: 10 July 2014
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Abstract The study provides an overview of the research activity carried out in the field of cybernetics. To do so, all research papers from 1997 to 2011 (16,445 research papers) under the category of “Computer Science, Cybernetics” of Web of Science have been processed using our in-house software which is developed specifically for this purpose. Among its multiple capabilities, this software analyses individual and compound keywords, quantifies productivity taking into account the work distribution, estimates the impact of each article and determines the collaborations established at different scales. Keywords analysis identifies the evolution of the most important research topics in the field of cybernetics and their specificity in biological aspects, as well as the research topics with lesser interest. The analysis of productivity, impact and collaborations provides a framework to assess research activity in a specific and realistic context. The geographical and institutional distribution of publications reveals the leading countries and research centres, analysing their relation to main research journals. Moreover, collaborations analysis reveals great differences in terms of internationalization and complexity of research networks. The results of this study may be very useful for the characterization and the decisions made by research in the field of cybernetics.

Keywords Bibliometric analysis · Computer science · Cybernetics · Web of science · Research activity

1 Introduction

The results of most of the research are disseminated through a process of written communication, in the form of scientific and research publications. Precise quantification of scientific output in the short term is not an easy task, but is critical to evaluate scientists, laboratories, departments and institutions (Kreiman and Maunsell 2011). In the situation of high volume of scientific production, bibliometric analysis has been extensively used to carry out overall analysis.

Bibliometrics is a set of methods to quantitatively analyse scientific and technological literature. Bibliometric studies are systematically conducted to evaluate the relative importance of scientific production in a specific field. This approach provides a pivotal tool to interpret the temporary evolution and the geographical distribution of research on a specific topic (Ugolini et al. 2010).

To know the status of research in a particular field, the analysis of scientific publications is the most prevalent and at the same time one of most debated methods, particularly in relation to quality analysis (qualitative evaluation) rather than quantity (quantitative evaluation) (Rojas-Sola and Jorda-Albinana 2009). Qualitative assessment of scientific publications can be performed in various ways, being the most utilized the number of received citations and the impact factor (IF) published by the Institute for Scientific Information (ISI). Despite the many criticisms that the IF may have, there is no other system which is widely accepted by the scientific community and academic administrators (Rojas-Sola and Jorda-Albinana 2009).

Bibliometric indicators can be used to take investment decisions related to R&D projects and to identify rate of change of the usage of specific technology, selection process of researchers, promotion of researchers and research centres, etc. At the management and policy level, bibliomet-

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Figure 53: Abstract Cybernetics publication.

7.1.2. Publication in Communications of the ACM Journal

Communications of the ACM (COMMUN ACM).

Publisher: Association for Computing Machinery, Association for Computing Machinery.

Journal description: Communications of the ACM is the internationally acknowledged premier journal of the Association for Computing Machinery (ACM). Topics covered includes: object-oriented programming, graphical user interfaces, and security technology, all areas of computer science and information systems, and range in subject matter from programming and design to law, market trends, technology transfer, business enterprises. While the content is subject to peer review, the articles published are often summaries of research.

Ranking: 3/51 in 2015 in "Computer Science, Hardware & Architecture" category.

The screenshot shows the homepage of the Communications of the ACM journal. At the top, there is a navigation bar with links to ACM.org, Join ACM, About Communications, ACM Resources, Alerts & Feeds, and a SIGN IN button. Below this is the journal's title 'COMMUNICATIONS OF THE ACM' and a search bar. The main navigation menu includes HOME, CURRENT ISSUE, NEW, BLOG, OPINION, RESEARCH, PRACTICE, CAREERS, ARCHIVE, and VIDEO. The breadcrumb trail indicates the current page is 'Home / Magazine Archive / January 2015 (Vol. 58, No. 1) / Analyzing worldwide research in hardware architecture... / Abstract'.

The featured article is 'Analyzing Worldwide Research in Hardware Architecture, 1997-2011' by Virender Singh, Ailola Perdigones, José Luis García, Ignacio Cañas-Guerrero, and Fernando R. Mazarrón. The article is from Communications of the ACM, Vol. 58 No. 1, Pages 76-85, with the DOI 10.1145/2688498.2688499. There is a 'Comments' link below the author information.

Below the article title, there is a 'VIEW AS:' section with icons for different devices and a 'SHARE:' section with social media icons. To the right of the article title is a 'SIGN IN for Full Access' box with fields for 'User Name' and 'Password', and links for 'Forgot Password?' and 'Create an ACM Web Account'. Below this is a 'SIGN IN' button.

The article abstract is displayed on the left, accompanied by a word cloud image. The word cloud contains terms like 'Algorithm', 'Performance', 'network', 'Power', 'Circuit', 'Model', 'Reliability', 'Complexity', 'Communication', 'System', 'Energy', 'Stability', 'Security', 'Sensors', 'Networks', 'ATM', 'VLS', 'Neural', 'chips', 'productivity', 'collaboration', 'impact', 'research', 'activity', 'realistic', 'context', 'geographic', 'institutional', 'distributions', 'studied', 'publications', 'examined', 'changes', 'collaboration-weighted', 'productivity', 'major', 'research', 'countries', 'research', 'centers', 'journals', 'results', 'published'.

The abstract text reads: 'This work covers research in the field of hardware architecture in the years 1997 to 2011. More than 51,000 journal articles (conference articles excluded) were analyzed using a specially developed in-house software application able to analyze keyword evolution, estimate an article's impact, determine collaborations established at different scales, and calculate collaboration-weighted productivity of countries and research centers. Keyword analysis allows rapidly growing research topics (such as networks, sensors, security, stability, energy, and chips), as well as topics of lesser interest (such as neural networks, ATM, and VLS), to be identified and tracked. The changes detected in productivity, collaboration, and impact scores over time can be used as a framework for assessing research activity in a realistic context. The geographic and institutional distributions of the studied publications were also examined, along with changes in collaboration-weighted productivity, the impact of the major research countries and research centers, and the journals in which their results were published.'

On the right side, under 'MORE NEWS & OPINIONS', there are three links: 'Photonics Breakthrough Paving the Way for Improved Wireless Communication Systems' by University of Sydney, 'What to Expect Now That Internet Providers Can Collect and Sell Your Web Browser History' by The Washington Post, and 'Fact Versus Frivolity in Facebook' by Robin K. Hill.

Figure 54: Screen shot Hardware Architecture publication.

contributed articles

DOI:10.1145/2688498.2688499

Results showed more published papers, collaboration with U.S. colleagues, preference for English, and uneven research impact.

BY VIRENDER SINGH, ALICIA PERDIGONES, JOSÉ LUIS GARCIA, IGNACIO CAÑAS-GUERRERO, AND FERNANDO R. MAZARRÓN

Analyzing Worldwide Research in Hardware Architecture, 1997–2011

THIS WORK COVERS research in the field of hardware architecture in the years 1997 to 2011. More than 51,000 journal articles (conference articles excluded) were analyzed using a specially developed in-house software application able to analyze keyword evolution, estimate an article's impact, determine collaborations established at different scales, and calculate collaboration-weighted productivity of countries and research centers. Keyword analysis allows rapidly growing research topics (such as networks, sensors, security, stability, energy, and chips), as well as topics of lesser interest (such as neural networks, ATM, and VLS),

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» key insights

- Analysis of keywords identifies evolution of the most important research topics in hardware architecture, as well as research topics with lesser interest.
- Analysis of collaborations reveals great differences in terms of internationalization and complexity of research networks in hardware architecture.
- These results should be very useful for characterization and decision-making by research institutions in the field of hardware architecture.

Figure 55: Abstract Hardware Architecture publication.

7.2. ANNEX 2. REVIEW OF HIGHLY CITED RESEARCH PUBLICATIONS

In this section scientometrics articles with higher number of citations have been discussed, it reveals bigger heterogeneity in research field, which is applicable for both in methodology and indicators used, as well as for research topic.

De Solla Price (de Solla Price, 1976) has proposed models and statistically explained multiple situations in which success breeds success through a general theory of bibliometric and other cumulative advantage processes. He stated that it is common in bibliometrics matters and in many diverse social phenomena's where success seems to breed success for example paper which has been cited many times is more likely to be cited again than one which has been little cited or author of many papers is more likely to publish again than one who has been less prolific. Same is applicable to a journal, journal which has been frequently consulted for some purpose is more likely to be turned to again than one of previously infrequent use.

Subramanyam (Subramanyam, 1983) has investigated about the scientific research and its increasingly collaborative endeavor. He stated that nature and magnitude of collaboration vary from one discipline to another, and depend upon factors like nature of the research problem, the research environment, and demographics He mentioned that earlier studies have shown a high degree of correlation between collaboration and research productivity, and between collaboration and financial support for research. He stated that bibliometric methods offer a convenient and non-reactive tool for studying collaboration in research. In his research paper, several types of collaboration have been identified, and earlier research on collaboration has been reviewed. Proposal of further research has been given to refine the methods of defining and assessing collaboration and its impact on the organization of research and communication in science.

Rip and Courtial (Rip & Courtial, 1984) have analysed developments of scientific fields through scientometric tools. They explained how the cognitive scientometrics is illustrated by using a data of ten-year period of articles from a biotechnology core journal. They stated that after coding of key-words, the relations between articles are brought out by co-word analysis i.e. through Maps of given fields, while showing connections between research areas and their changes over time, with respect to the institutions in which research is performed. In addition, other approaches are explored, including an indicator of 'theoretical level' of articles bodies.

King (King, 1987) has stated in his research paper that recent reductions in research budgets have led to the need for greater selectivity in resource allocation. He stated that measures of past performance are still among the most promising means of deciding between competing interests. In this state-of-the- art review the various methodologies that have been developed are outlined in terms of their strengths, weaknesses and applications. He suggested future directions for the developments of techniques with respect to present limitations of science indicators in research evaluation.

Hamers et al. (Hamers et al., 1989) has investigated the influence of the choice of citation and co-citation thresholds and extent to which the general co-citation cluster depends on the formula used to compute the co-

citation strength. In his research paper, he demonstrated that in most practical cases Salton's cosine formula yields a numerical value that is twice of Jaccard's index.

Moedet al. (Moed et al., 1995) investigation was aimed at the development and application of bibliometric indicators in science and research policy. In the investigation, attempt has been made to cope with several points of critique on previous studies and explored new bibliometric indicators of the past research performance of research groups, focusing on the impact of a group as compared to some international standard, and on its scientific cooperation with other groups. In this study, Indicators revealing both cognitive orientations of a research group, as well as its impact have been compared to a world average citation rate. This research gave an outline of a new bibliometric database based upon all articles published by authors from the Netherlands, during the time 1980-1993 by the Institute for Scientific Information (ISI) for the Science Citation Index (SCI).

VanRaen (vanRaen, 1996) discussed about the application of advanced bibliometric methods to research performance evaluation and, more generally, monitoring scientific developments and the role of actors in these developments. It stated that bibliometric methods should never be used in 'isolation', so the application of bibliometric research performance indicators have been put in the framework of peer-based evaluation procedures. The research was focused on the use of bibliometric performance indicators, citation-analysis, as an indispensable support tool of peer review.

Katz and Hicks (Katz & Hicks, 1997) explored about how the impact (average citations per paper) varies with different types of collaborations. It has been demonstrated by this study that sole author papers appear to be in the minority and have less impact and the highest impact comes from publications involving collaboration with foreign institutions plus using the distribution of impact by the number of authors, domestic institutions and countries researcher can calibrate i.e. impact increases as the number of same, domestic and foreign authors increase. It was stated in the research that impact increases exponentially with the number of collaborating authors from the same institution and linearly with increasing number of domestic and foreign institutions. However, research papers involving collaboration with a foreign institution have greater impact than papers with collaborations with an author from the same or another domestic institution.

Van Raen (VanRaen, 1997) argued that the core research activities of scientometrics fall in four interrelated areas: science and technology indicators, information systems on science and technology, the interaction between science and technology, and cognitive as well as socio-organizational structures in science and technology. He emphasized that an essential condition for the healthy development of the field is a careful balance between application and basic work, in which the applied side is the driving force. In other words: scientometrics is primarily a field of applied science. This means that the interaction with 'users' is at least as important as the interaction with colleague-scientists. He stated that this situation is very stimulating, it strengthens methodology and it activates basic work. He considered that the idea of scientometrics lacking theoretical content or being otherwise in a 'crisis-like' situation as groundless. Per him scientometrics is in a typical developmental stage in which the creativity of its individual researchers and the 'climate' and facilities of their institutional environments determine the progress in the field and, particularly, its relation with other disciplines.

Katz and Hicks (Katz & Hicks, 1997) have explored that how the impact (average citations per paper) varies with different types of collaborations. In this study, calibrated bibliometric model was derived to demonstrate that collaboration with an author from the home institution or another domestic institution increases the average impact by approximately 0.75 citations while collaboration with an author from a foreign institution increases the impact by about 1.6 citations.

Glanzel and Schoepflin (Glanzel & Schoepflin, 1999) have studied the "ageing" of scientific journal literature and has processed and SSCI databases where totality of the bibliographic citations indexed in the 1993 annual accumulation to identify fields where the role of non-serial literature is considerable or critical in terms of bibliometric standard methods. The finding included a demonstration of different ageing behaviors in the sciences and social sciences also it has been shown through this research paper that within the sciences, theoretical papers are significantly "slower" than technology oriented or experimental research papers although these studies could shed light upon some of the underlying mechanisms of obsolescence of scientific literature, but many more questions remained unanswered. It has been stated that to formulate a closer consider the notions of citations and references, the reference structure of papers published in selected science and social science areas have been analyzed with the help of bibliometric tools. Statistics was used to identify subjects with a great share of non-serial documents and to analyze the correlation. The results were expected to contribute to the validation of citation-based indicators in scientometrics particularly in science areas which have proved to be "problematic" in bibliometrics such as mathematics, soft science and technology and to show the possibilities and limitations of bibliometric indicators applied to the social sciences.

Grant et al. (Grant et al., 2000) have developed a methodology for evaluating the impact of research on health care, and to characterize the papers cited on clinical guidelines. Research was expanded on the pilot study by increasing the sample size to permit characterize the papers cited on clinical guidelines. Researchers have scanned these bibliographic details onto bespoke database. After standardization of the bibliographic data, researchers had looked up all papers on the SCI and in libraries to add the addresses of the authors and any missing information such as paper titles, volume numbers, etc. Plus, comparisons have been made with all UK biomedical publications between 1988 and 1995 using the Wellcome Trust's research output database (ROD). Research Analysis has provided a useful, clinically relevant method for evaluating research outcomes and different strategies in research and development.

Vinkler (Vinkler, 2000) has reviewed that the evaluation of real scientometric systems which needs compromises among the parties interested, between the practical applicability and the theoretical requirements of scientometrics. In the Chemical Research centre of the Hungarian Academy of Sciences, special scientometric indicators have been used for evaluating publication activity of research teams for about 30 years. Modified Garfield impact factors for journals as well as relative citedness of papers were applied as indicators because of differences among subfields in scientometric features of the assessed publications.

Grant et al. (Grant et al., 2000) has collected and analysed bibliographic details of the papers cited in 15 clinical guidelines which was developed in and for the United Kingdom, while using applied bibliometric

techniques. He has developed a methodology for evaluating the impact of research on health care, which could be used to characterize the papers cited on clinical guidelines.

Ivancheva (Ivancheva, 2001) has attempted to give an answer to the question: Why do most Bibliometric and scientometric laws reveal characters of Non-Gaussian distributions, i.e., have unduly long "tails" Application of the approach of the so-called "Universal Law," discovered by G. Stankov is implemented. The basic principle used was that of the reciprocity of energy and space. A new "wave concept" of scientific information has been propounded, in which the terms of the well-known Bibliometric and scientometric distributions find a rather satisfactory explanation. One of the made corollaries is that $\alpha = 1$ which is the most reasonable value for the family of Zipf laws, applied to information or social phenomena.ⁱ

Ding et al. (Ding et al., 2001) aim of this study was to map the intellectual structure of the field of Information Retrieval (IR) during the period of 1987–1997. This study demonstrated the feasibility of co-word analysis as a viable approach for extracting patterns from, and identifying trends, in large corpora where the texts collected are from the same domain or sub-domain and are divided into roughly equivalent quantities for different time periods. Overall, this study has led us to an increased confidence in the co-word analysis. Data were collected from Science Citation Index (SCI) and Social Science Citation Index (SSCI) for the period of 1987–1997. It has been demonstrated by the study that IR field is rapidly evolving, as was demonstrated by the increasing number of keywords in Internet, digital library, library networks and online database. The analysis of the 1987–1991 data has shown a research trend focusing on traditional library science, library education, user theory, and information storage and retrieval.

Glanzel (Glanzel, 2002) study has been used to describe the common and the distinguishing features of co authorship trends and patterns in selected science fields. The relation between co authorship schemes and other bibliometric features, such as publication activity and citation impact has been analyzed. Author has shown, while co publication activity has grown considerably, the extent of co- authorship and its relation with productivity and citation impact largely varies among fields. Besides universally valid tendencies, subject specific features have been found. The trend in co authorship patterns of individual papers, the distribution of coauthors over publications have been determined for the following four years: 1980, 1986, 1992, and 1998. The mean cooperatively (nil), that is, the average number of authors contributing to one paper, has been used as an indicator of collaboratively at the micro level.

Glanzel and Moed (Glanzel & Moed, 2002) investigated about Journal impact measures in bibliometric research. He explained about journal citation measures, which were designed to assess significance and performance of individual journals, their role and position in the international formal communication network, their quality or prestige as perceived by scholars. He concluded that scientific journals may differ with respect to their importance of their position in the journal communication system, their status or prestige. It has been found that the robustness, comprehensibility, methodological reproducibility, apparent simplicity, availability and popularity of the ISI journal impact factor is contrasted by several severe methodological shortcomings and its technical irreproducibility. Plus, it has been found that recent bibliometric studies have, however, shown that methodological improvements in combination with additional, multi-dimensional measures and appropriate

methodological and technological documentation might help to overcome limitations of the original measures, so the question of reproducibility can thus be solved at least for those who have access to the underlying bibliographic databases and the technology to reproduce these indicators.

Glanzel and Schubert (Glanzel & Schubert, 2003) has designed a system for scientometric (evaluation) where results of article classification, the disciplinary affiliation of their authors can be determined, either individually or by group. It has been stated that authors' activity is often not limited to a single subfield, it usually covers a range of subfields with varying weights and their field/subfield profile can be constructed. Such profiles are of primary importance in scientometric evaluation, since standards of scientometric indicators can be set only within subfields, therefore it is only the activity profile that can be accompanied by matching profiles of indicators like, e.g., impact measures, citation rates or reference age.

Van Leeuwen et al. (van Leeuwen et al., 2003) presented a comparative analysis of a number of indicators of research performance, and particularly of scientific excellence using techniques applied in studies conducted by CWTS in recent years. It has been found that each type of indicator reflects a dimension of the general concept of research performance. Consequently, the application of a single indicator may provide an incomplete picture of a unit performance. It has been argued in the research that one needs to combine the various types of indicators to provide policy makers and evaluators with valid and useful assessment tools. This study was based on a national research performance assessment in the field of chemistry and related fields, initiated by the collaborating Dutch universities, organized in the Association of Universities in the Netherlands (VSNU).

Persson et al. (Persson et al., 2004) has analysed objective in two-fold first that if patterns of documented scientific communication and collaboration have changed in the last two decades and if these tendencies have inflationary features. The second question was concerned with the role of scientific collaboration in this context. The objectives have been answered through this research, about what extent co-authorship and publication activity, on one hand, and co-authorship and citation impact, on the other hand, do interact. So, accomplish this several research studies and reports on national and European science and technology indicators have been presented in form of figures reflecting intensifying scientific collaboration and increasing citation impact practically all science areas and at all levels of aggregation.

Aksnes and Taxt (Aksnes & Taxt, 2004) investigated the relationship between bibliometric indicators and the outcomes of peer reviews. In this study of research groups at the University of Bergen we have found positive but relatively weak correlations between peer ratings and bibliometric indicators. The peer evaluations were carried out at national levels and in different years: chemistry in 1997, the earth sciences in 1997/1998, biology/biomedicine in 1999/2000, physics in 2000, mathematics and information and communication technology in 2001/2002. However, it has been an important point of this study that the peer ratings cannot generally be considered as standards to which the bibliometric indicators should be expected to correspond. Instead researchers have found that shortcomings of the peers' judgements, of the bibliometric indicators, as well as lack of comparability can explain why the correlation was not stronger. The results indicated that a bibliometric analysis can never function as a substitute for a peer review. However, a bibliometric analysis can counterbalance shortcomings and mistakes in the peers' judgments.

Khalsa (Khalsa, 2004) has carried out through bibliometric analysis on the biomedical journal literature involving research on the clinical application of yoga and has revealed an increase in publication frequency over the past 3 decades with a substantial and growing use of randomized controlled trials. Total of 181 publications in 81 different journals published in 15 different countries were identified that met the criteria for the analysis. It is hoped that the analysis and bibliography presented in this study has elucidated the existing research literature in this area and will support research efforts evaluating the psycho physiological effects of yoga practice.

Glanzel et al. (Glanzel et al., 2004) provided a large-scale analysis of the share and the ageing of self-citations, as well as a breakdown by science fields on the basis of the total publication output indexed in selected annual updates of the Web of Science. The objective of this study was not finding arguments pro or contra excluding self-citations from bibliometric analyses; the aim was to understand basic regularities of self-citations within the process of documented scientific communication to pave the methodological way for a possible critical view at self-citation patterns in empirical studies.

Uzun (Uzun, 2004) assessed internationality of scholarly journals through foreign authorship patterns: The case of major journals in information science, and scientometrics. *Scientometrics*, 61 (3), 457-465 reported the findings from a study of patterns of foreign authorship of articles, and international composition of journal editorial boards in five leading journals in the field of information science, and scientometrics. The study covered an American journal and four European journals. Bibliographic data about foreign authors and their national affiliation from five selected years of publication were analysed for all journals. It has been stated that the foreign inputs of articles were extremely high in Information Processing & Management, and *Scientometrics*, and were relatively low in the other three journals. The numbers of foreign countries contributing in all journals have increased rapidly since 1996. Canada, England, Belgium, Netherlands, China, and Spain were the countries with high contributions in *JASIST*. The authors from the USA have dominated the foreign-authored articles in all European journals. A simple linear regression analysis showed that 60% of variation in the proportion of foreign-authored articles in the set of five journals over the selected years could be explained by the percentage of foreign members on the editorial boards of the journals

Van Raan (Van Raan, 2005) has stated that ranking of research institutions by bibliometric methods is an improper tool for research performance evaluation, even at the level of large institutions. He further clarified that the indicators used for ranking were often not advanced enough, and this situation is part of the broader problem of the application of insufficiently developed bibliometric indicators used by persons who do not have clear competence and experience in the field of quantitative studies of science. Major technical and methodological problems in the application of publication and citation data in the context of evaluation have been discussed in this paper. The question of the appropriateness of the methodology has been discussed. He also emphasized that quality of the technical system is the first source of problems should be tackled. He stated that methodological problems are certainly also present, but it is not very useful to discuss them if basic technical problems -to arrive at a reliable data system on which, as a next step, a bibliometric indicator methodology can be based- are not solved.

Cameron (Cameron, 2005) highlighted the history of the development of impact factors, described the limitations in their use, and provided a critique of the usage of impact factors in academic settings. The development of citation indexes and impact factors, the way this data has been used in the past and present, and the implications of emerging uses have been discussed. The limitations of ISI data are also presented. He stated that despite the many problems of this bibliometric tool, it is unlikely that the most well-known mechanism for addressing journal quality will be abandoned. It has been found that that some means of evaluating published research and publications were required. As per him, Impact factors only consider one type of usage, it is not likely that the usage of ISI data is to be abandoned. He concluded that recent initiatives to open scientific research and free it from for profit publishers may be the best hope for researchers to have of easing our reliance on ISI data. Cameron has not only highlighted the history of the development of impact factor but also described the limitations in their use, and provided a critique of the usage of impact factors in academic settings.

Chiu and Ho (Chiu & Ho, 2005) has shed light on the bibliometric analysis technique which has been used to examine the topic that does not exist in the literature. The objective of this study was to conduct a bibliometric analysis of all homeopathy-related publications in Science Citation Index (SCI). A systematic search was performed using the SCI for publications during the period of 1991 to 2003. Documents used in this study were based on the database of the SCI subscribed from the ISI Web of Science, Philadelphia, PA, USA. 'Homoeopathy, homoeopathic, homeopathy, and homeopathic' were used as keywords to search titles, abstracts, or keywords. Articles, biographical items, book reviews, corrections, corrections and additions, editorial materials, letters, meeting abstracts, news items, notes, and reviews were obtained from the results of the search for document types. It has been found that two linear relations between yearly cumulative number of publications and the year were obtained for the two periods from 1991 to 1997 and 1997 to 2003 in which there were 50 average annual publications for the early period and 100 for the latter period. Per said researcher's English remained the dominant language while German contributed a high number of publications and small-group collaboration was a popular method of co-authorship. Moreover; a linear model was successfully applied to describe the relationship between the cumulative number of citations in three years after publication and paper life.

Vergidis et al. (Vergidis et al., 2005) have estimated worldwide trends in research productivity in the field of microbiology by evaluating the contributions of nine different world regions between 1995 and 2003 while taking demographic and socioeconomic parameters into account. For this study authors, have analyzed data from 74 journals that were included in both the "microbiology" category of the Journal Citation Reports (JCR) database of the Institute for Scientific Information and in the electronic PubMed database. Data concerning the absolute and relative production of articles along with the mean IF of the articles produced in each world region has been presented. In summary, to evaluate worldwide trends in research productivity in the field of microbiology, an elaborate system to retrieve data from journals tracked by the Institute for Scientific Information, through its Journal Citation Reports, and cited in PubMed is required.

Moin et al. (Moin et al., 2005) evaluated the scientific production of Iran during 1967 to 2003 and compared it with 15 selected countries. They found that Iran has had an increasing growth after the Iraq-Iran war.

Saad (Saad, 2006) has explored various empirical issues associated with the h-index within fields of relevance to the business sciences, which have received little attention from the scientometric community. First, this study has explored the correlation between authors' total citation counts and their h-indices, the expectation being that these two measures are highly correlated. Second, this study has compared authors' h-indices which have been obtained from two separate services namely Thompson/ISI and Google Scholar (Beta version). Finally, correlated journals' h-indices with their ISI impact factors. Note: The h-index, a new metric for capturing a scholar's productivity, which he defined as follows "A scientist has index h if h of his or her N_p papers have at least h citations each and the other $(N_p - h)$ papers have $\leq h$ citations each."

Van Raan (Van Raan, 2006) has investigated to answer the question at the level of research groups that how does the h-index relate to citation impact indicators based on advanced bibliometric indicators, and to the outcomes of peer review? Through his investigation the above question at the level of research groups has been answered, i.e., statistically a level directly above that of the individual scientist thus he considered that research group as the most important work floor unit in research, particularly in the natural sciences. In most cases, however, the work of experienced, leading scientists closely approaches the oeuvre of their research group. In this sense, unique material has been presented, as the research group is not an entity directly available in databases such as authors or journals. Research groups are defined by the internal structure of universities or other R&D institutions. He presented characteristics of the statistical correlation between the h-index and several standard bibliometric indicators, as well as with the results of peer review judgment focus was on all publications of 147 chemistry research groups for the years 1991-1998, total number of publications about 18,000, and count the citations for a time window of three years starting with the publication year (i.e., for publications from 1991, citations are counted in the period 1991-1993, and for publications from 1998, citations are counted in the period 1998-2000). Only 'external' citations, i.e., citations corrected for self-citations, were considered.

Nederhof (Nederhof, 2006) found that bibliometric analyses that focus solely on research published in journals may not give an accurate representation of SSH research output. In addition, bibliometric analyses reflect the biases of the databases used. For example, the Social Science Citation Index (SSCI) and the Arts and Humanities Citation Index (AHCI) of Thomson ISI over-represent research output published in English. Original findings were produced by this study show that the bias results in an estimated 20-25% over-representation of English material in the two databases. Findings from the scientific literature support those of Science-Metrix. He also found that bibliometric methods have not yet been refined to the point where they can serve to identify emerging fields. In this regard, the methods with the greatest potential are co-citation analysis, co-word analysis and bibliographic coupling. However, their usefulness for policy development has been challenged. It is therefore preferable to combine bibliometrics with research monitoring and peer review for identifying emerging fields. Another approach was to track the development of bibliometric methods, which nonetheless show promise on many fronts.

Chao et al. (Chao et al., 2007) shed a light on (Radio frequency identification) RFID trends, and contributions, a historical review and bibliometric analysis. The bibliometric analytical technique has been used to examine this topic in SCI journals from 1991 through November of 2005. Also, a historical review method has

been used to analyze RFID innovation, adoption by organizations, and market diffusion. From the analysis of the study's findings, supply chain management (SCM), health industry, and privacy issues emerge as the major trends in RFID. Also, the contributions of the RFID industry and forecasts of technological trends were also analyzed, concluding that RFID will be more ubiquitously diffused and assimilated into our daily lives soon.

Wen-Ta and Yuh-Shan (Wen-Ta & Yuh-Shan, 2007) has performed a bibliometric analysis of all tsunami related publications in the Science Citation Index (SCI). Analysed parameters included document type, language of publication, publication output, authorship, publication patterns, distribution of subject category, distribution of author keywords, and country of publication, most-frequently cited article and document distribution after the Indonesia tsunami. It has been found that US and Japan produced 53% of the total output where the seven major industrial countries accounted for most the total production and English was the dominant language, comprising 95% of articles. A simulation model was applied to describe the relationship between the number of authors and the number of articles, the number of journals and the number of articles, and the percentage of total articles and the number of times a certain keyword was also used.

Hou et al. (Hou et al., 2008) have explained the structure of scientific collaboration networks in scientometrics. It was investigated at the level of individuals by using bibliographic data of all papers published in the international journal *Scientometrics* retrieved from the Science Citation Index (SCI) of the years 1978-2004. Combined analysis of social network analysis (SNA), co-occurrence analysis, cluster analysis and frequency analysis of words is explored to reveal: (1)The microstructure of the collaboration network on scientists' aspects of scientometrics; (2)The major collaborative fields of the whole network and of different collaborative sub-networks; (3)The collaborative centre of the collaboration network in scientometrics.

Xie et al. (Xie et al., 2008) attempted to bibliometrically evaluate the SCI scientific literature on atmospheric aerosol. This paper has provided some additional insights into the current state of aerosol research during the time span from 1991 to 2006, such as the characteristics of research activities, publication patterns, research hotspot tendencies or irregularities, and basis for future projection. It has been observed by this research that English was by far the dominant language; while 16 other languages were also used, indicating that aerosol research became more globally connected. A linear and a logarithmic model were applied to illuminate the relations between cumulative number of articles and the year. Significant growth was observed, particularly in the recent period 1995–2006. Collaborative articles, the number of which increasing conspicuously, had shifted from domestic collaboration to international collaboration. The G7, owning a longer research tradition in this field, had not only the absolute ascendancy of production, but also the most-frequent partners. Finally, it was proved that more research attention was transferred from medical fields to physical chemistry fields, agreeing with the previous publication pattern analysis for subject categories and journals.

Osareh and McCain (Osareh & McCain, 2008) studied the intellectual structure of Iranian chemistry research in Science Citation Index (SCI) during 1990 to 2006. The results of this study showed that since 1990, Iranian chemistry research, as represented in the SCI, has grown at a rate of roughly 26% and 7 major clusters were formed during the study period. The topic areas were firstly in Organic Chemistry, and secondly in Analytical Chemistry.

Tian et al. (Tian et al., 2008) conducted a bibliometric analysis to evaluate global scientific production of Geographic Information System (GIS) papers from 1997 to 2006 in Science Citation Index. Results indicated that GIS research steadily increased over the period and the annual paper production in 2006 was about three times higher comparing to 1997s paper productions.

Arruda et al. (Arruda et al., 2009) analysed the distribution of some characteristics of computer scientists in Brazil according to region and gender. Findings revealed that in the areas of artificial intelligence, computers in education and human-computer interface, Brazilian computer scientists had 5.3 journal publications per male researchers and 6.0 per female researchers, and the difference is statistically significant. And for conferences, the productivity is 23.73 and 30.92 for males and females, respectively. On the other hand, there is not a significant difference in male and female productivity in areas of hardware, network, distributed systems, and theory. Also, research has found about regional differences, there were some statistically significant differences in productivity among different regions, and some differences in the concentration of researchers in a few research topics.

Vinkler (Vinkler, 2009) has highlighted several simple and sophisticated scientometric indicators generally applied in the literature (e.g. total number of publications and citations, citations per journal paper, relative citedness indexes, Hirsch index, etc.), which may characterize the publications of scientists both qualitatively and quantitatively. The calculation methods generally use data referring to the total set of papers studied. Scientific progress, however, may be attributed primarily to information in the highly cited publications. Therefore, a new indicator (p-index) was suggested for comparative assessment of scientist's activity in similar subject fields. The p-index is equal to one hundredth of the number of citations.

Van Eck and Waltman (van Eck & Waltman, 2010) has developed computer program "VOSviewer" for constructing and viewing bibliometric maps. The functionality of VOSviewer is especially useful for displaying large bibliometric maps in an easy-to-interpret way. This kind of functionality is not incorporated into the computer programs that are commonly used by bibliometric researchers. Data set has been used that consists of co-citation frequencies of journals belonging to at least one of the following five closely related subject categories of Thomson Reuters: Business, Business-Finance, Economics, Management, and Operations Research & Management Science. The co-citation frequencies of journals were determined based on citations in articles published between 2005 and 2007 to articles published in 2005. A journal was included in the data set only if it had at least 25 co-citations. There were 232 journals that satisfied this condition. Based on a clustering technique, the journals in the data set were divided into five clusters. SPSS and Pajek both provide rather simple graphical representations of bibliometric maps. The programs both have serious problems with overlapping labels. Due to these problems, maps can be difficult to interpret, especially in the details. So, this research paper has demonstrated how VOSviewer overcomes the limitations of simple graphical representations provided by programs such as SPSS and Pajek.

Cantos-Mateos et al. (Cantos-Mateos et al., 2012) presented a dual analysis of Spain's scientific output in this field during the period 1997-2007. Basic bibliometric indicators have been used and on the other hand, techniques for the visualization and analysis of networks of scientific information based on a study of keywords

Plus have been utilized. The results demonstrated through this study gave substantial information about the state of research involving stem cells in Spain to date, and allow researcher to draw profiles from different viewpoints. This study has allowed researcher to depict a general panorama of Spain's research efforts surrounding stem cells by means of a bibliometric analysis, and evidences the possible influence of certain patterns of publication and collaboration.

7.3. ANNEX 3. OUTPUTS OF CYBERNETICS CATEGORY ANALYSIS

7.3.1. Keywords Analysis

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Compound Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k
CYBERNETICS	1296	32	48	57	70	72	67	97	112	98	93	102	113	143	106	86
SYSTEMS	954	38	61	49	53	63	58	43	57	68	69	64	90	69	84	88
DESIGN	799	21	30	32	38	40	35	35	46	59	67	87	79	72	72	86
MODEL	763	35	27	39	34	32	36	45	60	52	70	61	75	59	73	65
SYSTEM	449	17	16	12	28	16	28	28	35	32	28	41	29	44	45	50
INFORMATION	445	17	21	14	20	23	12	17	38	36	34	34	40	54	41	44
PERFORMANCE	444	13	21	15	20	24	23	16	35	30	27	37	30	39	55	59
ALGORITHM	386	11	21	15	14	12	16	18	29	23	28	38	36	36	39	50
NEURAL NETWORKS	340	11	32	23	23	24	28	24	39	20	24	26	21	16	19	10
OPTIMIZATION	329	11	10	17	33	16	23	22	26	15	22	15	33	25	32	29
RECOGNITION	318	9	12	11	20	15	15	21	18	21	22	24	19	25	43	43
MODELS	316	6	11	11	16	18	19	18	26	15	30	19	35	27	29	36
STABILITY	271	2	11	13	17	12	13	24	22	11	21	24	31	31	23	16
CLASSIFICATION	265	5	8	7	8	12	10	12	17	28	21	21	25	22	23	46
ALGORITHMS	264	14	12	9	8	11	20	10	24	18	20	27	27	22	19	23
NETWORKS	260	11	12	15	15	19	12	17	17	14	20	14	23	24	24	23
DYNAMICS	240	14	7	19	15	12	17	16	21	18	13	16	24	21	15	12
KNOWLEDGE	238	17	21	16	13	17	16	9	12	13	20	14	18	9	20	23
IDENTIFICATION	231	7	14	6	16	12	4	12	25	13	19	15	24	21	19	24
COMMUNICATION	196	12	8	6	1	5	10	9	8	16	17	19	10	17	34	24
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 63: Computer application output, evaluation of Compound Keywords for 1-year interval for Cybernetics WOS category.

Description: Computer application output for compound keywords, evolution of the most frequently used keywords (counts keywords as they have been defined by the authors, whether keywords are single words or compound words) published in "Cybernetics" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 20/32745 records.

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Individual Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k
SYSTEMS	3465	113	155	182	207	172	165	175	246	225	267	263	331	354	329	281
CONTROL	2101	45	69	97	158	105	99	73	172	141	124	171	240	259	182	166
MODEL	1742	61	62	68	74	88	71	98	124	116	151	154	158	148	191	178
DESIGN	1615	38	72	51	89	93	72	66	106	107	119	162	139	154	161	186
SYSTEM	1391	36	54	51	87	54	63	86	97	75	100	103	141	142	141	161
CYBERNETICS	1319	34	49	58	71	73	68	97	112	99	95	104	113	144	106	96
INFORMATION	1299	41	75	43	65	70	46	53	79	72	120	99	121	138	131	146
FUZZY	1265	19	76	86	83	96	80	76	147	91	101	77	73	98	91	71
NETWORKS	1146	28	67	62	84	65	74	74	99	60	96	80	98	81	106	72
ANALYSIS	1100	25	27	42	67	45	45	64	88	82	102	77	108	123	111	94
OF	1002	17	21	110	264	36	25	58	47	46	45	56	51	71	76	79
NEURAL	1000	23	65	49	70	63	68	63	96	65	72	75	82	70	78	61
RECOGNITION	915	21	41	32	54	48	36	48	60	71	71	69	65	72	108	119
OPTIMIZATION	898	18	30	46	72	27	47	44	53	68	47	73	102	84	112	75
TIME	850	15	25	48	59	37	34	50	56	62	55	57	78	102	93	79
LEARNING	845	11	36	38	42	55	48	41	51	56	61	83	73	83	65	102
ALGORITHM	843	21	33	29	44	31	37	41	67	58	64	98	75	79	76	90
HUMAN	779	12	25	28	30	34	41	41	62	63	73	65	70	78	73	84
THEORY	753	13	14	15	14	32	16	27	50	41	75	61	86	124	106	79
COMPUTER	745	27	35	41	46	37	33	34	57	42	75	74	68	67	61	48
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 64: Computer application output, evaluation of Individual Keywords for 1-year interval for Cybernetics WOS category.

Description: Computer application output for individual keywords, evolution of the most frequently used words which are constituents of the keywords (either on their own or as part of keywords) published in "Cybernetics" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 20/12569 records.

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Individual Plural Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k
SYSTEM/SYSTEMS	4856	149	209	233	294	226	228	261	343	300	367	366	472	496	470	442
MODEL/MODELS	2486	77	83	99	120	132	110	137	178	150	206	205	242	219	268	260
CONTROL/CONTROLS	2113	45	70	99	158	107	100	73	172	143	124	172	241	261	182	166
NETWORK/NETWORKS	1845	43	96	94	119	91	114	112	153	112	149	141	160	143	178	140
DESIGN/DESIGNS	1628	38	72	51	90	93	73	66	107	107	119	164	144	155	162	187
ALGORITHM/ALGORITHMS	1482	44	59	62	86	63	77	87	123	100	107	151	131	130	117	145
CYBERNETIC/CYBERNETICS	1323	35	49	58	71	73	68	97	113	99	95	104	113	145	107	96
INFORMATION/INFORMATIONS	1300	41	75	43	65	70	46	53	79	72	120	100	121	138	131	146
FUZZY	1265	19	76	86	83	96	80	76	147	91	101	77	73	98	91	71
ANALYSIS	1100	25	27	42	67	45	45	64	88	82	102	77	108	123	111	94
OF	1002	17	21	110	264	36	25	58	47	46	45	56	51	71	76	79
NEURAL	1000	23	65	49	70	63	68	63	96	65	72	75	82	70	78	61
RECOGNITION	915	21	41	32	54	48	36	48	60	71	71	69	65	72	108	119
OPTIMIZATION/OPTIMIZATIONS	899	18	30	46	72	27	47	44	54	68	47	73	102	84	112	75
TIME/TIMES	865	15	25	48	62	37	34	50	56	62	57	57	80	107	95	80
LEARNING	845	11	36	38	42	55	48	41	51	56	61	83	73	83	65	102
COMPUTER/COMPUTERS	838	27	37	43	52	40	36	39	61	48	88	85	79	79	71	53
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 65: Computer application output, evaluation of Individual Plural Keywords for 1-year interval for Cybernetics WOS category.

Description: Computer application output for individual plural keywords, evolution of the most frequently used words which are constituents of the keywords (unifying terms in singular and plural forms) published in "Cybernetics" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 17/11272 records.

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Compound Plural Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k
SYSTEM/SYSTEMS	1403	55	77	61	81	79	86	71	92	100	97	105	119	113	129	138
CYBERNETICS	1296	32	48	57	70	72	67	97	112	98	93	102	113	143	106	86
MODEL/MODELS	1079	41	38	50	50	50	55	63	86	67	100	80	110	86	102	101
DESIGN/DESIGNS	804	21	30	32	38	40	35	35	46	59	67	89	81	73	72	86
ALGORITHM/ALGORITHMS	650	25	33	24	22	23	36	28	53	41	48	65	63	58	58	73
NEURAL NETWORK/NEURAL NETWORKS	452	14	43	32	32	27	36	30	46	25	32	30	32	21	27	25
INFORMATION	445	17	21	14	20	23	12	17	38	36	34	34	40	54	41	44
PERFORMANCE/PERFORMANCES	445	13	21	15	20	24	23	17	35	30	27	37	30	39	55	59
NETWORK/NETWORKS	376	15	18	23	22	23	15	28	25	25	34	25	30	31	31	31
OPTIMIZATION	329	11	10	17	33	16	23	22	26	15	22	15	33	25	32	29
RECOGNITION	318	9	12	11	20	15	15	21	18	21	22	24	19	25	43	43
STABILITY	271	2	11	13	17	12	13	24	22	11	21	24	31	31	23	16
CLASSIFICATION/CLASSIFICATIONS	266	5	8	7	8	13	10	12	17	28	21	21	25	22	23	46
DYNAMIC/DYNAMICS	249	15	7	19	16	12	17	16	21	20	16	16	25	21	16	12
ENVIRONMENT/ENVIRONMENTS	243	1	7	10	11	13	12	17	14	18	17	20	16	28	31	28
KNOWLEDGE	238	17	21	16	13	17	16	9	12	13	20	14	18	9	20	23
GENETIC ALGORITHM/GENETIC ALGORITHMS	237	6	9	13	23	12	11	23	24	20	16	15	18	21	14	12
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 66: Computer application output, evaluation of Compound Plural Keywords for 1-year interval for Cybernetics WOS category.

Description: Computer application output for compound plural keywords, evolution of the most frequently used keywords (unifying terms in singular and plural forms) published in "Cybernetics" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 20/311010 records.

Year	1997-2011			1997-1999			2000-2002		2003-2005		2006-2008		2009-2011	
Compound Plural Keywords	N _k	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank	
SYSTEM/SYSTEMS	1403	193	1	246	1	263	2	321	1	380	1			
CYBERNETICS	1296	137	2	209	2	307	1	308	2	335	2			
MODEL/MODELS	1079	129	3	155	3	216	3	290	3	289	3			
DESIGN/DESIGNS	804	83	5	113	4	140	4	237	4	231	4			
ALGORITHM/ALGORITHMS	650	82	6	81	6	122	5	176	5	189	5			
NEURAL NETWORK/NEURAL NETWORKS	452	89	4	95	5	101	6	94	7	73	15			
PERFORMANCE/PERFORMANCES	445	49	10	67	8	82	8	94	8	153	6			
INFORMATION	445	52	9	55	10	91	7	108	6	139	7			
NETWORK/NETWORKS	376	56	7	60	9	78	9	89	9	93	9			
OPTIMIZATION	329	38	12	72	7	63	11	70	11	86	12			
RECOGNITION	318	32	14	50	11	60	12	65	13	111	8			
STABILITY	271	26	20	42	15	57	14	76	10	70	16			
CLASSIFICATION/CLASSIFICATIONS	266	20	31	31	25	57	15	67	12	91	10			
DYNAMIC/DYNAMICS	249	41	11	45	14	57	13	57	15	49	32			
ENVIRONMENT/ENVIRONMENTS	243	18	40	36	17	49	17	53	17	87	11			
KNOWLEDGE	238	54	8	46	12	34	32	52	18	52	28			
GENETIC ALGORITHM/GENETIC ALGORITHMS	237	28	16	46	13	67	10	49	22	47	36			
IDENTIFICATION/IDENTIFICATIONS	232	28	17	32	24	50	16	58	14	64	22			
PERCEPTION/PERCEPTIONS	226	25	22	34	20	44	20	49	23	74	14			
COMMUNICATION/COMMUNICATIONS	221	33	13	29	29	35	30	47	27	77	13			
..	..	..	..	..	..	..	..	..	..	..	..	..	..	

Table 67: Computer application output, evaluation of Compound Plural Keywords for 3-year interval for Cybernetics WOS category.

Description: Computer application output for compound plural keywords, evolution of the most frequently used keywords (unifying terms in singular and plural forms) published in "Cybernetics" category research papers during the period 1997–2011, where N_k = number of times each word appears; (Rank) R_k : position in the ranking drawn from the number of words used during said period (i.e. 3-year Interval of total 15-years); table showing output from computer application: 20/31011 records.

Year	1997-2011			1997-1999		2000-2002		2003-2005		2006-2008		2009-2011	
Individual Plural Keywords	N _k	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank
SYSTEM/SYSTEMS	4856	591	1	748	1	904	1	1205	1	1408	1		
MODEL/MODELS	2486	259	2	362	3	465	2	653	2	747	2		
CONTROL/CONTROLS	2113	214	4	365	2	388	3	537	3	609	3		
NETWORK/NETWORKS	1845	233	3	324	5	377	4	450	4	461	5		
DESIGN/DESIGNS	1628	161	7	256	7	280	8	427	5	504	4		
ALGORITHM/ALGORITHMS	1482	165	6	226	8	310	6	389	6	392	7		
CYBERNETIC/CYBERNETICS	1323	142	10	212	9	309	7	312	8	348	8		
INFORMATION/INFORMATIONS	1300	159	8	181	11	204	11	341	7	415	6		
FUZZY	1265	181	5	259	6	314	5	251	11	260	15		
ANALYSIS	1100	94	14	157	12	234	9	287	9	328	9		
OF	1002	148	9	325	4	151	17	152	26	226	20		
NEURAL	1000	137	11	201	10	224	10	229	12	209	23		
RECOGNITION	915	94	15	138	15	179	12	205	18	299	11		
OPTIMIZATION/OPTIMIZATIONS	899	94	16	146	13	166	15	222	14	271	14		
TIME/TIMES	865	88	18	133	17	168	14	194	20	282	13		
LEARNING	845	85	20	145	14	148	18	217	15	250	16		
COMPUTER/COMPUTERS	838	107	12	128	18	148	19	252	10	203	24		
USER/USERS	812	57	39	126	20	132	21	211	17	286	12		
HUMAN/HUMANS	811	67	26	109	24	174	13	215	16	246	17		
..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 68: Computer application output, evaluation of Individual Plural Keywords for 3-year interval for Cybernetics WOS category.

Description: Computer application output for individual plural keywords, evolution of the most frequently used words which are constituents of the keywords (unifying terms in singular and plural forms) published in "Cybernetics" category research papers during the period 1997–2011, where N_k = number of times each word appears; (Rank) R_k : position in the ranking drawn from the number of words used during said period (i.e. 3-year Interval of total 15 years); table showing output from computer application: 19/11273 records.

Total keywords in Cybernetics Category	31009
N° Times Appeared	92294
%100 keywords	21%
%1000 keywords	47%
%5000 keywords	68%
%keywords >1 papers	27%
% keywords >10 paper	4%
% keywords >100 paper	0%
% keywords >1000 paper	0%

Table 69: Computer application output, evaluation of Keywords concentration in Cybernetics WOS category for 15-year interval.

Description: Computer application output template for keywords concentration, where N° = number of times each keyword appears to reveal the heterogeneity of research topics under study during the period 1997–2011.

7.3.2. Evaluation of geographical distribution of publications

Total	%	Year	1004	1100	988	1132	929	823	1057	1174	1251	1301	1104	1098	1162	1196	1126
		Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P
3302,31	20,10%	USA	227,73	231,17	212,5	202,9	201,4	182,35	239,65	235,98	271,93	203,53	236,14	216,96	198,24	212,37	229,45
1530,22	9,30%	UK	69,33	101	79,58	117,5	129,85	58,28	100,25	98,98	132,12	126,83	112,15	92,55	96,55	101,69	113,55
1495,77	9,10%	RUSSIA	122,17	104,75	116,67	125	100,9	100,5	111,5	97,25	95,5	81,5	91,17	95	92,5	81,33	80,03
1124,37	6,80%	PRCHINA	21,2	39,17	25,17	37,33	39,39	23,12	41,32	107	41,63	170,52	55,52	127,61	141,77	141,68	111,95
653,5	4,00%	GERMANY	50	41,98	38,17	68,04	29,83	33,33	38,03	37,12	60,02	52,32	35,2	50,92	31,88	49,73	36,93
588,56	3,60%	JAPAN	29,18	60	30,17	43,72	34,42	37,23	54,08	66,92	47,68	47,43	39,53	25,28	20,8	25,97	26,15
559,46	3,40%	FRANCE	42,13	32,17	42,75	30,17	36,78	35	43,67	26,62	53,76	45,92	29,5	31,38	35,57	42,48	31,57
552,48	3,40%	CANADA	26,67	38,5	20,33	24,42	33,23	27,75	36,58	39,28	36,65	56,9	41,3	44,38	52,19	40,79	33,5
550,15	3,30%	TAIWAN	18	22,5	30,33	34,42	29,33	29,75	39,25	46,03	38,17	39,58	45,79	45,67	41	43,14	47,18
451,05	2,70%	ITALY	28,42	31,58	33,83	32,08	22,08	20	28,17	30,48	49,17	29,67	24,45	31,37	26,48	36,85	26,42
429,55	2,60%	SPAIN	19	14,25	17,92	14,81	15,2	26,75	22,12	31,2	52,92	42,72	30,92	28,92	36,15	41,05	35,64
405,52	2,50%	POLAND	13,58	17,17	16,5	37,75	17,25	28,5	26,92	31,17	25,25	26,83	41,83	26,58	45,08	36,6	14,5
326,87	2,00%	S KOREA	9,83	12,33	9,67	28,17	13	10,07	14,83	26,83	16,67	51,85	21,67	27	35,17	30,43	19,35
325,26	2,00%	AUSTRALIA	19,67	24,17	10,67	22,08	19,6	11	17,33	35,67	14,75	27,01	27,57	16,12	31,65	22,8	25,18
320,18	1,90%	HOLLAND	33,5	20,75	21,58	17,92	24,92	13,17	17,5	11,83	27,95	23,33	12,67	18,67	27,67	23,2	25,53
291,78	1,80%	CZECHR	16,67	24,75	13,25	11,5	7,25	19	14,5	16,67	20,83	21,17	29,25	21,25	20,25	25	30,45
201,42	1,20%	NORWAY	16,33	10,33	8,5	9,83	11,8	14,67	15,77	8,75	11,5	14,67	16,73	16,58	18,17	15,78	12
193,5	1,20%	SWEDEN	8,25	14,83	9,83	14,75	15,47	10,53	24,92	8,83	12,25	23,83	17,25	8,45	6,81	8,75	8,74
189,92	1,20%	UKRAINE	2,5	6	55,83	94,33	3,5	1	4	2	4,5	2	1	6	2	3,08	2,17
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 70: Computer application output, evaluation of N_P for 1 year for Cybernetics WOS category.

Description: for $N_P = \sum_{i=1}^N \frac{1}{N_{c,i}}$, where N_P is the total number of weighted research papers published in the country during said period and $N_{c,i}$ the number of participating countries for each research paper "i", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19 /111 records.

Mean		11	12	12	12	15	13	11	13	9	8	8	7	4	3	1
	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}
14	USA	19	21	17	22	24	22	18	16	12	11	10	8	5	3	1
11	UNITED KINGDOM	14	17	17	15	14	16	10	19	11	9	10	10	6	3	1
1	RUSSIA	0	0	1	1	1	1	1	1	2	1	1	1	1	1	0
11	PEOPLES R CHINA	17	9	20	18	15	11	16	24	20	8	20	13	6	5	2
10	GERMANY	12	15	15	13	16	12	11	13	10	10	9	7	4	3	1
10	JAPAN	17	14	23	13	13	8	11	8	12	7	5	9	4	2	1
9	FRANCE	7	15	12	12	15	21	13	13	6	8	8	6	2	2	2
11	CANADA	24	16	16	16	13	18	15	17	9	14	11	8	4	3	1
13	TAIWAN	24	13	23	21	20	17	12	23	13	14	12	8	5	3	1
11	ITALY	23	10	15	17	8	17	11	19	9	10	10	7	5	3	1
8	SPAIN	15	4	10	15	22	17	9	10	4	11	9	5	4	4	1
5	POLAND	4	15	8	7	18	9	3	4	7	3	2	2	3	1	1
8	SOUTH KOREA	11	21	12	6	15	15	9	10	11	7	12	5	5	2	1
11	AUSTRALIA	15	16	24	20	24	16	11	5	8	16	7	8	6	2	2
12	NETHERLANDS	13	22	25	15	16	23	12	16	7	11	6	9	4	4	1
2	CZECH REPUBLIC	2	1	1	2	2	2	3	2	7	4	3	3	1	2	0
4	NORWAY	4	7	8	9	3	2	1	5	1	3	3	6	2	3	1
10	SWEDEN	9	12	8	21	6	21	16	15	6	8	5	7	2	1	1
1	UKRAINE	7	2	0	0	0	0	6	1	0	1	0	1	2	1	1
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 71: Computer application output, evaluation of N_{CI} for 1 year for Cybernetics WOS category.

Description: Computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/111 records.

Mean	Year	0,35	0,43	0,45	0,45	0,62	0,57	0,69	0,78	0,64	0,81	0,84	1,13	1,38	1,3	1,31
	Country	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF
1,03	USA	0,54	0,63	0,71	0,67	0,83	0,77	0,93	1,01	0,84	0,99	1,01	1,34	1,82	1,68	1,51
0,95	UNITED KINGDOM	0,39	0,54	0,67	0,54	0,6	0,78	0,86	0,83	0,73	0,87	0,95	1,37	1,97	1,47	1,31
0,09	RUSSIA	0	0,02	0,02	0,05	0,07	0,04	0,05	0,08	0,14	0,07	0,15	0,09	0,22	0,21	0,22
1,13	PEOPLES R CHINA	0,38	0,41	0,43	0,64	0,66	0,53	0,64	0,64	0,89	1,08	1,07	1,26	1,46	1,42	1,85
0,97	GERMANY	0,72	0,77	0,58	0,63	0,96	0,79	1,09	1,02	0,64	1,08	1,07	1,38	1,39	1,2	1,29
0,97	JAPAN	0,53	0,73	0,83	0,77	0,95	0,78	0,92	1,04	0,9	0,9	0,85	1,44	1,42	1,46	1,61
0,81	FRANCE	0,44	0,47	0,56	0,52	0,61	0,66	0,73	0,71	0,48	0,91	0,95	1,38	1,2	1,31	1,42
1,15	CANADA	0,41	0,63	0,59	0,64	0,75	0,62	1,03	0,97	0,84	1,03	1	1,53	2,24	1,93	1,71
1,01	TAIWAN	0,46	0,68	0,58	0,65	0,65	0,56	0,72	1	0,85	1,14	0,98	1,34	1,52	1,45	1,56
0,97	ITALY	0,51	0,53	0,54	0,46	0,86	0,84	0,78	1,2	0,62	1,04	0,9	1,09	2,11	1,47	1,59
0,86	SPAIN	0,33	0,4	0,32	0,4	0,66	0,53	0,57	0,62	0,52	0,81	0,75	1,02	1,57	1,55	1,34
0,49	POLAND	0,64	0,64	0,21	0,21	0,35	0,36	0,23	0,55	0,43	0,4	0,51	0,71	0,67	0,62	1,02
1,03	SOUTH KOREA	0,39	0,66	0,36	0,45	0,69	0,83	0,58	0,72	0,61	0,86	1	1,42	1,77	1,4	1,5
1,1	AUSTRALIA	0,57	0,54	0,71	0,65	0,88	0,64	0,81	0,73	0,76	0,94	1,08	1,57	1,72	1,56	1,97
1,09	NETHERLANDS	0,55	0,67	0,82	0,77	0,83	0,83	1,02	1,43	0,74	0,82	1,18	1,59	2,17	1,63	1,41
0,41	CZECH REPUBLIC	0,15	0,08	0,24	0,26	0,29	0,33	0,31	0,24	0,46	0,38	0,59	0,47	0,5	0,58	0,76
0,56	NORWAY	0,18	0,17	0,4	0,48	0,73	0,38	0,38	0,29	0,31	0,5	1,02	1,09	0,55	1,12	0,68
0,87	SWEDEN	0,43	0,54	0,53	0,49	0,67	0,86	0,92	1,06	0,58	0,82	1	1,51	1,38	1,45	1,49
0,08	UKRAINE	0,75	0,16	0,03	0	0,01	0,02	0,47	0,05	0,16	0,05	0,15	0,39	0,93	0,29	0,64
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 72: Computer application output, evaluation of YIF for 1 year for Cybernetics WOS category.

Description: Computer application output for $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19 /111 records.

Total	N°Col	Country/Year	111 1997	118 1998	134 1999	148 2000	133 2001	142 2002	164 2003	173 2004	187 2005	201 2006	176 2007	252 2008	249 2009	288 2010	260 2011
			N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col
3894	1132	USA	51	63	52	69	65	65	66	71	69	80	75	114	83	115	94
1841	566	UNITED KINGDOM	17	21	25	25	30	14	29	26	40	46	48	50	52	71	72
1529	64	RUSSIA	8	6	7	5	5	1	3	3	3	3	2	2	3	8	5
1394	542	PEOPLES R CHINA	10	17	11	15	20	15	24	32	14	35	32	99	67	78	73
832	328	GERMANY	17	12	22	22	16	13	24	17	17	30	20	28	28	33	29
688	177	JAPAN	9	9	14	10	10	16	19	7	9	14	10	13	12	12	13
726	313	FRANCE	15	7	16	20	14	32	21	20	44	21	18	20	23	21	21
724	312	CANADA	11	13	15	13	19	16	22	20	16	27	23	31	34	33	19
586	69	TAIWAN	2	1	3	5	3	5	3	7	5	3	7	9	6	5	5
543	171	ITALY	13	5	10	15	7	8	9	8	9	15	11	11	18	16	16
527	180	SPAIN	9	7	7	8	6	9	8	9	17	14	11	11	23	18	23
459	98	POLAND	4	5	5	8	6	6	8	10	6	4	4	6	11	10	5
397	128	SOUTH KOREA	5	5	1	3	0	5	4	8	5	15	13	17	17	21	9
424	179	AUSTRALIA	2	8	10	7	9	10	6	13	9	13	10	17	21	18	26
380	113	NETHERLANDS	6	10	11	5	8	5	6	5	9	9	3	6	7	9	14
339	84	CZECH REPUBLIC	4	2	4	3	4	6	7	5	4	7	6	10	9	5	8
235	66	NORWAY	1	1	6	4	5	2	7	3	1	1	6	7	6	10	6
237	75	SWEDEN	3	2	2	7	5	9	6	6	5	7	4	4	3	6	6
200	20	UKRAINE	1	2	3	5	1	0	2	0	1	0	0	0	0	3	2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 73: Computer application output, evaluation of N° Col for 1 year for Cybernetics WOS category.

Description: Computer application output for N°Col Number collaborations, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/111 records.

Total	%Col	Country\Year	11%	11%	14%	13%	14%	17%	16%	15%	15%	15%	16%	23%	21%	24%	23%
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col
3894	29%	USA	20%	24%	22%	29%	28%	30%	24%	26%	23%	33%	27%	40%	34%	42%	33%
1841	31%	UNITED KINGDOM	22%	19%	27%	19%	21%	21%	25%	23%	26%	30%	34%	42%	41%	50%	47%
1529	4%	RUSSIA	6%	6%	6%	4%	5%	1%	3%	3%	3%	4%	2%	2%	3%	9%	6%
1394	39%	PEOPLES R CHINA	38%	36%	35%	33%	40%	48%	45%	26%	29%	19%	44%	57%	38%	44%	49%
832	39%	GERMANY	29%	25%	44%	28%	41%	33%	47%	36%	25%	43%	43%	42%	60%	49%	54%
688	26%	JAPAN	26%	14%	37%	20%	25%	35%	30%	10%	17%	25%	22%	39%	43%	36%	37%
726	43%	FRANCE	30%	19%	31%	49%	32%	62%	38%	54%	56%	37%	46%	48%	48%	40%	49%
724	43%	CANADA	34%	29%	54%	42%	43%	44%	44%	39%	35%	38%	43%	50%	49%	55%	43%
586	12%	TAIWAN	11%	4%	9%	14%	10%	15%	7%	14%	12%	7%	14%	18%	14%	11%	10%
543	31%	ITALY	37%	15%	26%	38%	27%	33%	27%	23%	17%	39%	35%	30%	50%	35%	44%
527	34%	SPAIN	39%	39%	33%	42%	32%	28%	30%	25%	27%	27%	30%	31%	48%	35%	48%
459	21%	POLAND	25%	25%	26%	19%	29%	19%	25%	28%	21%	14%	9%	20%	22%	24%	29%
397	32%	SOUTH KOREA	42%	33%	10%	10%	0%	38%	24%	26%	26%	25%	45%	47%	39%	49%	36%
424	42%	AUSTRALIA	10%	29%	63%	27%	38%	63%	30%	30%	47%	37%	30%	65%	49%	55%	63%
380	30%	NETHERLANDS	16%	38%	41%	24%	28%	31%	30%	36%	27%	32%	21%	27%	23%	32%	41%
339	25%	CZECH REPUBLIC	21%	8%	25%	23%	44%	27%	39%	25%	17%	28%	18%	37%	36%	18%	23%
235	28%	NORWAY	6%	9%	50%	33%	36%	13%	37%	30%	8%	7%	30%	35%	29%	48%	40%
237	32%	SWEDEN	30%	13%	18%	37%	28%	60%	21%	50%	33%	25%	21%	36%	33%	50%	46%
200	10%	UKRAINE	33%	29%	5%	5%	25%	0%	40%	0%	20%	0%	0%	0%	0%	60%	67%
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 74: Computer application output, evaluation of Col (%) for 1 year for Cybernetics WOS category.

Description: Computer application output Col (%) percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another country and the total documents published, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/111 records.

Mean	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Country	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A
2,9	USA	2,5	2,5	2,5	2,8	2,5	2,9	2,8	2,9	3	3	2,8	3,2	3,1	3,1	3,2
2,7	UNITED KINGDOM	2,3	2,1	2,6	2,4	2,4	2,6	2,4	2,5	2,5	2,7	3	2,8	3,1	3,2	3
1,9	RUSSIA	1,6	1,6	1,9	1,8	2	1,9	1,8	1,9	1,8	1,8	2	1,8	2	2,1	2,3
3	PEOPLES R CHINA	2,4	2,1	2,3	2,8	2,7	2,8	2,6	2,6	2,9	3,1	3,1	3,2	3,3	3,2	3,3
2,9	GERMANY	2,7	2,4	2,4	2,4	2,3	2,7	2,8	3	2,5	3,1	2,9	3,3	3,1	3,6	4
3,1	JAPAN	2,3	2,9	3	2,9	2,7	3,4	3	3,3	3,2	3,2	2,7	3,3	3	3	3,9
2,9	FRANCE	2,5	2,2	2,4	2,6	2,7	2,9	2,7	2,9	3,1	2,8	3,1	3	2,9	3,5	4
2,8	CANADA	2,3	2,5	2,2	2,5	2,7	2,1	2,8	2,5	2,7	3	2,8	3	3,3	2,8	3,3
2,6	TAIWAN	2,3	2,3	2,3	2,4	2,3	3,5	2,2	2,5	2,3	2,5	2,5	2,9	2,6	3	2,5
3,1	ITALY	2,8	2,7	2,9	2,6	2,8	2,9	3	3	2,9	3,4	3,2	3,1	3,6	3,5	3,4
3,2	SPAIN	2,3	2,7	2,7	2,5	2,9	3,2	2,9	3	3,4	3,4	2,9	3,1	3,2	3,5	4,1
1,8	POLAND	1,7	1,5	1,7	1,9	1,9	1,6	1,8	1,8	1,6	1,7	1,5	1,9	2	2,2	2,2
2,7	SOUTH KOREA	2,5	2,3	2,4	2,8	2,5	2,4	2,6	2,3	2,9	3	2,8	2,9	2,5	2,9	3,2
2,7	AUSTRALIA	1,9	2,4	2,3	2,5	2,2	2,4	2,5	2,5	2,9	2,8	2,6	3,1	3,1	3,1	3,5
3	NETHERLANDS	2,3	2,9	2,8	2,8	2,4	2,6	2,5	3	3,2	2,6	2,8	3,6	3,5	4	3,9
2	CZECH REPUBLIC	1,5	1,7	1,7	1,8	2	1,9	2,2	2	2	1,8	2,2	2	2,1	2	2,7
2,4	NORWAY	2	1,8	2,3	1,8	2,5	2,5	2,1	3,1	2,1	3	3,1	2,4	2,5	2,4	2,7
2,9	SWEDEN	2,1	1,9	2,4	2,5	2,7	2,8	3,2	2,3	3,5	2,6	2,8	2,6	3,7	2,6	6,5
1,7	UKRAINE	2,7	1,3	1,9	1,7	1,3	2	1,8	1	1,6	1	1	1,2	2,5	2	3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 75: Computer application output, evaluation of N_A for 1 year for Cybernetics WOS category.

Description: Computer application output for $N_A = (\sum_{i=1}^N N_{A,i})/N$ where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/111 records.

Mean		1,4	1,4	1,5	1,5	1,5	1,6	1,5	1,5	1,5	1,5	1,6	1,8	1,7	1,8	1,8
	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Country	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}
1,9	USA	1,6	1,7	1,8	1,9	1,7	2	1,8	1,8	1,8	1,9	1,8	2,4	2	2,2	2,1
1,7	UNITED KINGDOM	1,5	1,5	1,6	1,5	1,5	1,6	1,5	1,6	1,6	1,7	1,8	2	2	2,1	2
1,2	RUSSIA	1,1	1,1	1,1	1,2	1,3	1,1	1,1	1,2	1,2	1,1	1,2	1,1	1,3	1,2	1,3
2	PEOPLES R CHINA	1,6	1,8	1,6	1,8	1,9	2	2,1	1,7	1,9	1,7	2,2	2,5	2,2	2,2	2,3
1,9	GERMANY	1,6	1,7	1,7	1,6	1,7	1,9	2	1,8	1,6	1,9	2,1	2	2,3	2	2,3
1,9	JAPAN	1,8	1,6	2,1	1,7	1,9	2,2	1,9	1,6	1,9	1,8	1,7	2,1	2	2,3	2,2
2	FRANCE	1,7	1,5	1,7	1,9	1,8	2,3	2,1	2,3	2	1,8	2,1	2,1	2,3	2,4	2,3
1,9	CANADA	1,6	1,6	1,9	2	2	1,7	2,2	1,9	1,7	1,8	2	2,1	2,1	2,2	2
1,7	TAIWAN	1,4	1,5	1,6	1,6	1,5	2,3	1,5	1,6	1,6	1,7	2	2	1,8	2	1,7
1,8	ITALY	1,9	1,6	2	1,8	2,1	1,8	1,6	1,6	1,4	1,8	2	1,8	2,3	1,9	2,1
1,8	SPAIN	1,7	1,6	1,8	1,5	1,6	1,7	1,5	1,6	1,6	1,8	1,7	1,6	1,9	2	2,1
1,5	POLAND	1,4	1,5	1,5	1,6	1,7	1,3	1,7	1,6	1,5	1,3	1,3	1,6	1,5	1,6	1,9
1,8	SOUTH KOREA	2	1,8	1,9	1,5	1,3	1,9	1,6	1,6	1,8	1,6	2	2,1	2	2	2,2
1,9	AUSTRALIA	1,3	1,4	1,8	1,6	1,7	2	1,8	1,5	1,8	2,1	1,7	2,3	2	2,1	2,6
1,8	NETHERLANDS	1,5	1,9	2,1	1,8	1,7	1,6	1,5	1,6	1,8	1,8	1,3	1,9	1,9	1,9	1,9
1,6	CZECH REPUBLIC	1,5	1,5	1,6	1,6	2,2	1,5	1,7	1,7	1,4	1,6	1,6	1,7	1,7	1,6	1,7
1,7	NORWAY	1,5	1,3	2,1	1,7	1,6	1,8	1,6	1,7	1,8	1,3	2	1,8	1,5	2,1	1,7
1,8	SWEDEN	1,5	1,4	1,5	1,8	1,9	2,3	1,9	1,6	1,7	1,5	1,7	1,8	2,7	2,1	2,8
1,4	UKRAINE	1,3	1,3	1,3	1,3	1,3	1	1,4	1,5	1,6	1,5	2	1,3	1	2,2	2,3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 76: Computer application output, evaluation of N_{RI} for 1 year for Cybernetics WOS category.

Description: Computer application output for $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$ where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/111 records.

Country\Year	1997-1999		2000-2002		2003-2005		2006-2008		2009-2011	
	Np	Rank	Np	Rank	Np	Rank	Np	Rank	Np	Rank
USA	671	1	587	1	748	1	657	1	640	1
UNITED KINGDOM	250	3	306	3	331	2	332	3	312	3
RUSSIA	344	2	326	2	304	3	268	4	254	4
PEOPLES R CHINA	86	8	100	7	190	4	354	2	395	2
GERMANY	130	4	131	4	135	6	138	6	119	7
JAPAN	119	5	115	5	169	5	112	8	73	16
FRANCE	117	6	102	6	124	7	107	9	110	9
CANADA	86	9	85	10	113	9	143	5	126	6
TAIWAN	71	11	94	9	123	8	131	7	131	5
ITALY	94	7	74	12	108	10	85	13	90	11
SPAIN	51	15	57	13	106	11	103	10	113	8
POLAND	47	16	84	11	83	12	95	12	96	10
SOUTH KOREA	32	22	51	16	58	14	101	11	85	12
AUSTRALIA	55	14	53	15	68	13	71	15	80	13
NETHERLANDS	76	10	56	14	57	15	55	16	76	14
CZECH REPUBLIC	55	13	38	18	52	17	72	14	76	15
NORWAY	35	19	36	20	36	23	48	19	46	17
SWEDEN	33	21	41	17	46	18	50	18	24	30
UKRAINE	64	12	99	8	11	38	9	38	7	40
SINGAPORE	21	25	22	23	55	16	51	17	37	22
..	..	..	..	..	..	..	..	..	..	..

Table 77: Computer application output, evaluation of N_p for 3 years' interval along with Rank Info for Cybernetics WOS category.

Description: Computer application output for $N_p = \sum_{i=1}^N \frac{1}{N_{ci}}$, where N_p is the total number of weighted research papers published in the country during said period and N_{ci} the number of participating countries for each research paper "i", total 15-year interval are divided in to 3-year interval table showing output from computer application: 20/110 records, Rank: position of ranking drawn from the number of publications produced during that period by the specific country table showing output from computer application: 20/110 records.

Total	3092	2884	3482	3503	3484
Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Country	N _P	N _P	N _P	N _P	N _P
USA	671,4	586,66	747,57	656,63	640,06
UNITED KINGDOM	249,92	305,63	331,35	331,53	311,79
RUSSIA	343,58	326,4	304,25	267,67	253,87
PEOPLES R CHINA	85,53	99,84	189,95	353,64	395,4
GERMANY	130,15	131,2	135,17	138,43	118,54
JAPAN	119,35	115,37	168,68	112,25	72,92
FRANCE	117,05	101,95	124,04	106,8	109,62
CANADA	85,5	85,39	112,52	142,58	126,49
TAIWAN	70,83	93,5	123,45	131,04	131,33
ITALY	93,83	74,17	107,82	85,48	89,75
SPAIN	51,17	56,76	106,23	102,55	112,84
POLAND	47,25	83,5	83,33	95,25	96,18
SOUTH KOREA	31,83	51,23	58,33	100,52	84,95
AUSTRALIA	54,5	52,68	67,75	70,7	79,63
NETHERLANDS	75,83	56	57,28	54,67	76,4
CZECH REPUBLIC	54,67	37,75	52	71,67	75,7
NORWAY	35,17	36,3	36,02	47,98	45,95
SWEDEN	32,92	40,75	46	49,53	24,3
UKRAINE	64,33	98,83	10,5	9	7,25
SINGAPORE	21	21,83	55	51,07	36,76
..	..	..	..	..	..

Table 78: Computer application output, evaluation of N_P for 3 years for Cybernetics WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{c,i}}$, where N_P is the total number of weighted research papers published in the country during said period and $N_{c,i}$ the number of participating countries for each research paper "i", total 15-year interval are divided in to 3-year interval table showing output from computer application: 20/110 records.

Figure 56: Computer application output N_p for countries, Cybernetics WOS category.

Description: Computer application output to see the changes in weighted publications of national and international research papers, where N_p is the total number of research papers published by the country during said period, total 15-year interval are divided in to 1 year interval.

Figure 57: Computer application output evaluation of N_A and N_{RI} for countries, Cybernetics WOS category.

Description: Computer application output to see evaluation of N_A and N_{RI} (changes in the number of national and international research papers), $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$, the number of research centers (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval.

Figure 58: Computer application output evaluation of YIF and N_{CI} for countries Cybernetics WOS category.

Description: Computer application output to see evaluation of YIF and N_{CI} (changes in the number of national and international research papers); $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period, and YIF is the IF to the journal of the year when each document "i" was published"; $N_{CI} = (\sum_{i=1}^N N_{CI,i}) / N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 1 year interval.

Figure 59: Computer application output, a triennium status graph N_p in the country, Cybernetics WOS category.

Description: Computer output for selected WOS category, $N_p = \sum_{i=1}^N \frac{1}{N_{c,i}}$, where N_p is the total number of weighted research papers published in the country during said period and $N_{c,i}$ the number of participating countries for each research paper "i", total 15-year interval are divided in to 3-year interval.

Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Country	YIF	YIF	YIF	YIF	YIF
USA	0,62	0,75	0,92	1,12	1,66
UNITED KINGDOM	0,54	0,61	0,79	1,04	1,56
RUSSIA	0,01	0,05	0,09	0,11	0,22
PEOPLES R CHINA	0,41	0,62	0,69	1,17	1,56
GERMANY	0,68	0,75	0,87	1,2	1,28
JAPAN	0,7	0,83	0,96	1,01	1,51
FRANCE	0,49	0,6	0,61	1,09	1,31
CANADA	0,55	0,68	0,95	1,19	1,99
TAIWAN	0,58	0,62	0,87	1,16	1,51
ITALY	0,53	0,68	0,83	1,01	1,71
SPAIN	0,35	0,53	0,56	0,85	1,49
POLAND	0,36	0,29	0,41	0,54	0,7
SOUTH KOREA	0,48	0,6	0,65	1,11	1,57
AUSTRALIA	0,59	0,73	0,76	1,17	1,76
NETHERLANDS	0,67	0,81	0,96	1,16	1,72
CZECH REPUBLIC	0,14	0,3	0,34	0,49	0,63
NORWAY	0,23	0,53	0,34	0,8	0,8
SWEDEN	0,51	0,66	0,86	1,02	1,45
UKRAINE	0,07	0	0,27	0,29	0,52
SINGAPORE	0,5	0,52	0,83	1,35	2,08
..	..	..	..	..	..

Table 79: Computer application output, evaluation of YIF for 3 years for Cybernetics WOS category.

Description: Computer application output for $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/111 records.

Figure 60: Computer application output, a triennium status graph YIF in the country, Cybernetics WOS category

Description: Computer output for selected WOS category, $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval.

Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Country	N_{CI}	N_{CI}	N_{CI}	N_{CI}	N_{CI}
USA	19	23	15	10	3
UNITED KINGDOM	16	15	13	10	3
RUSSIA	0	1	1	1	0
PEOPLES R CHINA	14	15	21	12	4
GERMANY	14	13	11	9	3
JAPAN	17	11	10	7	2
FRANCE	11	16	10	7	2
CANADA	18	16	14	11	3
TAIWAN	20	19	17	11	3
ITALY	16	14	12	9	3
SPAIN	10	18	7	8	3
POLAND	9	10	4	2	2
SOUTH KOREA	15	10	10	8	3
AUSTRALIA	18	20	7	11	3
NETHERLANDS	19	17	10	9	3
CZECH REPUBLIC	1	2	5	3	1
NORWAY	6	4	2	4	2
SWEDEN	10	16	13	7	1
UKRAINE	1	0	3	1	1
SINGAPORE	14	25	23	16	5
..	..	..	..	..	..

Table 80: Computer application output, evaluation of N_{CI} for 3 years for Cybernetics WOS category.

Description: Computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/111 records.

Figure 61: Computer application output, a triennium status graph N_{Ci} in the country, Cybernetics WOS category.

Description: Computer output for selected WOS category, $N_{Ci} = (\sum_{i=1}^N N_{Ci,i})/N$, where N is the total number of research papers of the country published during said period and $N_{Ci,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval.

Country	1997-2011						
	N _P	N _P (%)	Col (%)	YIF	N _{CI}	N _A	N _{RI}
USA	3302	20,10%	29,10%	1,03	14	2,9	1,9
UNITED KINGDOM	1530	9,30%	30,70%	0,95	11	2,7	1,7
RUSSIA	1496	9,10%	4,20%	0,09	1	1,9	1,2
PEOPLES R CHINA	1124	6,80%	38,90%	1,13	11	3	2
GERMANY	653	4,00%	39,40%	0,97	10	2,9	1,9
JAPAN	589	3,60%	25,70%	0,97	10	3,1	1,9
FRANCE	559	3,40%	43,10%	0,81	9	2,9	2
CANADA	552	3,40%	43,10%	1,15	11	2,8	1,9
TAIWAN	550	3,30%	11,80%	1,01	13	2,6	1,7
ITALY	451	2,70%	31,50%	0,97	11	3,1	1,8
SPAIN	430	2,60%	34,20%	0,86	8	3,2	1,8
POLAND	406	2,50%	21,40%	0,49	5	1,8	1,5
SOUTH KOREA	327	2,00%	32,20%	1,03	8	2,7	1,8
AUSTRALIA	325	2,00%	42,20%	1,1	11	2,7	1,9
..	..	..	..	..	..	..	..

Table 81: Computer application output, evaluation of N_P , $N_{P\%}$, $Col\%$, YIF , N_{CI} , N_A , N_{RI} for 15 years for Cybernetics WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{C,i}}$, where N_P is the total number of weighted research papers published in the country during said period and $N_{C,i}$ the number of participating countries for each research paper "i"; $N_P (\%) = \frac{N_P}{N_W}$ is the contribution of each country to the world production where N_P is the total number of research papers published by the country during said period and N_W the total number of published research papers of "Selected WOS category" at global level; $Col (\%)$ is percentage of international collaboration for a given period has been calculated as the ratio of the research papers published in collaboration with at least one centre of another country and the total documents published; $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published; $N_{CI} = (\sum_{i=1}^N N_{CI,i}) / N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time; $N_A = (\sum_{i=1}^N N_{A,i}) / N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; $N_{RI} = (\sum_{i=1}^N N_{RI,i}) / N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15 years' timetable showing output from computer application: 14/110 records.

7.3.3. Language Analysis

Country	ALGERIA		ARGENTINA		ARMENIA		AUSTRALIA		AUSTRIA		..
Language	N°Papers	%	N°Papers	%	N°Papers	%	N°Papers	%	N°Papers	%	..
English	51	100,00%	32	100,00%	6	100,00%	423	99,80%	165	100,00%	..
French	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	..
Welsh	0	0,00%	0	0,00%	0	0,00%	1	0,20%	0	0,00%	..

Table 82: Computer application output, % and N° of research papers published in each of the languages for Cybernetics WOS category.

Description: Computer application output, main production indicators of worldwide countries specific average values during the time of 1997–2011 from language information field it has been determined the % and N° of research papers published in each of the languages globally; table showing output from computer application: 5/111 records.

7.3.4. Evaluation of institutional distribution of publications

Total		Year	1004	1100	988	1132	929	823	1057	1174	1251	1301	1104	1098	1162	1196	1126
	Research centre	Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P
464,45	RUSSIAN ACAD SCI	RUSSIA	26,67	34,08	32,67	43,17	30,53	32,83	33,17	22,25	27,42	29	35	30,33	35,67	25,17	26,5
87,43	NATL UNIV SINGAPORE	SINGAPORE	2,5	4	4,5	9,33	3	2,5	6,83	14,17	5,83	6,37	9,67	8,7	3,33	3,34	3,35
81,2	POLISH ACAD SCI	POLAND	0,83	5,83	1,83	12	2,08	9,5	9,42	5,17	6,5	2,33	9,17	4,25	7,17	4,87	0,25
80,18	MIT	USA	5	5	10,92	7,45	5,8	4,83	7,58	6,17	7,3	5	3,83	3,33	1,14	2,67	4,17
79,16	NANYANG TECHNOL UNIV	SINGAPORE	3,5	2	3	2,5	0	4	6,83	11,5	4,58	6,5	7	7,33	6	6,83	7,58
69,83	NATL ACAD SCI UKRAINE	UKRAINE	0	0,5	27,83	34,67	0	0	0	0	1,5	0	0	1,5	2	1,5	0,33
69,33	UNIV ILLINOIS	USA	4,17	5	8,83	6,25	2,33	5,42	4,58	4,33	9	2,73	6	3,58	1	2,83	3,27
67,95	HONG KONG POLYTECH UNIV	PEOPLES R CHINA	1	6	2,5	2,5	4,67	1,33	1,75	8,57	4,33	13,83	3,62	2,23	3,92	7,37	4,33
66,75	CHINESE ACAD SCI	PEOPLES R CHINA	0	3,42	2	2,25	1,5	2	5,7	7,42	4,83	8,15	2,28	6,87	5,85	6,19	8,3
65,77	NORWEGIAN UNIV SCI & TECHNOL	NORWAY	1	4,33	5,67	4,33	6	2,33	6,2	4,25	3,5	5,92	6,9	8,5	3,83	1,5	1,5
64,49	GEORGIA INST TECHNOL	USA	4,67	2,83	5,33	5,32	3,25	3,67	2,75	3,5	5,08	3,92	5,92	4,53	4,73	1,73	7,27
63,94	UCL	UNITED KINGDOM	4	1	2	5,5	2,7	4,5	5,83	4,53	7,42	4,03	7,58	5	1,5	4,76	3,58
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 83: Computer application research centres specific output, evaluation of N_P for 1 year for Cybernetics WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval is divided in to 1 year interval; table showing output from computer application: 12/6197 records.

Mean	Research centre	Country	0,35 1997	0,43 1998	0,45 1999	0,45 2000	0,62 2001	0,57 2002	0,69 2003	0,78 2004	0,64 2005	0,81 2006	0,84 2007	1,13 2008	1,38 2009	1,3 2010	1,31 2011
			YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF
0,12	RUSSIAN ACAD SCI	RUSSIA	0,01	0,05	0,04	0,07	0,12	0,03	0,07	0,14	0,15	0,1	0,15	0,12	0,25	0,24	0,31
1,08	NATL UNIV SINGAPORE	SINGAPORE	0,3	0,29	0,65	0,49	0,68	0,37	0,66	0,98	0,9	0,99	1,1	1,64	2,54	1,51	1,61
0,55	POLISH ACAD SCI	POLAND	-	0,38	0,48	0,22	0,47	0,38	0,35	0,68	0,36	0,4	0,47	1,08	1,03	1,1	0,24
1,23	MIT	USA	0,89	0,97	1,24	0,74	1,21	0,7	1,21	0,91	1,38	1,07	1,46	1,43	2,36	1,91	2
1,39	NANYANG TECHNOL UNIV	SINGAPORE	0,43	0,44	0,88	0,72	-	0,46	0,76	0,74	0,83	1,12	1,18	1,67	1,99	2,27	2,13
0,05	NATL ACAD SCI UKRAINE	UKRAINE	-	0,01	0	-	-	-	-	-	0,11	-	-	0,08	0,93	0,19	1,59
0,9	UNIV ILLINOIS	USA	0,54	0,73	0,76	0,71	0,76	0,58	0,55	0,77	0,63	1,05	1,2	1,87	1,86	2,02	1,25
1,28	HONG KONG POLYTECH UNIV	PEOPLES R CHINA	0,51	0,54	0,15	0,69	0,63	0,58	0,48	0,89	0,91	1,32	1,23	1,86	2,46	1,9	1,53
1,51	CHINESE ACAD SCI	PEOPLES R CHINA	-	0,4	0,67	1,11	0,47	0,41	0,53	0,63	0,83	1,24	0,96	1,89	2,14	2,35	2,66
0,45	NORWEGIAN UNIV SCI & TECHNOL	NORWAY	-	0,19	0,39	0,64	0,8	0,41	0,37	0,08	0,35	0,5	-	0,84	0,44	0,5	0,62
1,11	GEORGIA INST TECHNOL	USA	0,67	0,5	0,68	0,65	0,98	0,66	0,61	0,6	1,24	1,41	1,2	1,7	1,78	1,46	1,51
1,14	UCL	UNITED KINGDOM	0,3	0,69	1,85	1,13	1,12	0,97	0,64	1,08	0,76	1,08	0,5	1,94	1,99	1,65	1,54
1,23	CARNEGIE MELLON UNIV	USA	0,51	0,62	1,07	0,92	0,74	0,53	1,66	2,26	1,19	0,78	1,09	1,94	2,18	1,8	1,47
0,76	TECHNION ISRAEL INST TECHNOL	ISRAEL	0,61	0,44	0,22	0,6	0,83	0,5	0,44	0,96	0,79	0,71	0,75	1,32	0,76	1,73	0,92
0,41	UNIV PARIS 06	FRANCE	0,17	0,36	0,3	0,32	0,28	0,63	0,2	0,19	0,14	0,57	0,18	0,86	0,32	1,41	1,53
0,09	TECH UNIV	RUSSIA	-	-	-	0,02	0,01	0,02	0,01	0,05	0,11	0,05	0,15	0,08	0,17	0,19	0,17
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 84: Computer application research centres specific output, evaluation of YIF for 1 year for Cybernetics WOS category.

Description: Computer application output for $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 1 year interval table showing output from computer application: 16/11273 records.

Mean	Research centre	Year	11	12	12	12	15	13	11	13	9	8	8	7	4	3	1
		Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}
1	RUSSIAN ACAD SCI	RUSSIA	0	1	1	1	3	1	1	1	3	2	1	1	1	1	0
16	NATL UNIV SINGAPORE	SINGAPORE	10	7	34	9	39	9	28	26	13	18	17	15	9	4	1
8	POLISH ACAD SCI	POLAND	10	31	38	8	8	14	5	5	8	11	2	2	2	2	0
22	MIT	USA	33	32	16	38	15	42	35	28	18	16	13	16	12	1	1
17	NANYANG TECHNOL UNIV	SINGAPORE	8	6	16	59	-	38	33	24	10	36	18	17	6	8	2
0	NATL ACAD SCI UKRAINE	UKRAINE	-	0	0	0	-	-	-	-	0	-	-	1	2	1	2
13	UNIV ILLINOIS	USA	13	13	14	42	5	7	7	5	4	1	28	11	5	3	1
12	HONG KONG POLYTECH UNIV	PEOPLES R CHINA	36	11	8	10	22	10	16	20	14	8	13	28	6	3	1
19	CHINESE ACAD SCI	PEOPLES R CHINA	-	1	7	13	31	7	11	76	18	8	19	21	10	6	2
3	NORWEGIAN UNIV SCI & TECHNOL	NORWAY	0	4	6	6	3	1	1	5	0	3	2	2	1	1	1
14	GEORGIA INST TECHNOL	USA	16	9	8	16	125	8	10	13	17	4	7	3	9	6	1
14	UCL	UNITED KINGDOM	4	7	56	45	11	20	10	22	16	13	5	11	1	4	4
15	CARNEGIE MELLON UNIV	USA	46	31	16	25	21	5	39	22	5	17	11	7	3	3	1
9	TECHNION ISRAEL INST TECHNOL	ISRAEL	32	8	7	11	5	3	10	9	2	5	5	20	5	2	0
5	UNIV PARIS 06	FRANCE	2	5	15	6	19	12	3	4	2	4	0	3	2	2	3
1	TECH UNIV	RUSSIA	-	-	1	1	0	0	1	1	3	1	1	1	0	1	0
14	UNIV MARYLAND	USA	26	5	12	26	7	47	20	9	17	14	6	8	1	2	1
..																	

Table 85: Computer application research centres specific output, evaluation of N_{CI} for 1 year for Cybernetics WOS category.

Description: Computer application output along with data for selected Cybernetics WOS Category, Main production indicators of worldwide research centres, (1997–2011), total 15-year interval is divided in 1 year interval, N_{CI} is average number of citation for each research centre; table showing output from computer application: 17/11273 records.

Total	N°Col	Research centre\Year	111	118	134	148	133	142	164	173	187	201	176	252	249	288	260
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col
464	15	RUSSIAN ACAD SCI	1	1,75	0,83	1,5	1,2	0,5	0,5	0,5	0	0,67	0,33	1	1,5	2,33	1,17
87	16	NATL UNIV SINGAPORE	0,5	0,5	0,5	0,33	0	0,5	0,83	2,17	0,83	0,87	2,67	2,53	1,83	0,68	1,05
81	20	POLISH ACAD SCI	0,83	0,83	0,83	2,17	0,58	1,5	1,75	3,17	1	0,33	0,67	1,25	2,83	1,53	0,25
80	15	MIT	0,5	1	1	1,5	0,5	0	0,25	2,33	0,2	1,5	0,83	1,83	1	0,67	1,83
79	25	NANYANG TECHNOL UNIV	0,5	0	1	0	0	1	1,83	1,17	1,58	1	1,5	3,83	3	3,83	5,08
70	3	NATL ACAD SCI UKRAINE	0	0,5	1,5	1	0	0	0	0	0	0	0	0	0	0	0
69	8	UNIV ILLINOIS	0	0,5	1	0,75	0	1,58	0	0,83	1	1,33	0,33	0,25	0,33	0,33	0,1
68	9	HONG KONG POLYTECH UNIV	0	1	0	0	0	0,33	0,25	0,33	0	1,5	1,7	1,23	1,25	0,53	0,5
67	23	CHINESE ACAD SCI NORWEGIAN UNIV SCI & TECHNOL	0	0,58	0	0	0	0	0,87	3,42	1,17	2,23	0,45	3,43	1,82	3,85	5,03
66	13	GEORGIA INST TECHNOL	0	0,33	1,67	0,33	1,5	0,33	1,7	1,25	0,5	0,67	0,9	0,5	1,17	1,17	0,5
64	9	UCL	0,67	0	1,5	1,65	0,25	0,17	0,5	0	0	1	0,25	0	1,5	0,73	1,18
64	12	CARNEGIE MELLON UNIV	0	0	1	0,83	0	0	0	0,45	1,5	1,67	2	0,5	1,17	2,4	2,6
64	14	TECHNION ISRAEL INST TECHNOL	0	0	1	0,83	0	0	0	0,45	1,5	1,67	2	0,5	1,17	2,4	2,6
63	9	UNIV PARIS 06	0,33	1,58	1,17	0,33	0	0,5	0	1,5	0,5	0,5	0,5	1,25	0	0	0,33
62	28	TECH UNIV	0	1	0,5	2,17	0,2	4,33	1,58	2,67	10,5	1,67	1	0,5	1,08	0,33	0,5
61	1	UNIV MARYLAND	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0
61	9	ACAD SCI CZECH REPUBL	1,17	1,08	0	0,33	0,33	1	0	0	0,75	1,02	0,75	0,5	0,6	1,58	0
60	9	NATL CHIAO TUNG UNIV	0,83	0,25	0,92	0,67	0,58	0,5	2	0,83	1,17	1	0	0	0	0	0
59	1		0	0	0	0	0,5	0,67	0	0	0	0	0	0,25	0	0	0
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 86: Computer application research centres specific output, evaluation of N° Col for 1 year for Cybernetics WOS category.

Description: Sample of computer application output for N°Col Number of collaborations, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/11273 records.

Total	%Col	Research centre\Year	11% 1997	11% 1998	14% 1999	13% 2000	14% 2001	17% 2002	16% 2003	15% 2004	15% 2005	15% 2006	16% 2007	23% 2008	21% 2009	24% 2010	23% 2011
			%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col
464	3%	RUSSIAN ACAD SCI	4%	5%	3%	3%	4%	2%	2%	2%	0%	2%	1%	3%	4%	9%	4%
87	18%	NATL UNIV SINGAPORE	20%	13%	11%	4%	0%	20%	12%	15%	14%	14%	28%	29%	55%	20%	31%
81	24%	POLISH ACAD SCI	100%	14%	45%	18%	28%	16%	19%	61%	15%	14%	7%	29%	40%	32%	100%
80	19%	MIT	10%	20%	9%	20%	9%	0%	3%	38%	3%	30%	22%	55%	88%	25%	44%
79	32%	NANYANG TECHNOL UNIV	14%	0%	33%	0%	0%	25%	27%	10%	35%	15%	21%	52%	50%	56%	67%
70	4%	NATL ACAD SCI UKRAINE	0%	100%	5%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
69	12%	UNIV ILLINOIS	0%	10%	11%	12%	0%	29%	0%	19%	11%	49%	6%	7%	33%	12%	3%
68	13%	HONG KONG POLYTECH UNIV	0%	17%	0%	0%	0%	25%	14%	4%	0%	11%	47%	55%	32%	7%	12%
67	34%	CHINESE ACAD SCI	0%	17%	0%	0%	0%	0%	15%	46%	24%	27%	20%	50%	31%	62%	61%
66	19%	NORWEGIAN UNIV SCI & TECHNOL	0%	8%	29%	8%	25%	14%	27%	29%	14%	11%	13%	6%	30%	78%	33%
64	15%	GEORGIA INST TECHNOL	14%	0%	28%	31%	8%	5%	18%	0%	0%	26%	4%	0%	32%	42%	16%
64	18%	UCL	0%	0%	0%	27%	26%	0%	6%	23%	8%	38%	21%	33%	67%	19%	21%
64	22%	CARNEGIE MELLON UNIV	0%	0%	20%	29%	0%	0%	0%	11%	16%	35%	40%	11%	58%	64%	68%
63	13%	TECHNION ISRAEL INST TECHNOL	6%	21%	24%	11%	0%	11%	0%	23%	17%	25%	33%	33%	0%	0%	10%
62	45%	UNIV PARIS 06	0%	17%	8%	42%	17%	81%	61%	100%	84%	63%	100%	33%	27%	14%	21%
61	1%	TECH UNIV	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%
61	15%	UNIV MARYLAND	18%	17%	0%	6%	10%	30%	0%	0%	20%	23%	14%	20%	30%	58%	0%
60	15%	ACAD SCI CZECH REPubl	19%	2%	12%	16%	18%	11%	40%	23%	15%	20%	0%	0%	0%	0%	0%
59	2%	NATL CHIAO TUNG UNIV	0%	0%	0%	0%	8%	14%	0%	0%	0%	0%	0%	7%	0%	0%	0%
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 87: Computer application research centres specific output, evaluation of Col (%) for 1 year for Cybernetics WOS category.

Description: Sample of computer application output for Col (%) percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another research institution and the total documents published, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/11273 records.

Mean	Research centre	Country	2,1 1997	2,2 1998	2,2 1999	2,3 2000	2,3 2001	2,5 2002	2,4 2003	2,5 2004	2,6 2005	2,7 2006	2,6 2007	2,8 2008	2,8 2009	2,9 2010	3 2011
			N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A
2,1	RUSSIAN ACAD SCI	RUSSIA	1,8	1,9	2,2	1,9	2,1	2,3	2,1	2,1	1,9	2,1	2	1,8	2,3	2,3	2,2
3,4	NATL UNIV SINGAPORE	SINGAPORE	2	2,6	2,4	2,4	5	3	3,1	3,2	3,6	3,5	3,4	3,4	4	4,5	4,7
2	POLISH ACAD SCI	POLAND	1,5	1,3	1,7	2,1	2	1,4	2	2,7	1,8	2	1,4	1,9	2,2	2,9	4
3,2	MIT	USA	4,3	3,3	2,8	3,3	2,4	2,1	2,2	2,9	2,4	5,3	2,8	4,1	5	3,6	3
3,2	NANYANG TECHNOL UNIV	SINGAPORE	2,8	2,5	2	2,3	-	2,6	2,9	2,2	2,7	2,9	2,8	3,3	3,4	3,8	4,4
1,9	NATL ACAD SCI UKRAINE	UKRAINE	-	2	2	1,8	-	-	-	-	1,5	-	-	1	2,5	1	2
2,9	UNIV ILLINOIS	USA	1,8	1,7	2,8	2,7	1,7	2,5	2,9	2	2	4,8	3,4	2,7	3	4	6,8
3,1	HONG KONG POLYTECH UNIV	PEOPLES R CHINA	2	2,1	2	2,7	2,3	3,5	4	2,8	2,8	3,1	3,4	4,2	3,8	3,3	3,3
3,4	CHINESE ACAD SCI	PEOPLES R CHINA	-	2,5	1,5	4	2	1,5	2,4	2,8	2,6	3,6	4,4	3,5	3,9	3,8	4
2,5	NORWEGIAN UNIV SCI & TECHNOL	NORWAY	1	2,5	2,3	1,6	2,1	3	2,2	3	2,2	2,9	3,5	2,5	2,4	2,3	2,5
3,7	GEORGIA INST TECHNOL	USA	3,6	3	2,8	3,3	2,8	5,2	4	3,4	5,8	2,9	3	2,3	4,6	3,5	4,3
3,3	UCL	UNITED KINGDOM	2,3	1	1,5	2,7	4,8	2,2	2,6	4,3	3,3	4,8	2,5	4	3	3,8	3,5
3,5	CARNEGIE MELLON UNIV	USA	2,8	2	2,6	3	2	2	2,7	3,8	3,2	5,9	2,6	3,9	3,4	4	5,4
2,2	TECHNION ISRAEL INST TECHNOL	ISRAEL	2	2,3	2	2,3	2,1	2	1,3	2,4	3	2,3	1,5	2,3	1,5	3	3
2,6	UNIV PARIS 06	FRANCE	2,3	2,1	2,3	2,3	3,5	2,8	2,6	2,3	2,7	3	3,5	3	2,1	2,8	2,5
1,9	TECH UNIV	RUSSIA	-	-	3,3	1,5	2	2	1,4	1,3	2	1,4	1,7	2,3	2	2,3	1,7
3,3	UNIV MARYLAND	USA	2,4	2,8	2	3,1	3,3	2,4	3,6	3,6	3,5	5	3,1	3,5	5	3,4	2,5
1,7	ACAD SCI CZECH REPUBL	CZECH REPUBLIC	1,7	1,5	1,5	1,8	1,7	1,6	2,2	2,3	1,7	1,4	-	-	-	-	-
2,7	NATL CHIAO TUNG UNIV	TAIWAN	2,2	2,3	2,5	2,4	2,5	3,4	2,3	3,4	2	2,3	2,4	3,1	3	3,2	2,4
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 88: Computer application research centres specific output, evaluation of N_A for 1 year for Cybernetics WOS category.

Description: Computer application output for $N_A = (\sum_{i=1}^N N_{A,i})/N$ where N is the total number of research papers of the research institution published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/11273 records.

Mean	Research centre	Country	1,4 1997	1,4 1998	1,5 1999	1,5 2000	1,5 2001	1,6 2002	1,5 2003	1,5 2004	1,5 2005	1,5 2006	1,6 2007	1,8 2008	1,7 2009	1,8 2010	1,8 2011
			N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}
1,3	RUSSIAN ACAD SCI	RUSSIA	1,2	1,3	1,2	1,3	1,5	1,2	1,2	1,2	1,3	1,3	1,3	1,2	1,4	1,3	1,4
1,8	NATL UNIV SINGAPORE	SINGAPORE	1,3	1,4	1,2	1,2	1	1,3	1,4	1,3	2	1,8	1,7	2,3	2,6	3,2	2,7
2	POLISH ACAD SCI	POLAND	2,5	1,6	2	2	2,5	1,6	2,2	2,3	1,9	2	1,5	2	2,1	2,6	4
2,1	MIT	USA	2,1	1,9	1,8	2,3	1,4	1,7	1,6	2	1,8	2,9	2,3	3	3,3	2,2	2,5
2	NANYANG TECHNOL UNIV	SINGAPORE	1,3	1	1,5	1,3	-	1,4	1,6	1,4	1,9	1,5	1,8	2,2	2,1	2,9	3,2
1,4	NATL ACAD SCI UKRAINE	UKRAINE	-	2	1,4	1,4	-	-	-	-	1,5	-	-	1,5	1	1,5	2
1,9	UNIV ILLINOIS	USA	1,4	1,7	1,6	2,1	1,7	2,3	1,9	1,7	1,2	2,4	1,8	1,8	2,5	1,8	3,2
2	HONG KONG POLYTECH UNIV	PEOPLES R CHINA	1	1,5	1,3	1,3	1,5	2	2	1,8	1,4	1,9	2,6	3,2	2,6	2,1	1,7
2,6	CHINESE ACAD SCI	PEOPLES R CHINA	-	2,3	1	2	1,5	1	2,2	2,5	2,2	2,4	3	2,8	3	3,2	2,7
1,7	NORWEGIAN UNIV SCI & TECHNOL	NORWAY	1	1,5	1,9	1,4	1,5	1,7	1,8	1,7	1,6	1,4	1,9	1,7	1,6	2,3	1,5
2,3	GEORGIA INST TECHNOL	USA	1,9	1,8	2	2,5	2,2	3	1,8	1,6	1,9	2,4	2	1,9	2,8	3	2,7
2	UCL	UNITED KINGDOM	1	1	1	1,4	2,4	1,2	1,6	1,9	1,8	2,7	1,9	2,3	2	2,9	2,2
2,2	CARNEGIE MELLON UNIV	USA	2	1,4	1,6	2	1,3	2	1	2,2	1,8	3,2	1,8	2,4	2,4	2,7	3,6
1,4	TECHNION ISRAEL INST TECHNOL	ISRAEL	1,3	1,5	1,7	1,8	1	1,2	1	1,4	1,5	1,7	1,5	2	1	2	1,5
2	UNIV PARIS 06	FRANCE	1,4	1,3	1,1	1,9	2,5	2,3	2,4	2,3	2,1	2	2	1,5	2,1	2,7	2
1,2	TECH UNIV	RUSSIA	-	-	1	1,5	2	1,6	1,1	1,2	1,1	1	1	1,3	1,5	1,4	1
2	UNIV MARYLAND	USA	1,8	1,6	1,4	1,9	1,5	1,8	2	1,4	1,3	2,9	1,6	3,2	2,8	2,7	1,5
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 89: Computer application research centres specific output, evaluation of N_{RI} for 1 year for Cybernetics WOS category.

Description: Computer application output for $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the research institution published during this said period, and $N_{RI,i}$, the number of research centres (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval table showing output from computer application: 17/11273 records.

Research Institution	Country	1997-1999		2000-2002		2003-2005		2006-2008		2009-2011	
		N _P	Rank	N _P	Rank	N _P	Rank	N _P	Rank	N _P	Rank
RUSSIAN ACAD SCI	RUSSIA	93	1	107	1	83	1	94	1	87	1
NATL UNIV SINGAPORE	SINGAPORE	11	22	15	7	27	2	25	2	10	37
POLISH ACAD SCI	POLAND	9	37	24	3	21	5	16	13	12	21
MIT	USA	21	4	18	5	21	6	12	28	8	61
NANYANG TECHNOL UNIV	SINGAPORE	9	38	7	73	23	4	21	5	20	4
NATL ACAD SCI UKRAINE	UKRAINE	28	2	35	2	2	493	2	534	4	204
UNIV ILLINOIS	USA	18	6	14	9	18	9	12	26	7	75
HONG KONG POLYTECH UNIV	PEOPLES R CHINA	10	30	9	39	15	19	20	6	16	11
CHINESE ACAD SCI	PEOPLES R CHINA	5	96	6	85	18	8	17	8	20	5
NORWEGIAN UNIV SCI & TECHNOL	NORWAY	11	23	13	14	14	21	21	4	7	80
GEORGIA INST TECHNOL	USA	13	15	12	17	11	34	14	18	14	16
UCL	UNITED KINGDOM	7	57	13	13	18	10	17	11	10	40
CARNEGIE MELLON UNIV	USA	15	10	8	42	16	15	14	20	10	42
TECHNION ISRAEL INST TECHNOL	ISRAEL	18	7	15	8	13	28	7	81	11	24
UNIV PARIS 06	FRANCE	19	5	12	23	18	11	5	128	9	49
TECH UNIV	RUSSIA	4	138	7	61	23	3	14	19	13	20
UNIV MARYLAND	USA	17	9	12	19	13	27	12	27	8	68
ACAD SCI CZECH REPubL	CZECH REPUBLIC	27	3	12	21	16	16	5	133	0	-
NATL CHIAO TUNG UNIV	TAIWAN	13	13	18	4	10	48	10	43	9	51
PURDUE UNIV	USA	10	29	12	18	9	60	13	23	14	13
..	..	..	..	..	..	..	..	..	..	..	..

Table 90: Computer application research centres specific output, evaluation of N_P for 3 years along with Rank info for Cybernetics WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and N_{RI,i} the number of participating research institutions in each document "i", total 15-year interval are divided in to 3-year interval, Rank: position of ranking drawn from the number of publications produced by the specific research centre during that period; table showing output from computer application: 20/619 records.

Total		3092	2884	3482	3503	3484
Research centre	Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
	Country	N _P	N _P	N _P	N _P	N _P
RUSSIAN ACAD SCI	RUSSIA	93,42	106,53	82,83	94,33	87,33
NATL UNIV SINGAPORE	SINGAPORE	11	14,83	26,83	24,73	10,03
POLISH ACAD SCI	POLAND	8,5	23,58	21,08	15,75	12,28
MIT	USA	20,92	18,08	21,05	12,15	7,98
NANYANG TECHNOL UNIV	SINGAPORE	8,5	6,5	22,92	20,83	20,41
NATL ACAD SCI UKRAINE	UKRAINE	28,33	34,67	1,5	1,5	3,83
UNIV ILLINOIS	USA	18	14	17,92	12,32	7,1
HONG KONG POLYTECH UNIV	PEOPLES R CHINA	9,5	8,5	14,65	19,68	15,62
CHINESE ACAD SCI	PEOPLES R CHINA	5,42	5,75	17,95	17,3	20,34
NORWEGIAN UNIV SCI & TECHNOL	NORWAY	11	12,67	13,95	21,32	6,83
GEORGIA INST TECHNOL	USA	12,83	12,23	11,33	14,37	13,73
UCL	UNITED KINGDOM	7	12,7	17,78	16,62	9,84
CARNEGIE MELLON UNIV	USA	15,15	8,33	16,28	14,32	9,53
TECHNION ISRAEL INST TECHNOL	ISRAEL	17,75	14,5	12,5	7,25	11,33
UNIV PARIS 06	FRANCE	19	11,7	17,75	5,17	8,75
TECH UNIV	RUSSIA	4	7,17	23,33	14,33	12,5
UNIV MARYLAND	USA	16,83	12	12,67	12,22	7,6
ACAD SCI CZECH REPUBL	CZECH REPUBLIC	26,92	11,92	16,25	5	0
NATL CHIAO TUNG UNIV	TAIWAN	13,17	18,17	9,65	9,75	8,7
PURDUE UNIV	USA	9,58	12,2	8,62	13,17	14,4
..	..	..	..	..	..	..

Table 91: Computer application research centres specific output, evaluation of N_P for 3 years for Cybernetics WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/6197 records.

Figure 62: Computer application output, a triennium status graph N_p by research centre, Cybernetics WOS category.

Description: Computer output for selected WOS category, $N_p \cdot \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_p is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval is divided in to 3-year interval.

	Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Research centre	Country	YIF	YIF	YIF	YIF	YIF
RUSSIAN ACAD SCI	RUSSIA	0,03	0,07	0,12	0,12	0,27
NATL UNIV SINGAPORE	SINGAPORE	0,41	0,5	0,88	1,31	1,92
POLISH ACAD SCI	POLAND	0,46	0,3	0,45	0,65	1,02
MIT	USA	1,08	0,86	1,17	1,35	2,05
NANYANG TECHNOL UNIV	SINGAPORE	0,61	0,56	0,77	1,38	2,15
NATL ACAD SCI UKRAINE	UKRAINE	0	-	0,11	0,08	0,77
UNIV ILLINOIS	USA	0,7	0,66	0,64	1,35	1,64
HONG KONG POLYTECH UNIV	PEOPLES R CHINA	0,49	0,64	0,83	1,43	2
CHINESE ACAD SCI	PEOPLES R CHINA	0,48	0,73	0,65	1,54	2,41
NORWEGIAN UNIV SCI & TECHNOL	NORWAY	0,28	0,68	0,27	0,57	0,49
GEORGIA INST TECHNOL	USA	0,64	0,73	0,9	1,4	1,62
UCL	UNITED KINGDOM	0,69	1,08	0,84	1,14	1,67
CARNEGIE MELLON UNIV	USA	0,74	0,8	1,54	1,19	1,74
TECHNION ISRAEL INST TECHNOL	ISRAEL	0,43	0,67	0,81	1,05	1,03
UNIV PARIS 06	FRANCE	0,28	0,49	0,15	0,55	0,96
TECH UNIV	RUSSIA	-	0,02	0,06	0,1	0,18
UNIV MARYLAND	USA	0,55	0,56	0,95	1,11	1,56
ACAD SCI CZECH REPUBL	CZECH REPUBLIC	0,16	0,32	0,38	0,29	-
NATL CHIAO TUNG UNIV	TAIWAN	0,53	0,66	0,92	1,3	1,56
PURDUE UNIV	USA	0,41	0,65	0,68	0,9	1,21
..	..	..	..	..	..	..

Table 92: Computer application research centres specific output, evaluation of YIF for 3 years for Cybernetics WOS category.

Description: computer application output for $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/6197 records.

Figure 63: Computer application output, a triennium status graph YIF by the research centre, Cybernetics WOS category.

Description: Computer output for selected WOS category, $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval.

	Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Research centre	Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}
RUSSIAN ACAD SCI	RUSSIA	1	1	2	1	1
NATL UNIV SINGAPORE	SINGAPORE	18	15	23	16	5
POLISH ACAD SCI	POLAND	29	10	6	4	2
MIT	USA	24	33	27	15	3
NANYANG TECHNOL UNIV	SINGAPORE	11	46	24	22	5
NATL ACAD SCI UKRAINE	UKRAINE	0	0	0	1	1
UNIV ILLINOIS	USA	14	21	5	16	2
HONG KONG POLYTECH UNIV	PEOPLES R CHINA	12	17	18	13	3
CHINESE ACAD SCI	PEOPLES R CHINA	3	17	44	15	6
NORWEGIAN UNIV SCI & TECHNOL	NORWAY	5	3	2	2	1
GEORGIA INST TECHNOL	USA	11	39	14	5	5
UCL	UNITED KINGDOM	19	28	16	9	4
CARNEGIE MELLON UNIV	USA	30	21	14	12	2
TECHNION ISRAEL INST TECHNOL	ISRAEL	14	6	8	13	3
UNIV PARIS 06	FRANCE	7	10	2	3	2
TECH UNIV	RUSSIA	1	0	1	1	0
UNIV MARYLAND	USA	15	28	15	9	1
ACAD SCI CZECH REPUBL	CZECH REPUBLIC	1	2	3	1	-
NATL CHIAO TUNG UNIV	TAIWAN	19	29	22	10	4
PURDUE UNIV	USA	31	8	8	8	2
CHINESE UNIV HONG KONG	PEOPLES R CHINA	13	19	19	8	5
PENN STATE UNIV	USA	24	25	16	11	2
..	..	..	..	..	..	..

Table 93: Computer application research centres specific output, evaluation of N_{CI} for 3 years for Cybernetics WOS category.

Description: Computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/6197 records.

Figure 64: Computer application output, a triennium status graph N_{Ci} by research centre, Cybernetics WOS category.

Description: Computer output for selected WOS category, $N_{Ci} = (\sum_{i=1}^N N_{Ci,i})/N$, where N is the total number of research papers of the country published during said period and N_{Ci} , "i" is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval, total 15-year interval are divided in to 3-year interval.

Research institution	Year Country	1997-2011						
		N _P	N _P (%)	Col (%)	YIF	N _{CI}	N _A	N _{RI}
RUSSIAN ACAD SCI	RUSSIA	464	2,80%	6,50%	0,12	1	2,1	1,3
NATL UNIV SINGAPORE	SINGAPORE	87	0,50%	35,00%	1,08	16	3,4	1,8
POLISH ACAD SCI	POLAND	81	0,50%	42,50%	0,55	8	2	2
MIT	USA	80	0,50%	27,80%	1,23	22	3,2	2,1
NANYANG TECHNOL UNIV	SINGAPORE	79	0,50%	53,20%	1,39	17	3,2	2
NATL ACAD SCI UKRAINE	UKRAINE	70	0,40%	7,00%	0,05	0	1,9	1,4
UNIV ILLINOIS	USA	69	0,40%	20,60%	0,9	13	2,9	1,9
HONG KONG POLYTECH UNIV	PEOPLES R CHINA	68	0,40%	20,80%	1,28	12	3,1	2
CHINESE ACAD SCI	PEOPLES R CHINA	67	0,40%	50,00%	1,51	19	3,4	2,6
NORWEGIAN UNIV SCI & TECHNOL	NORWAY	66	0,40%	30,00%	0,45	3	2,5	1,7
GEORGIA INST TECHNOL	USA	64	0,40%	23,90%	1,11	14	3,7	2,3
UCL	UNITED KINGDOM	64	0,40%	33,30%	1,14	14	3,3	2
..	..	..	..	..	..	..	..	..

Table 94: Computer application output, evaluation of N_P , $N_{P\%}$, $Col\%$, YIF , N_{CI} , N_A , N_{RI} for 15 years for Cybernetics WOS category.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i"; $N_P (\%) = \frac{N_P}{N_W}$ is the contribution of each research centre to the world production, where N_W is the total number of published research papers of "Selected WOS category" at global level; $Col (\%)$ percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another research centre and the total documents published; $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published"; $N_{CI} = (\sum_{i=1}^N N_{CI,i}) / N$, where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time; $N_A = (\sum_{i=1}^N N_{A,i}) / N$, where N is the total number of research papers of the research centre published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; $N_{RI} = (\sum_{i=1}^N N_{RI,i}) / N$, where N is the total number of research papers of the research centre published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15 years' time; table showing output from computer application: 13/6197 records.

7.3.5. Evaluation of the diffusion and internationalization of the worldwide research journals

Abbreviated Journal	Mean IF	N° papers	1093	516	440	579	205	138	171	..
			USA	UNITED KINGDOM	RUSSIA	PEOPLES R CHINA	GERMANY	JAPAN	FRANCE	..
HUM-COMPUT INTERACT	3,41	51	45	15	0	0	1	0	1	..
IEEE T SYST MAN CY B	2,5	691	20	8	0	26	1	2	3	..
INT REV NEUROBIOL	2,47	16	9	15	0	0	2	0	6	..
USER MODEL USER-ADAP	1,86	67	25	8	0	0	5	0	2	..
BIOL CYBERN	1,72	339	23	11	1	2	14	6	5	..
IEEE T SYST MAN CY A	1,69	541	35	5	0	13	1	3	2	..
IEEE T SYST MAN CY C	1,67	373	27	8	0	11	2	2	3	..
INT J HUM-COMPUT ST	1,66	319	28	17	0	1	5	1	3	..
IEEE T HAPTICS	1,49	90	33	4	1	1	5	10	4	..
ACM T COMPUT-HUM INT	1,3	95	47	15	0	1	2	3	2	..
INTERACT COMPUT	1,24	225	19	27	0	1	4	1	5	..
MACH VISION APPL	1,14	245	23	6	0	6	3	4	6	..
BEHAV INFORM TECHNOL	0,91	241	21	15	0	6	5	2	2	..
..	..	..	..	..	..	..	..	..	..	..

Table 95: Computer application research centres specific output, percentage of the total number of papers published by a journal due to researchers of a specific country (JI_j (%)), for Cybernetics WOS category.

Description: Computer application output, JI_j (%) = N_{PJ} / N_j shows the influence of each country in the existing journals, JI_j (%) = N_{PJ} / N_j , where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_j is the total number of research papers published by this journal, and JI_j (%) is percentage of the total number of papers published by a journal due to researchers of a specific country (the sum of each row is 100%, representing the total number of papers published by each journal); table showing output from computer application: 13/110 records.

		N° papers	1093	516	440	579	205	138	171	..
Abbreviated Journal	Mean IF		USA	UNITED KINGDOM	RUSSIA	PEOPLES R CHINA	GERMANY	JAPAN	FRANCE	..
HUM-COMPUT INTERACT	3,41	51	2,1	1,5	0	0	0,2	0	0,3	..
IEEE T SYST MAN CY B	2,5	691	12,6	10,8	0		4	11,8	10,3	..
INT REV NEUROBIOL	2,47	16	0,1	0,5	0	0	0,1	0	0,6	..
USER MODEL USER-ADAP	1,86	67	1,5	1,1	0	0	1,5	0	0,7	..
BIOL CYBERN	1,72	339	7,1	7,2	0,6	1,3	22,5	13,9	10,1	..
IEEE T SYST MAN CY A	1,69	541	17,5	5,2	0,2	12,6	3,8	12	5,6	..
IEEE T SYST MAN CY C	1,67	373	9,3	5,9	0	7,2	2,8	4,5	5,8	..
INT J HUM-COMPUT ST	1,66	319	8,1	10,2	0	0,7	8	2,2	6,5	..
IEEE T HAPTICS	1,49	90	2,7	0,8	0,1	0,2	2,3	6,7	1,9	..
ACM T COMPUT-HUM INT	1,3	95	4,1	2,8	0	0,1	1	1,8	1,2	..
INTERACT COMPUT	1,24	225	3,8	11,8	0	0,5	4,4	1,5	6,2	..
MACH VISION APPL	1,14	245	5,2	2,9	0	2,5	3,3	7,1	9,3	..
BEHAV INFORM TECHNOL	0,91	241	4,6	6,9	0	2,5	6,2	3,5	2,2	..
PRESENCE-TELEOP VIRT	0,9	185	4,8	2	0	0,4	10,1	6,1	7,6	..
CYBERNET SYST	0,75	194	0,9	1	0,5	1,8	4,8	3,9	1,2	..
INT J HUM-COMPUT INT	0,58	194	6,3	3,7	0	1,8	2	10,5	3	..
MODEL IDENT CONTROL	0,49	60	0	0	0	0	0	0	0,3	..
..	..	..	..	..	..	..	..	..	..	..

Table 96: Computer application research centres specific output, percentage of the total number of weighted papers of one country published in a specific journal ($Jl_c(\%)$) for Cybernetics WOS category.

Description: Computer application output, $Jl_c(\%) = N_{PJ} / N_P$ shows the dissemination of the papers of each country in the different journals of the field, where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_P is the total number of weighted research papers published by the country (in every journal). ($Jl_c(\%)$) is percentage of the total number of weighted papers of one country published in a specific journal (the sum of each column is 100%, representing the total number of papers published by each country); table showing output from computer application: 19/110 records.

7.4. ANNEX 4. OUTPUTS OF HARDWARE ARCHITECTURE ANALYSIS

7.4.1. Keywords Analysis

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Compound Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k
DESIGN	2652	60	63	69	88	85	130	161	149	176	190	235	240	307	345	354
SYSTEMS	2092	80	95	81	79	79	94	123	155	162	164	173	179	187	208	233
NETWORKS	1907	68	90	76	98	85	124	105	132	151	131	155	127	171	184	210
ALGORITHMS	1873	66	65	65	82	89	105	111	122	113	144	164	131	210	215	191
PERFORMANCE	1859	59	51	78	64	70	84	78	114	87	130	188	179	203	239	235
ALGORITHM	1704	63	67	82	75	84	78	86	124	130	146	129	151	132	177	180
OPTIMIZATION	1236	42	49	65	62	71	72	55	73	80	105	104	84	101	126	147
MODEL	954	30	38	41	41	50	37	61	65	65	85	68	84	78	96	115
CIRCUITS	876	37	40	47	57	45	55	57	50	59	70	51	63	79	76	90
SYSTEM	816	32	34	36	40	40	47	56	59	59	65	65	49	62	72	100
SIMULATION	748	33	43	31	56	49	32	47	43	64	74	62	57	55	45	57
NEURAL NETWORKS	705	54	57	58	57	47	43	58	41	41	61	24	43	32	39	50
ARCHITECTURE	674	20	28	21	31	25	35	39	46	48	45	55	49	69	74	89
RELIABILITY	627	28	19	13	26	16	23	22	35	39	40	66	51	79	80	90
CMOS	610	15	13	28	29	35	34	36	35	50	52	35	40	57	66	85
LOW POWER	588	13	21	23	20	34	36	38	35	51	40	44	44	52	68	69
SECURITY	575	7	9	8	8	16	17	19	39	34	49	70	64	69	70	96
NETWORK	571	23	21	29	34	27	28	43	27	23	43	44	44	68	62	55
SCHEDULING	565	21	17	27	32	25	33	34	37	43	50	43	49	47	57	50
ROUTING	564	27	27	19	39	27	29	33	31	37	52	43	51	45	53	51
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 97: Computer application output, evaluation of Compound Keywords for 1-year interval for Hardware Architecture WOS category.

Description: Computer application output for compound keywords, evolution of the most frequently used keywords (counts keywords as they have been defined by the authors, whether keywords are single words or compound words) published in "Hardware Architecture" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 20/81952 records.

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Individual Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k
NETWORKS	8061	314	328	338	347	371	447	408	482	531	606	617	650	682	854	1086
SYSTEMS	5729	260	274	250	262	259	249	328	391	382	440	470	487	526	527	624
DESIGN	5463	156	173	209	229	250	326	348	346	384	416	479	481	534	562	570
NETWORK	4582	185	155	185	200	192	226	246	274	263	358	385	396	483	474	560
PERFORMANCE	3704	121	149	181	171	168	202	188	263	220	263	333	304	354	391	396
ALGORITHM	3676	135	169	172	186	181	186	198	261	302	321	268	320	283	334	360
SYSTEM	3611	141	170	173	190	229	191	260	256	268	273	276	277	287	293	327
POWER	3280	75	91	95	98	163	231	191	243	272	232	260	279	302	348	400
TIME	3278	158	154	166	168	167	213	208	205	233	220	249	247	274	301	315
ANALYSIS	3201	126	124	127	157	167	196	224	227	212	285	222	258	269	292	315
ALGORITHMS	3199	133	124	140	157	152	190	200	203	202	257	266	247	312	312	304
MODEL	3097	96	115	125	159	162	151	196	203	263	262	237	259	293	287	289
CONTROL	3017	111	121	134	136	178	184	161	219	244	240	255	220	286	210	318
OPTIMIZATION	2586	86	108	123	121	160	139	143	161	152	204	203	211	225	247	303
CIRCUITS	2456	115	121	145	179	114	171	195	166	163	202	130	196	186	176	197
NEURAL	2431	153	193	173	158	144	168	168	145	145	170	155	165	156	152	186
DATA	2299	68	102	87	131	97	136	142	130	173	165	191	160	235	252	230
AND	2102	74	92	84	106	119	112	113	176	143	164	162	151	215	172	219
OF	1997	87	86	97	112	116	133	124	143	153	142	187	171	145	139	162
ROUTING	1929	79	90	90	104	95	88	114	124	116	164	150	147	182	197	189
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 98: Computer application output, evaluation of Individual Keywords for 1-year interval for Hardware Architecture WOS category.

Description: Computer application output for individual keywords, evolution of the most frequently used words which are constituents of the keywords (either on their own or as part of keywords) published in "Hardware Architecture" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 20/21725 records.

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Individual Plural Keywords	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k	N_k
NETWORK/NETWORKS	12643	499	483	523	547	563	673	654	756	794	964	1002	1046	1165	1328	1646
SYSTEM/SYSTEMS	9340	401	444	423	452	488	440	588	647	650	713	746	764	813	820	951
ALGORITHM/ALGORITHMS	6875	268	293	312	343	333	376	398	464	504	578	534	567	595	646	664
DESIGN/DESIGNS	5575	157	183	216	238	256	329	353	351	398	421	490	493	538	566	586
MODEL/MODELS	4171	140	162	159	216	225	207	258	286	337	347	330	339	392	385	388
CIRCUIT/CIRCUITS	3935	187	205	227	270	190	262	312	271	262	319	223	293	295	303	316
PERFORMANCE/PERFORMANCES	3711	121	149	181	171	169	202	188	263	220	263	334	305	356	392	397
TIME/TIMES	3365	161	159	172	172	172	219	210	205	242	227	257	255	280	312	322
POWER/POWERS	3288	75	92	95	99	165	233	191	243	272	232	260	280	303	348	400
ANALYSIS	3201	126	124	127	157	167	196	224	227	212	285	222	258	269	292	315
CONTROL/CONTROLS	3032	113	122	134	136	178	185	161	220	244	243	257	222	287	210	320
OPTIMIZATION/OPTIMIZATIONS	2628	86	108	127	121	163	139	147	169	156	207	205	215	228	249	308
NEURAL	2431	153	193	173	158	144	168	168	145	145	170	155	165	156	152	186
DATA	2299	68	102	87	131	97	136	142	130	173	165	191	160	235	252	230
ARCHITECTURE/ARCHITECTURES	2170	66	83	104	100	98	104	126	144	165	146	161	176	231	218	248
AND	2102	74	92	84	106	119	112	113	176	143	164	162	151	215	172	219
FAULT/FAULTS	2077	141	140	117	145	79	127	165	140	121	166	117	128	156	160	175
OF	1997	87	86	97	112	116	133	124	143	153	142	187	171	145	139	162
ROUTING/ROUTINGS	1933	79	90	90	104	96	89	115	124	116	164	150	148	182	197	189
COMMUNICATION/COMMUNICATIONS	1897	93	104	88	103	106	87	116	134	123	134	132	111	187	169	210
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 99: Computer application output, evaluation of Individual Plural Keywords for 1-year interval for Hardware Architecture WOS category.

Description: Computer application output for individual plural keywords, evolution of the most frequently used words which are constituents of the keywords (unifying terms in singular and plural forms) published in "Hardware Architecture" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 20/19315 records.

Year	1997-2011	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Compound Plural Keywords	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k	N _k
ALGORITHM/ALGORITHMS	3577	129	132	147	157	173	183	197	246	243	290	293	282	342	392	371
SYSTEM/SYSTEMS	2908	112	129	117	119	119	141	179	214	221	229	238	228	249	280	333
DESIGN/DESIGNS	2702	60	68	74	92	87	131	165	150	180	192	240	245	308	348	362
NETWORK/NETWORKS	2478	91	111	105	132	112	152	148	159	174	174	199	171	239	246	265
PERFORMANCE/PERFORMANCES	1865	59	51	78	64	70	84	78	114	87	130	189	180	205	240	236
MODEL/MODELS	1403	48	64	53	65	73	62	85	97	98	120	101	116	120	139	162
OPTIMIZATION/OPTIMIZATIONS	1252	42	49	66	62	72	72	57	76	81	106	105	86	101	127	150
CIRCUIT/CIRCUITS	1066	42	48	55	72	54	67	78	61	70	84	61	77	92	94	111
NEURAL NETWORK/NEURAL NETWORKS	1001	79	83	74	79	64	57	73	65	54	83	41	63	55	61	70
ARCHITECTURE/ARCHITECTURES	958	27	34	38	42	36	47	57	61	74	61	73	71	106	107	124
SIMULATION/SIMULATIONS	795	34	44	31	57	51	34	48	48	69	80	69	63	58	49	60
RELIABILITY	627	28	19	13	26	16	23	22	35	39	40	66	51	79	80	90
CMOS	610	15	13	28	29	35	34	36	35	50	52	35	40	57	66	85
LOW POWER	588	13	21	23	20	34	36	38	35	51	40	44	44	52	68	69
SECURITY/SECURITIES	576	7	9	8	8	17	17	19	39	34	49	70	64	69	70	96
SCHEDULING	565	21	17	27	32	25	33	34	37	43	50	43	49	47	57	50
ROUTING/ROUTINGS	565	27	27	19	39	27	29	34	31	37	52	43	51	45	53	51
FAULT TOLERANCE/FAULT TOLERANCES	511	45	36	25	32	17	32	34	41	26	44	36	29	42	30	42
VLSI/VLSIS	501	29	34	41	45	34	44	31	30	34	36	35	26	33	23	26
FPGA/FPGAS	498	14	16	13	18	14	18	31	33	30	42	54	32	54	66	63
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 100: Computer application output, evaluation of Compound Plural Keywords for 1-year interval for Hardware Architecture WOS category.

Description: Computer application output for compound plural keywords, evolution of the most frequently used keywords (unifying terms in singular and plural forms) published in "Hardware Architecture" category research papers during the period 1997–2011, where N_k = number of times each word appears; (1-year Interval of total 15 years) table showing output from computer application: 20/77070 records.

Year	1997-2011		1997-1999		2000-2002		2003-2005		2006-2008		2009-2011	
Compound Plural Keywords	N _k		N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank
ALGORITHM/ALGORITHMS	3577		408	1	513	1	686	1	865	1	1105	1
SYSTEM/SYSTEMS	2908		358	2	379	3	614	2	695	2	862	3
DESIGN/DESIGNS	2702		202	5	310	4	495	3	677	3	1018	2
NETWORK/NETWORKS	2478		307	3	396	2	481	4	544	4	750	4
PERFORMANCE/PERFORMANCES	1865		188	6	218	5	279	6	499	5	681	5
MODEL/MODELS	1403		165	7	200	8	280	5	337	6	421	6
OPTIMIZATION/OPTIMIZATIONS	1252		157	8	206	6	214	7	297	7	378	7
CIRCUIT/CIRCUITS	1066		145	9	193	9	209	8	222	8	297	9
NEURAL NETWORK/NEURAL NETWORKS	1001		236	4	200	7	192	9	187	11	186	15
ARCHITECTURE/ARCHITECTURES	958		99	13	125	11	192	10	205	10	337	8
SIMULATION/SIMULATIONS	795		109	10	142	10	165	11	212	9	167	17
RELIABILITY	627		60	22	65	29	96	23	157	13	249	10
CMOS	610		56	25	98	13	121	13	127	18	208	12
LOW POWER	588		57	24	90	16	124	12	128	16	189	13
SECURITY/SECURITIES	576		24	109	42	67	92	27	183	12	235	11
SCHEDULING	565		65	21	90	15	114	14	142	15	154	24
ROUTING/ROUTINGS	565		73	15	95	14	102	17	146	14	149	26
FAULT TOLERANCE/FAULT TOLERANCES	511		106	11	81	19	101	18	109	27	114	35
VLSI/VLSIS	501		104	12	123	12	95	24	97	34	82	61
FPGA/FPGAS	498		43	41	50	47	94	26	128	17	183	16
COMMUNICATION/COMMUNICATIONS	492		67	19	72	22	98	21	100	31	155	23
..	..		..	..	..	..	..	..	..	..	..	..

Table 101: Computer application output, evaluation of Compound Plural Keywords for 3 year's interval along with Rank Info for Hardware Architecture WOS category.
Description: Computer application output for compound plural keywords, evolution of the most frequently used keywords (unifying terms in singular and plural forms) published in "Hardware Architecture" category research papers during the period 1997–2011, where N_k = number of times each word appears; (Rank)Rk: position in the ranking drawn from the number of words used during said period (i.e. 3-year Interval of total 15 years); table showing output from computer application: 21/77070 records.

Year	1997-2011		1997-1999		2000-2002		2003-2005		2006-2008		2009-2011	
Individual Plural Keywords	N _k		N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank	N _k	Rank
NETWORK/NETWORKS	12643		1505	1	1783	1	2204	1	3012	1	4139	1
SYSTEM/SYSTEMS	9340		1268	2	1380	2	1885	2	2223	2	2584	2
ALGORITHM/ALGORITHMS	6875		873	3	1052	3	1366	3	1679	3	1905	3
DESIGN/DESIGNS	5575		556	5	823	4	1102	4	1404	4	1690	4
MODEL/MODELS	4171		461	8	648	6	881	5	1016	5	1165	5
CIRCUIT/CIRCUITS	3935		619	4	722	5	845	6	835	7	914	8
PERFORMANCE/PERFORMANCES	3711		451	9	542	8	671	8	902	6	1145	6
TIME/TIMES	3365		492	7	563	7	657	10	739	10	914	9
POWER/POWERS	3288		262	20	497	11	706	7	772	8	1051	7
ANALYSIS	3201		377	11	520	9	663	9	765	9	876	10
CONTROL/CONTROLS	3032		369	12	499	10	625	11	722	11	817	12
OPTIMIZATION/OPTIMIZATIONS	2628		321	14	423	13	472	12	627	12	785	13
NEURAL	2431		519	6	470	12	458	13	490	16	494	24
DATA	2299		257	24	364	14	445	14	516	14	717	14
ARCHITECTURE/ARCHITECTURES	2170		253	25	302	22	435	15	483	17	697	15
AND	2102		250	26	337	18	432	16	477	18	606	16
FAULT/FAULTS	2077		398	10	351	16	426	18	411	25	491	26
OF	1997		270	18	361	15	420	19	500	15	446	33
ROUTING/ROUTINGS	1933		259	21	289	24	355	24	462	20	568	17
COMMUNICATION/COMMUNICATIONS	1897		285	16	296	23	373	22	377	30	566	18
..	..		..	..	..	..	..	..	..	..	..	..

Table 102: Computer application output, evaluation of Individual Plural Keywords for 3 year's interval along with Rank Info for Hardware Architecture WOS category.

Description: Computer application output for individual plural keywords, evolution of the most frequently used words which are constituents of the keywords (unifying terms in singular and plural forms) published in "Hardware Architecture" category research papers during the period 1997–2011, where N_k = number of times each word appears; (Rank) R_k : position in the ranking drawn from the number of words used during said period (i.e. 3-year Interval of total 15 years); table showing output from computer application: 20/19315 records.

Total keywords	77069
N° Times Appeared	264657
%100 keywords	18%
%1000 keywords	41%
%5000 keywords	61%
%keywords >1 papers	28%
% keywords >10 paper	4%
% keywords >100 paper	0%
% keywords >1000 paper	0%

Table 103: Computer application output, evaluation of Keywords concentration in Hardware Architecture WOS category for 15-year interval.

Description: Computer application output for keywords concentration, where N° = number of times each keyword appears to reveal the heterogeneity of research topics under study during the period 1997–2011.

Figure 65: Computer application output, change in use of most frequently employed compound plural keywords for Hardware Architecture WOS category.

Description: Sample of computer application output change in the use of the most frequently employed compound plural keywords (unifying terms in singular and plural forms) as they appeared in the selected papers between 1997–2011.

7.4.2. Evaluation of geographical distribution of publications

Total		3159	2983	2719	2826	2770	2817	3703	3900	3903	4005	3497	3599	3771	3742	4075
	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Country	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P
16742,68	USA	1158,57	1099,95	1090,22	1026,93	1012,54	1021,98	1202,73	1260,2	1316,88	1238,18	1150,07	1086,42	1097,62	997,85	982,56
5169,38	JAPAN	312,99	327,53	353,32	357,17	336,48	319,76	377,7	356,48	374,99	396,68	327,82	379,76	361,59	295,7	291,41
3474,48	PEOPLES R CHINA	54,73	42,5	52,03	129,98	121,63	149,18	240,37	207,53	343,87	339,37	267,32	304,15	324,78	404,56	492,47
2527,4	TAIWAN	89,17	99,25	101,33	127,33	113,67	135,53	134,38	195,48	168,55	194,32	227,88	215,18	248,17	230,57	246,59
2179,19	SOUTH KOREA	64,67	55,5	61,92	81,67	81,3	85,95	185,83	162,62	212,33	283,52	137,38	177,1	185,67	210,84	192,9
2073,27	UNITED KINGDOM	119,66	142,56	114,28	149,97	138,39	127,18	141,23	156,56	137,89	130,12	143,24	122,33	123,76	153,66	172,46
2035,01	CANADA	94,39	108,82	108,92	101,05	88,13	115,49	115,9	137,6	150,56	169,23	186,2	161,13	168,2	169,4	160
1782,51	ITALY	68,49	101,23	97,22	104,72	147,22	110,25	131,9	139	130,89	133,38	98,03	110,37	142,43	116,87	150,51
1637,02	GERMANY	88,97	126,48	109,14	109,25	98,1	82,18	130,42	172,74	122,34	125,75	82,06	88,95	93,61	94,29	112,74
1270,37	SPAIN	29,15	39,35	42,28	37,8	54,89	54,78	105,37	109,62	86,4	77,65	89,19	104,09	128,32	118,84	192,64
1239,46	FRANCE	47,38	73,43	63,12	72,22	60,8	71,18	96,02	99,13	94,12	104,79	68,05	88,9	91,66	93,85	114,81
798,2	INDIA	38,17	38,78	33,87	41,92	33,23	31,32	68,27	76,17	53,48	50,78	69,7	49,1	68,56	66,62	78,23
779,05	AUSTRALIA	65,57	48,2	61,52	30,2	37,25	32,42	50,53	44,82	43,42	55,27	50,55	52,28	70,68	65,25	71,1
748,65	GREECE	14,29	26,42	17,98	40,23	38,39	44,22	49,11	70,9	70,75	54,15	64,87	71,08	66,67	59,65	59,93
681,56	SINGAPORE	30	24,87	31,53	33,57	36,5	51,17	37	44,83	70,83	69,2	40,45	55,06	54,27	52,29	49,98
602,02	NETHERLANDS	26,12	32,45	28,75	46,92	33,17	31,05	53,33	65,95	45,72	42,08	38,02	41,25	41,55	35,09	40,58
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 104: Computer application output, evaluation of N_P for 1 year for Hardware Architecture WOS category.

Description: for $N_P = \sum_{i=1}^N \frac{1}{N_{ci}}$, where N_P is the total number of weighted research papers published in the country during said period and N_{ci} the number of participating countries for each research paper "i", total 15-year interval are divided in to 1 year interval table showing output from computer application: 16/117 records.

Mean		14	13	19	17	16	18	12	11	10	9	8	6	4	3	1
	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}
16	USA	24	21	28	26	25	26	19	18	15	13	9	8	4	3	2
4	JAPAN	5	6	6	6	8	6	6	4	4	3	3	3	2	1	1
7	PEOPLES R CHINA	15	31	11	9	11	11	8	9	7	7	8	7	5	4	2
7	TAIWAN	11	10	10	12	9	24	10	7	9	8	7	5	4	2	1
4	SOUTH KOREA	5	7	4	5	8	9	6	6	6	3	7	3	3	2	1
10	UNITED KINGDOM	14	11	17	12	14	16	12	14	12	12	8	8	5	3	2
9	CANADA	14	12	16	14	15	17	14	11	13	8	8	6	4	3	1
10	ITALY	17	10	16	20	10	18	12	8	11	9	9	5	5	3	2
11	GERMANY	15	13	15	15	39	11	10	8	9	8	9	8	4	4	2
6	SPAIN	11	10	10	5	10	15	7	5	6	8	7	6	4	3	1
10	FRANCE	29	14	17	13	14	17	10	13	11	9	8	7	5	2	1
7	INDIA	13	7	16	20	12	14	6	8	5	5	7	5	3	1	1
10	AUSTRALIA	16	11	22	14	16	12	12	9	12	8	14	6	6	4	3
6	GREECE	10	8	10	7	8	9	8	6	8	8	6	6	4	2	1
11	SINGAPORE	12	10	15	24	7	20	18	16	19	11	6	7	6	5	2
12	NETHERLANDS	11	24	10	20	23	11	16	9	14	9	15	9	5	3	1
15	ISRAEL	22	58	21	19	19	21	15	18	16	6	9	6	7	2	1
9	BELGIUM	14	18	16	16	19	10	13	9	9	10	7	6	4	2	2
14	SWITZERLAND	20	10	22	26	25	10	13	19	20	19	10	13	5	2	1
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 105: Computer application output, evaluation of N_{CI} for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$ where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/117 records.

Mean		0,51	0,53	0,7	0,68	0,88	0,83	1,06	0,91	0,92	0,9	1,03	1,54	1,32	1,22	1,1
	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Country	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF
1,22	USA	0,69	0,75	0,89	0,88	1,12	1,1	1,42	1,25	1,21	1,1	1,25	1,99	1,66	1,57	1,3
0,48	JAPAN	0,3	0,34	0,39	0,37	0,42	0,45	0,55	0,5	0,45	0,45	0,5	0,69	0,61	0,61	0,54
1,03	PEOPLES R CHINA	0,69	0,68	0,71	0,64	1	0,5	0,71	0,79	0,71	0,82	0,98	1,55	1,28	1,2	1,24
0,84	TAIWAN	0,52	0,42	0,49	0,57	0,59	0,7	0,82	0,71	0,74	0,75	0,8	1,39	1,11	0,98	0,99
0,72	SOUTH KOREA	0,41	0,37	0,42	0,44	0,65	0,55	0,7	0,56	0,56	0,59	0,8	1,09	0,97	0,87	0,81
1,06	UNITED KINGDOM	0,53	0,47	0,65	0,59	0,76	0,78	1,08	0,88	1,02	1,13	1,26	1,83	1,48	1,47	1,29
1,04	CANADA	0,63	0,52	0,72	0,63	0,84	0,9	1	0,91	1,06	0,97	1	1,58	1,37	1,3	1,27
1,04	ITALY	0,71	0,59	0,78	0,68	0,73	0,88	1,06	0,9	1,09	0,94	1,09	1,75	1,4	1,29	1,24
1,08	GERMANY	0,58	0,64	0,68	0,66	0,83	1,18	1,13	0,93	0,91	1,21	1,5	1,84	1,58	1,31	1,21
1,01	SPAIN	0,69	0,55	0,51	0,51	0,73	0,65	0,89	0,75	0,86	1	1,04	1,58	1,28	1,21	1,11
1,05	FRANCE	0,7	0,68	0,66	0,69	0,67	0,94	1,09	0,8	1,01	1,02	1,02	1,55	1,48	1,36	1,19
0,9	INDIA	0,4	0,44	0,56	0,64	0,9	0,69	1,03	0,88	0,72	0,71	0,9	1,45	1,24	1,27	0,95
1,07	AUSTRALIA	0,49	0,61	0,49	0,8	0,88	1,01	1,07	0,93	1,04	0,96	1,38	1,54	1,56	1,4	1,25
1,09	GREECE	0,7	0,65	0,69	0,57	0,7	0,94	1,31	0,82	1,08	0,95	0,98	1,62	1,72	1,06	1,25
1,19	SINGAPORE	0,36	0,52	0,53	0,58	0,68	0,7	0,97	1,14	1,08	1,13	1,18	2,19	1,89	1,46	1,46
0,99	NETHERLANDS	0,47	0,48	0,68	0,71	1,08	0,76	1,02	0,7	0,82	1,1	1,27	1,75	1,43	1,36	1,01
1,33	ISRAEL	0,67	0,95	1,01	0,92	1,21	1,06	1,25	1,21	1,28	1,44	1,56	1,84	1,8	1,94	1,32
0,95	BELGIUM	0,67	0,6	0,61	0,58	0,74	0,75	1,03	0,65	0,73	0,9	1,01	1,54	1,15	1,39	1,17
1,35	SWITZERLAND	0,76	0,69	0,85	0,76	1,26	1,27	1,59	0,91	0,93	1,51	1,44	2,35	1,92	1,86	1,27
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 106: Computer application output, evaluation of YIF for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the country published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/117 records.

Total	N°Col		314	380	406	442	427	473	613	607	658	702	683	731	776	864	1052
		Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		Country	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col
19252	5001	USA	207	227	260	282	281	292	333	337	385	393	377	360	390	402	475
5586	790	JAPAN	27	52	43	54	39	53	46	41	52	59	51	70	74	69	60
4283	1549	PEOPLES R CHINA	28	28	33	46	43	54	77	88	105	127	110	148	162	216	284
2731	398	TAIWAN	21	17	15	19	20	21	31	25	26	23	23	32	28	42	55
2510	643	SOUTH KOREA	15	13	17	22	17	25	43	28	72	57	57	60	60	74	83
2723	1142	UNITED KINGDOM	29	43	34	52	51	66	76	67	90	90	91	111	96	119	127
2727	1246	CANADA	48	59	56	55	55	74	68	85	71	98	105	95	113	135	129
2216	796	ITALY	27	46	45	42	45	44	54	43	54	53	62	64	63	59	95
2177	948	GERMANY	38	55	57	50	45	61	71	67	70	67	67	53	71	86	90
1578	559	SPAIN	9	13	13	14	15	15	43	40	45	43	41	50	62	57	99
1707	863	FRANCE	23	45	32	48	34	38	60	49	64	57	56	76	79	83	119
992	343	INDIA	10	10	14	17	21	17	28	31	26	33	34	27	20	21	34
1053	495	AUSTRALIA	24	21	35	15	25	22	25	32	31	29	30	42	51	53	60
922	316	GREECE	7	7	11	11	12	22	35	33	20	16	20	24	39	20	39
887	371	SINGAPORE	10	8	12	16	14	12	16	23	30	29	27	39	38	51	46
826	405	NETHERLANDS	18	17	19	25	23	24	28	30	26	30	30	33	24	37	41
742	370	ISRAEL	28	21	24	19	20	24	28	23	24	34	25	22	34	22	22
644	298	BELGIUM	10	8	21	8	17	16	20	28	21	28	24	22	23	15	37
626	363	SWITZERLAND	9	13	9	16	18	15	27	29	25	31	25	36	30	41	39
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 107: Computer application output, evaluation of N°Col for 1 year for Hardware Architecture WOS category.

Description: Computer application output for N°Col Number collaborations, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/117 records.

Total	%Col		10%	13%	15%	16%	15%	17%	17%	16%	17%	18%	20%	20%	21%	23%	26%
		Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		Country	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col
19252	26%	USA	16%	19%	21%	24%	24%	25%	24%	24%	25%	27%	28%	28%	30%	33%	39%
5586	14%	JAPAN	8%	15%	11%	14%	11%	15%	11%	11%	13%	14%	14%	17%	18%	21%	19%
4283	36%	PEOPLES R CHINA	40%	48%	48%	30%	30%	30%	27%	35%	26%	31%	34%	39%	40%	42%	44%
2731	15%	TAIWAN	21%	16%	14%	14%	16%	14%	21%	12%	14%	11%	10%	14%	11%	17%	20%
2510	26%	SOUTH KOREA	21%	21%	24%	24%	19%	26%	21%	16%	29%	18%	34%	29%	28%	30%	35%
2723	42%	UNITED KINGDOM	21%	26%	25%	29%	31%	40%	41%	34%	48%	50%	46%	59%	53%	54%	51%
2727	46%	CANADA	40%	42%	41%	42%	46%	47%	44%	46%	37%	44%	43%	45%	49%	55%	55%
2216	36%	ITALY	32%	37%	37%	33%	26%	33%	34%	27%	34%	33%	47%	44%	36%	40%	47%
2177	44%	GERMANY	35%	35%	40%	36%	37%	53%	42%	32%	43%	41%	55%	44%	53%	61%	54%
1578	35%	SPAIN	26%	28%	26%	31%	24%	23%	33%	31%	40%	43%	37%	38%	38%	38%	40%
1707	51%	FRANCE	38%	47%	40%	49%	43%	42%	46%	39%	51%	43%	56%	58%	59%	59%	66%
992	35%	INDIA	23%	23%	33%	33%	47%	43%	34%	33%	38%	47%	38%	42%	25%	27%	35%
1053	47%	AUSTRALIA	30%	35%	43%	38%	50%	50%	39%	52%	51%	41%	45%	55%	52%	56%	57%
922	34%	GREECE	37%	23%	46%	24%	27%	40%	51%	38%	24%	25%	26%	29%	44%	28%	48%
887	42%	SINGAPORE	29%	27%	31%	38%	32%	21%	36%	40%	34%	34%	50%	51%	49%	62%	61%
826	49%	NETHERLANDS	49%	40%	49%	41%	49%	55%	41%	37%	43%	52%	56%	56%	44%	66%	64%
742	50%	ISRAEL	56%	55%	49%	56%	54%	53%	51%	37%	55%	47%	50%	41%	55%	47%	52%
644	46%	BELGIUM	43%	44%	62%	36%	46%	36%	31%	57%	45%	50%	43%	50%	45%	38%	64%
626	58%	SWITZERLAND	28%	41%	33%	48%	46%	63%	47%	49%	57%	66%	74%	67%	79%	82%	71%
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 108: Computer application output, evaluation of Col (%) for 1 year for Hardware Architecture WOS category.

Description: Computer application output Col (%) percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another country and the total documents published, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/117 records.

Mean	Number	2,3	2,5	2,7	2,8	2,7	2,8	2,9	3	3	3	3,1	3,3	3,3	3,2	3,3
	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Number	Country	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A
3,1	USA	2,4	2,6	2,8	2,8	2,9	3	2,9	3,1	3,3	3,1	3,3	3,5	3,4	3,4	3,7
3,2	JAPAN	2,9	3	3	3,1	2,8	3	3,1	3,1	3,1	3,2	3,2	3,6	3,4	3,5	3,4
3,4	PEOPLES R CHINA	2,7	2,5	2,9	3	2,9	3	3,2	3,3	3,2	3,3	3,3	3,5	3,7	3,7	3,8
2,8	TAIWAN	2,3	2,3	2,4	2,6	2,6	2,6	2,8	2,7	2,8	2,8	2,8	2,9	3	3	3,2
3,2	SOUTH KOREA	2,7	2,9	3	2,7	3	3	3,2	3,2	3,1	3,2	3,3	3,4	3,2	3,4	3,2
3,1	UNITED KINGDOM	2,7	2,7	2,8	2,6	2,8	2,8	3,2	3	3,4	3	3,5	3,7	3,7	3,3	3,4
3	CANADA	2,5	2,7	2,6	2,7	2,7	2,8	2,7	3	3,1	2,8	2,9	3,6	3,1	3,3	3,4
3,5	GERMANY	2,9	2,7	3,1	2,8	2,8	3,5	3,3	3,6	3,6	3,1	4,2	4,4	4,5	3,9	4,3
4	SPAIN	3,3	3,6	3,5	3,4	3,5	3,9	3,8	3,8	3,7	3,8	3,7	4,4	4,5	4,3	4
3,4	FRANCE	2,6	2,6	2,7	3	3,4	3	3,4	3,2	3,4	3,5	3,4	4,1	4	3,8	3,8
3,1	INDIA	2,3	2,5	2,6	2,6	2,8	2,6	2,6	3,1	3,2	2,9	3,1	5,2	3,7	3,4	3,2
2,9	AUSTRALIA	2,5	2,3	2,5	2,5	2,6	2,4	2,6	2,7	2,9	2,7	3	3,5	3,2	3,1	3,6
3,5	GREECE	3,5	3,2	4,1	3,2	3,1	2,9	4,1	3,5	3,4	3,6	3,2	3,8	3,7	3,1	3,6
3	SINGAPORE	2,3	2,6	2,8	2,8	2,8	2,5	2,9	3,2	2,9	3	3,1	3,2	3,2	3,6	3,3
3,3	NETHERLANDS	2,6	2,8	3,1	3	2,9	3	3,2	3,4	3,3	3,3	3,5	3,5	3,5	4,3	3,7
3,1	ISRAEL	2,9	2,4	2,9	2,9	2,9	2,6	3,1	2,6	3,3	2,8	3,2	2,9	4	3,4	4,3
3,8	BELGIUM	3,2	3,1	3,9	3,7	3,8	3,2	3,6	4,1	3,7	4	3,9	4,2	4,6	3,8	3,9
3,8	SWITZERLAND	2,8	3	3,3	3,3	3,3	3,4	3,8	3,3	3,4	3,1	3,9	6,6	4,8	4	3,9
3,3	AUSTRIA	2,4	2,3	2,4	3,3	2,6	3,2	3	2,9	3,3	3,1	3,5	5,9	3,8	2,9	4,2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 109: Computer application output, evaluation of N_A for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 19/117 records.

Mean	Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Country	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}
1,9	USA	1,6	1,7	1,8	1,8	1,9	1,9	1,8	1,8	1,8	1,9	1,9	2	2	2,1	2,1
1,6	JAPAN	1,3	1,6	1,6	1,6	1,5	1,7	1,6	1,6	1,7	1,7	1,7	1,7	1,8	1,8	1,8
1,9	PEOPLES R CHINA	1,7	1,8	1,9	1,7	1,7	1,7	1,7	1,8	1,6	1,8	1,8	2	2	2	2,1
1,7	TAIWAN	1,5	1,5	1,5	1,6	1,7	1,6	1,8	1,7	1,8	1,7	1,7	1,7	1,7	1,8	1,8
1,8	SOUTH KOREA	1,5	1,8	1,8	1,6	1,7	1,7	1,7	1,7	1,7	1,6	2	1,9	1,8	2	1,9
1,9	UNITED KINGDOM	1,5	1,6	1,6	1,6	1,6	1,8	1,8	1,7	1,9	2	2	2,3	2,2	2,1	2,1
1,9	CANADA	1,9	1,9	1,9	1,9	1,9	2	1,8	1,9	1,8	1,9	1,9	1,9	2,1	2,1	2,1
1,9	ITALY	1,9	2	1,9	2	1,8	2	1,9	1,8	1,9	1,8	2	2	2	1,8	2,1
2	GERMANY	1,8	1,8	2	1,8	1,8	2	1,9	1,7	1,9	1,9	2	2,4	2,3	2,3	2,5
1,9	SPAIN	1,6	1,8	1,8	1,7	1,6	1,8	1,7	1,8	1,9	2	1,8	2,2	2,1	2	2
2,2	FRANCE	1,7	1,8	1,9	2,1	2	1,9	1,9	1,8	2	2,1	2,3	2,4	2,6	2,5	2,6
1,9	INDIA	1,6	1,8	1,8	1,8	2	2	1,7	1,8	1,8	1,9	1,9	1,9	2	2,1	2
1,9	AUSTRALIA	1,7	1,7	1,8	1,7	1,8	1,8	1,7	1,9	2	1,8	1,9	2,2	2	2,1	2,1
1,9	GREECE	2,1	1,7	2,2	1,7	1,7	1,9	2,2	1,9	1,8	1,7	1,8	2,1	2,2	1,9	2,1
1,8	SINGAPORE	1,3	1,6	1,7	1,6	1,6	1,4	1,7	1,7	1,6	1,7	1,9	1,9	2,2	2,3	2,1
2,1	NETHERLANDS	2	1,8	1,9	1,8	2,2	2	2,1	1,7	2	2	2,2	2,1	2,3	2,6	2,6
2,1	ISRAEL	2	2,2	2,2	2,2	2,2	2,1	2,2	1,8	2,1	2	2,1	1,9	2,4	2,3	2,1
2,1	BELGIUM	2	1,8	2	1,9	2,2	1,8	1,9	2,1	2	2,3	1,9	2,4	2,2	2,1	2,3
2,2	SWITZERLAND	1,6	1,8	1,6	1,8	1,7	2,3	2,1	1,8	2,1	2,4	2,6	2,4	2,8	2,7	2,4
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 110: Computer application output, evaluation of N_{RI} for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$, the number of research centres (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval table showing output from computer application: 19/117 records.

Country\Year	1997-1999		2000-2002		2003-2005		2006-2008		2009-2011	
	Np	Rank	Np	Rank	Np	Rank	Np	Rank	Np	Rank
USA	3349	1	3061	1	3780	1	3475	1	3078	1
JAPAN	994	2	1013	2	1109	2	1104	2	949	3
PEOPLES R CHINA	149	11	401	4	792	3	911	3	1222	2
TAIWAN	290	6	377	5	498	5	637	4	725	4
SOUTH KOREA	182	9	249	9	561	4	598	5	589	5
UNITED KINGDOM	377	3	416	3	436	6	396	7	450	7
CANADA	312	5	305	7	404	8	517	6	498	6
ITALY	267	7	362	6	402	9	342	8	410	9
GERMANY	325	4	290	8	426	7	297	9	301	10
SPAIN	111	13	147	11	301	10	271	10	440	8
FRANCE	184	8	204	10	289	11	262	11	300	11
INDIA	111	12	106	15	198	12	170	13	213	12
AUSTRALIA	175	10	100	16	139	16	158	15	207	13
GREECE	59	19	123	12	191	13	190	12	186	14
SINGAPORE	86	16	121	13	153	15	165	14	157	16
NETHERLANDS	87	15	111	14	165	14	121	17	117	18
ISRAEL	97	14	78	18	116	18	133	16	104	20
BELGIUM	55	21	81	17	125	17	114	18	106	19
SWITZERLAND	73	17	68	20	113	19	79	22	77	22
TURKEY	16	32	32	24	80	22	89	21	147	17
..	..	..	..	..	..	..	..	..	..	..

Table 111: Computer application output, evaluation of N_P for 3 years along with Rank Info for Hardware Architecture WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{ci}}$, where N_P is the total number of weighted research papers published in the country during said period and N_{ci} the number of participating countries for each research paper "i", total 15-year interval are divided in to 3-year interval; Rank: position of ranking drawn from the number of publications produced during that period by the specific country table showing output from computer application: 20/117 records.

Total	Year	8861	8413	11506	11101	11588
	Country	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
		N _P	N _P	N _P	N _P	N _P
16742,68	USA	3348,73	3061,46	3779,81	3474,67	3078,02
5169,38	JAPAN	993,84	1013,4	1109,17	1104,26	948,7
3474,48	PEOPLES R CHINA	149,27	400,79	791,77	910,83	1221,82
2527,4	TAIWAN	289,75	376,53	498,41	637,38	725,32
2179,19	SOUTH KOREA	182,08	248,92	560,78	598	589,41
2073,27	UNITED KINGDOM	376,5	415,54	435,68	395,68	449,87
2035,01	CANADA	312,13	304,68	404,06	516,55	497,6
1782,51	ITALY	266,94	362,19	401,79	341,78	409,81
1637,02	GERMANY	324,59	289,53	425,5	296,76	300,64
1270,37	SPAIN	110,78	147,48	301,38	270,94	439,8
1239,46	FRANCE	183,93	204,2	289,27	261,74	300,32
798,2	INDIA	110,82	106,47	197,92	169,58	213,42
779,05	AUSTRALIA	175,29	99,87	138,77	158,09	207,03
748,65	GREECE	58,69	122,84	190,76	190,1	186,26
681,56	SINGAPORE	86,4	121,23	152,67	164,71	156,55
602,02	NETHERLANDS	87,32	111,13	164,99	121,35	117,22
528,17	ISRAEL	96,76	78,29	116,17	132,72	104,25
480,4	BELGIUM	54,5	81,28	125,2	113,54	105,88
408,91	SWITZERLAND	72,75	67,8	112,8	78,64	76,92
363,09	TURKEY	16,03	31,61	79,92	88,84	146,68
..	..	..	..	..	..	..

Table 112: Computer application output, evaluation of N_P for 3 years for Hardware Architecture WOS category.

Description: Computer application output along with data for selected Hardware Architecture WOS category. Total 15-year interval is divided in to 3-year interval where N_P is the Number of weighted research papers published in the country; table showing output from computer application: 20/117 records.

Figure 66: Computer application output N_P for countries, Hardware Architecture WOS category.

Description: Computer application output to see the changes in weighted publications of national and international research papers, where N_P is the total number of research papers published by the country during said period, total 15-year interval are divided in to 1 year interval.

Figure 67: Computer application output evaluation of N_A and N_{RI} for countries, Hardware Architecture WOS categories category.

Description: Computer application output to see evaluation of N_A and N_{RI} (changes in the number of national and international research papers); $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$ the number of research centers (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval.

Figure 68: Computer application output evaluation of YIF and N_{CI} for countries Hardware Architecture WOS category.

Description: Computer application output to see evaluation of YIF and N_{CI} (changes in the number of national and international research papers); $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period, and YIF is the IF to the journal of the year when each document "i" was published"; $N_{CI} = (\sum_{i=1}^N N_{CI,i}) / N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time; total 15-year interval are divided in to 1 year interval.

Figure 69: Computer application output, a triennium status graph N_p in the country, in Hardware Architecture WOS category.

Description: Computer output for selected WOS category, $N_p = \sum_{i=1}^N \frac{1}{N_{c,i}}$, where N_p is the total number of weighted research papers published in the country during said period and $N_{c,i}$, the number of participating countries for each research paper "i", total 15-year interval are divided in to 3-year interval.

Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Country	YIF	YIF	YIF	YIF	YIF
USA	0,77	1,03	1,29	1,44	1,51
JAPAN	0,35	0,41	0,5	0,55	0,59
PEOPLES R CHINA	0,69	0,66	0,74	1,15	1,24
TAIWAN	0,47	0,62	0,75	1	1,03
SOUTH KOREA	0,4	0,55	0,59	0,84	0,88
UNITED KINGDOM	0,55	0,71	0,98	1,43	1,4
CANADA	0,62	0,8	0,99	1,18	1,31
ITALY	0,69	0,76	1,02	1,27	1,3
GERMANY	0,64	0,88	0,97	1,52	1,35
SPAIN	0,57	0,64	0,82	1,25	1,18
FRANCE	0,68	0,77	0,96	1,22	1,32
INDIA	0,47	0,74	0,87	1,02	1,14
AUSTRALIA	0,52	0,9	1	1,33	1,4
GREECE	0,68	0,75	1,04	1,22	1,36
SINGAPORE	0,47	0,66	1,07	1,53	1,6
NETHERLANDS	0,54	0,84	0,83	1,44	1,25
ISRAEL	0,88	1,07	1,24	1,62	1,71
BELGIUM	0,62	0,71	0,8	1,14	1,22
SWITZERLAND	0,77	1,09	1,1	1,87	1,65
TURKEY	0,58	0,64	0,79	0,95	1,03
..	..	..	..	..	..

Table 113: Computer application output, evaluation of YIF for 3 years for Hardware Architecture WOS category.

Description: Computer application output for $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/117 records.

Figure 70: Computer application output, a triennium status graph YIF in the country, Hardware Architecture WOS category.

Description: Computer output for selected WOS category, $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval.

Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}
USA	24	26	17	10	3
JAPAN	6	7	5	3	1
PEOPLES R CHINA	19	10	8	7	3
TAIWAN	10	15	9	6	2
SOUTH KOREA	5	7	6	4	2
UNITED KINGDOM	14	14	13	9	3
CANADA	14	15	12	7	3
ITALY	14	15	10	8	3
GERMANY	14	21	9	8	3
SPAIN	10	11	6	7	3
FRANCE	19	15	11	8	3
INDIA	12	16	6	6	2
AUSTRALIA	17	14	11	9	4
GREECE	9	8	7	6	3
SINGAPORE	12	17	18	9	4
NETHERLANDS	15	18	13	11	3
ISRAEL	32	20	17	7	4
BELGIUM	16	14	11	8	2
SWITZERLAND	17	22	17	14	3
TURKEY	13	16	13	7	4
..	..	..	..	..	..

Table 114: Computer application output, evaluation of N_{CI} for 3 years for Hardware Architecture WOS category.

Description: Computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/117 records.

Figure 71: Computer application output, a triennium status graph N_{Ci} in the country, Hardware Architecture WOS category.

Description: Computer output for selected WOS category, $N_{Ci} = (\sum_{i=1}^N N_{Ci,i})/N$, where N is the total number of research papers of the country published during said period and $N_{Ci,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval.

Country	1997-2011						
	N_P	N_P (%)	Col (%)	IF	N_{CI}	N_A	N_{RI}
USA	16743	32,50%	26,00%	1,22	16	3,1	1,9
JAPAN	5169	10,00%	14,10%	0,48	4	3,2	1,6
PEOPLES R CHINA	3474	6,80%	36,20%	1,03	7	3,4	1,9
TAIWAN	2527	4,90%	14,60%	0,84	7	2,8	1,7
SOUTH KOREA	2179	4,20%	25,60%	0,72	4	3,2	1,8
UNITED KINGDOM	2073	4,00%	41,90%	1,06	10	3,1	1,9
CANADA	2035	4,00%	45,70%	1,04	9	3	1,9
ITALY	1783	3,50%	35,90%	1,04	10	3,5	1,9
GERMANY	1637	3,20%	43,50%	1,08	11	3,5	2
SPAIN	1270	2,50%	35,40%	1,01	6	4	1,9
FRANCE	1239	2,40%	50,60%	1,05	10	3,4	2,2
INDIA	798	1,60%	34,60%	0,9	7	3,1	1,9
AUSTRALIA	779	1,50%	47,00%	1,07	10	2,9	1,9
GREECE	749	1,50%	34,30%	1,09	6	3,5	1,9
..	..	..	..	..	..	..	..

Table 115: Computer application output, evaluation of N_P , $N_{P\%}$, Col%, YIF, N_{CI} , N_A , N_{RI} for 15 years for Hardware Architecture WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{C,i}}$, where N_P is the total number of weighted research papers published in the country during said period and $N_{C,i}$ the number of participating countries for each research paper "i"; N_P (%) = $\frac{N_P}{N_W}$ is the contribution of each country to the world production where N_W the total number of published research papers of "Selected WOS category" at global level; Col (%) is percentage of international collaboration for a given period has been calculated as the ratio of the research papers published in collaboration with at least one centre of another country and the total documents published; YIF = $(\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the country published during said period and YIF is the IF to the journal of the year when each document "i" was published; N_{CI} = $(\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the country published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time; N_A = $(\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; N_{RI} = $(\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the country published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15 years' time. Table showing output from computer application: 14/117 records.

7.4.3. Language Analysis

	ALGERIA		ARGENTINA		ARMENIA		AUSTRALIA		AUSTRIA		..
	N°Papers	%	N°Papers	%	N°Papers	%	N°Papers	%	N°Papers	%	..
English	32	88,90%	43	100,00%	4	100,00%	1053	100,00%	343	100,00%	..
French	4	11,10%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	..
Japanese	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	..
Welsh	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%	..

Table 116: Computer application output, % and N° of research papers published in each of the languages for Hardware Architecture WOS category.
Description: Computer application output, main production indicators of worldwide countries specific average values during the time of 1997–2011 from language information field it has been determined the % and N° of research papers published in each of the languages globally; table showing output from computer application: 5/117 records.

7.4.4. Evaluation of institutional distribution of publications

Total	Research centre	Year	3159	2983	2719	2826	2770	2817	3703	3900	3903	4005	3497	3599	3771	3742	4075
		Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P	N _P
632,82	IBM CORP	USA	53,1	69,1	55,22	40,7	47,08	62,94	42,79	46,14	45,84	41,83	27,88	37,08	23,83	14,03	25,25
388,36	UNIV ILLINOIS	USA	24,68	29,58	24,35	17,06	20,5	22,57	31,41	23,87	32,92	36,04	26,62	25,71	24,08	23,21	25,76
346,03	UNIV TEXAS	USA	32,25	26,38	29,58	22,58	22,83	25,29	39,32	29,53	46,37	36,12	35,78	0	0	0	0
337,74	NANYANG TECHNOL UNIV	SINGAPORE	14	15,33	19,95	15,33	18,5	28,83	12,33	21,5	39,33	33,53	16	29,08	20,01	25,08	28,92
323,2	TOKYO INST TECHNOL	JAPAN	28,42	22,67	20	16,08	22,67	16,25	19,58	17,33	26,08	22,33	23,73	27,17	24,9	16,42	19,57
310,27	NATL CHIAO TUNG UNIV	TAIWAN	22	19,83	26	18,33	17,83	21,17	19,23	25,52	18,53	16,42	20,53	18,75	24,78	16,58	24,75
288,62	INTEL CORP	USA	10,05	16,9	10	21,42	13,33	15,12	28,1	29,32	26,37	27,65	16,87	23,6	22,78	12,96	14,17
287,22	MIT	USA	20,69	13,78	21,25	21,92	24,03	24,52	21,7	30,2	18,51	17,76	12,67	21,48	14,13	11,43	13,15
287,11	GEORGIA INST TECHNOL	USA	15,53	13,67	11,17	18	15,42	16,83	21	29,25	25,5	27,36	19,4	13,58	26,2	11,23	22,98
284,55	PURDUE UNIV	USA	10,27	12,28	7	7,58	19,92	14,93	14,43	23,23	27,37	35,57	25,17	19,06	19,28	26,62	21,85
277,32	UNIV CALIF BERKELEY	USA	20,02	18,98	13,58	18,83	19,35	17,48	25,46	19,9	24,4	22,87	12,95	20,21	14,29	16,83	12,15
277,21	CHINESE ACAD SCI	PEOPLES R CHINA	1	2	1,5	15,37	16,4	19,75	23,83	25,58	30,43	28,92	19,33	15,25	20,6	23,82	33,43
276,75	CARNEGIE MELLON UNIV	USA	18,14	12,03	25,34	19,95	20,2	20,37	15,56	18,65	19,37	28,2	16,03	17,63	12,73	19,76	12,78
260,03	STANFORD UNIV	USA	15,46	24,4	18,58	22,45	21,7	27,52	15,9	13,62	18,73	16,08	11	11,87	12,92	15,73	14,07
258,98	INDIAN INST TECHNOL	INDIA	17,17	17,58	16,67	11,83	13,53	8,83	25,03	27,67	15,58	15,25	24,5	17,58	16,83	16,33	14,58
254,87	NATL TAIWAN UNIV	TAIWAN	9,17	13,83	5,33	11,42	12	16,17	17,5	20,18	15,93	18,07	21,9	28,9	21,43	17,02	26,02
250,59	UNIV MARYLAND	USA	12,45	17,53	9,52	18,53	13,43	16,55	21,33	17,08	20,63	24,48	15,33	19,63	14,73	14,44	14,92
245,33	UNIV CALIF SAN DIEGO	USA	10,87	6,71	24,42	10,28	15,49	19,3	15,39	25,25	20,48	21,45	18,98	13,04	13,5	17,41	12,76
244,8	UNIV SO CALIF	USA	15,17	21,95	16,2	14,67	11,02	11,45	16,45	21,08	21,93	16,38	13	20,43	17,68	9,62	17,77
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 117: Computer application research centres specific output, evaluation of N_P for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval is divided in to 1 year interval; table showing output from computer application: 19/11694 records.

Mean	Research centre	Year	0,51	0,53	0,7	0,68	0,88	0,83	1,06	0,91	0,92	0,9	1,03	1,54	1,32	1,22	1,1
		Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF	YIF
1,55	IBM CORP	USA	0,93	0,9	1,1	1,05	1,51	2,37	2	1,46	1,19	1,25	1,73	3,01	2,11	2,71	1,01
1,26	UNIV ILLINOIS	USA	0,72	0,53	0,92	0,73	1,09	0,98	1,38	1,42	1,42	1,14	1,16	2,29	1,58	1,42	1,56
1,09	UNIV TEXAS	USA	0,71	0,76	0,87	0,86	1,07	1,1	1,34	1,34	1,21	1,08	1,37	-	-	-	-
1,02	NANYANG TECHNOL UNIV	SINGAPORE	0,15	0,27	0,56	0,54	0,32	0,58	0,95	0,67	0,94	0,94	1,12	1,73	1,93	1,45	1,4
0,45	TOKYO INST TECHNOL	JAPAN	0,2	0,32	0,3	0,32	0,42	0,36	0,56	0,44	0,43	0,43	0,45	0,64	0,76	0,48	0,4
0,9	NATL CHIAO TUNG UNIV	TAIWAN	0,74	0,61	0,58	0,78	0,64	0,89	0,99	0,84	0,91	0,81	0,89	1,52	1,16	0,85	1,12
1,08	INTEL CORP	USA	0,61	0,85	0,59	0,84	0,99	0,91	1,27	1,08	0,98	0,88	1,06	1,58	1,41	1,34	1,22
1,42	MIT	USA	0,93	1,07	1,14	1,03	1,35	1,21	1,78	1,32	1,64	1,49	1,5	1,95	2,29	1,8	1,44
1,28	GEORGIA INST TECHNOL	USA	0,79	0,71	1,09	0,87	1,12	1,23	1,68	1,27	1,3	0,83	1,54	1,81	1,66	1,44	1,41
1,32	PURDUE UNIV	USA	0,95	0,62	1,12	0,79	0,98	1,02	1,62	1,25	1,5	1,15	0,97	2,67	1,57	1,37	1,23
1,29	UNIV CALIF BERKELEY	USA	0,7	0,95	0,87	0,92	0,98	1,17	1,39	1,33	1,28	1,13	1,56	2,05	2	1,61	1,44
0,77	CHINESE ACAD SCI	PEOPLES R CHINA	0,16	0,52	1,14	0,48	0,84	0,17	0,27	0,48	0,57	0,53	0,78	0,98	1,34	1,15	1,17
1,3	CARNEGIE MELLON UNIV	USA	0,83	0,87	0,82	0,99	1,13	1,06	1,58	1,32	1,08	1,2	1,52	1,69	1,93	1,86	1,45
1,39	STANFORD UNIV	USA	0,96	0,96	0,95	0,82	1,04	1,06	2,04	1,32	1,33	1,2	1,58	2,77	2,51	2,1	1,63
0,87	INDIAN INST TECHNOL	INDIA	0,23	0,42	0,54	0,79	0,93	0,85	1,12	0,95	0,58	0,73	0,85	1,18	1,27	1,38	1,14
1,01	NATL TAIWAN UNIV	TAIWAN	0,45	0,28	0,48	0,53	0,62	0,75	0,97	0,82	0,93	0,94	1,06	2,21	1,1	1,15	1,03
1,23	UNIV MARYLAND	USA	0,77	0,65	1,16	1	1,21	0,87	1,35	1,37	1,38	1,19	1,33	1,78	1,64	1,28	1,33
1,16	UNIV CALIF SAN DIEGO	USA	0,91	0,92	0,91	0,81	1,11	1,16	1,25	1,08	1,2	1,07	1,09	1,7	1,2	1,49	1,37
1,19	UNIV SO CALIF	USA	0,73	0,67	0,81	0,86	0,86	0,88	1,15	1,53	1,32	1,05	1,08	2,01	1,63	1,28	1,33
1,13	UNIV CALIF LOS ANGELES	USA	0,77	0,77	0,67	0,91	1,09	0,88	1,32	1,36	0,99	0,94	0,9	2,01	1,48	1,22	1,15
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 118: Computer application research centres specific output, evaluation of YIF for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 20/11694 records.

Mean	Research centre	Year	14	13	19	17	16	18	12	11	10	9	8	6	4	3	1
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}
22	IBM CORP	USA	22	25	34	33	42	28	24	18	16	24	12	15	3	5	1
17	UNIV ILLINOIS	USA	25	22	35	27	16	30	30	16	16	12	9	8	3	3	2
15	UNIV TEXAS	USA	17	18	22	23	15	20	15	16	11	9	11	-	-	-	-
10	NANYANG TECHNOL UNIV	SINGAPORE	5	8	18	24	3	16	11	5	16	14	6	6	8	6	2
3	TOKYO INST TECHNOL	JAPAN	2	8	3	5	3	3	5	3	4	2	2	3	2	2	1
9	NATL CHIAO TUNG UNIV	TAIWAN	15	10	12	10	11	20	11	9	15	9	9	3	3	1	1
13	INTEL CORP	USA	19	21	31	17	9	16	23	20	16	7	5	6	6	1	2
35	MIT	USA	45	74	27	43	61	35	73	40	20	16	18	14	11	5	1
30	GEORGIA INST TECHNOL	USA	35	14	67	14	27	154	27	21	37	40	23	11	7	3	2
13	PURDUE UNIV	USA	31	14	40	44	15	15	34	11	19	12	8	6	4	3	1
32	UNIV CALIF BERKELEY	USA	56	40	59	53	45	73	35	36	16	23	9	7	11	13	3
5	CHINESE ACAD SCI	PEOPLES R CHINA	3	20	3	3	7	4	5	5	5	6	13	4	7	3	2
21	CARNEGIE MELLON UNIV	USA	56	49	24	20	36	22	29	31	17	14	14	8	7	4	2
29	STANFORD UNIV	USA	54	44	39	32	30	47	20	23	40	23	22	9	7	5	4
7	INDIAN INST TECHNOL	INDIA	6	7	23	12	13	8	7	6	4	6	6	3	3	2	1
13	NATL TAIWAN UNIV	TAIWAN	21	5	14	14	14	91	9	6	12	10	9	5	3	2	1
18	UNIV MARYLAND	USA	33	28	17	21	19	32	22	43	11	10	11	4	4	5	2
15	UNIV CALIF SAN DIEGO	USA	35	14	24	14	38	36	16	11	13	9	12	6	3	2	1
28	UNIV SO CALIF	USA	95	17	17	60	94	29	32	37	16	10	17	13	4	2	1
25	UNIV CALIF LOS ANGELES	USA	52	23	20	92	18	28	22	46	19	12	8	4	4	3	2
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 119: Computer application research centres specific output, evaluation of N_{CI} for 1 year for Hardware Architecture WOS category.

Description: Computer application output along with data for selected Cybernetics WOS Category. N_{CI} is average number of citation for each research centre; table showing output from computer application:20/11694 records.

Total	N°Col		314	380	406	442	427	473	613	607	658	702	683	731	776	864	1052
		Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		Research centre	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col	N°Col
1007	228	IBM CORP	11	18	12	15	13	23	11	14	31	12	10	18	14	9	17
660	148	UNIV ILLINOIS	5	7	7	7	8	10	10	5	9	15	16	14	8	10	17
580	113	UNIV TEXAS	8	5	5	7	10	5	13	10	15	23	12	0	0	0	0
440	131	NANYANG TECHNOL UNIV	2	1	7	5	1	6	7	3	11	10	5	18	10	23	22
429	38	TOKYO INST TECHNOL	0	7	2	3	0	3	3	2	1	2	4	3	3	3	2
437	57	NATL CHIAO TUNG UNIV	9	3	2	4	4	6	2	2	4	6	1	3	3	3	5
557	120	INTEL CORP	6	5	4	3	9	6	8	10	8	13	11	12	10	8	7
468	101	MIT	2	9	6	8	9	6	7	9	11	13	3	2	4	5	7
446	82	GEORGIA INST TECHNOL	1	2	3	4	7	3	3	7	7	6	10	6	10	4	9
503	98	PURDUE UNIV	2	6	2	1	2	5	8	8	8	11	9	11	5	11	9
499	143	UNIV CALIF BERKELEY	12	11	8	10	8	7	10	11	7	14	7	10	12	7	9
429	110	CHINESE ACAD SCI	2	1	1	2	2	3	5	10	14	8	14	8	11	13	16
460	96	CARNEGIE MELLON UNIV	3	1	7	4	3	7	5	2	9	6	11	13	8	10	7
442	122	STANFORD UNIV	5	11	6	10	8	12	3	5	12	8	10	4	5	9	14
369	122	INDIAN INST TECHNOL	2	5	10	8	9	5	10	18	5	15	15	6	7	3	4
377	76	NATL TAIWAN UNIV	1	1	0	2	2	4	8	6	9	3	8	8	5	8	11
394	78	UNIV MARYLAND	6	3	10	3	7	5	5	8	6	3	3	3	6	6	4
432	118	UNIV CALIF SAN DIEGO	4	4	7	8	10	6	5	10	7	13	10	7	6	11	10
396	90	UNIV SO CALIF	3	8	4	3	4	2	6	5	7	7	10	10	8	6	7
426	106	UNIV CALIF LOS ANGELES	4	3	1	7	7	2	2	13	8	13	8	11	6	13	8
**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

Table 120: Computer application research centres specific output, evaluation of N°Col for 1 year for Hardware Architecture WOS category.

Description: Sample of computer application output for N°Col Number of collaborations, total 15-year interval are divided in to 1 year interval; table showing output from computer application: 20/11694 records.

Total	%Col	Year	10%	13%	15%	16%	15%	17%	17%	16%	17%	18%	20%	20%	21%	23%	26%
		Research centre	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
			%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col	%Col
1007	23%	IBM CORP	14%	19%	15%	25%	17%	26%	17%	18%	38%	18%	20%	26%	33%	30%	39%
660	22%	UNIV ILLINOIS	12%	17%	18%	23%	24%	24%	18%	12%	19%	24%	36%	28%	19%	24%	35%
580	19%	UNIV TEXAS	16%	11%	11%	17%	23%	13%	21%	19%	20%	36%	20%	0%	0%	0%	0%
440	30%	NANYANG TECHNOL UNIV	13%	6%	27%	26%	5%	18%	41%	12%	23%	24%	24%	46%	32%	55%	51%
429	9%	TOKYO INST TECHNOL	0%	24%	8%	14%	0%	12%	11%	7%	3%	7%	13%	8%	9%	12%	8%
437	13%	NATL CHIAO TUNG UNIV	31%	12%	7%	16%	15%	21%	7%	5%	14%	24%	3%	11%	9%	13%	14%
557	22%	INTEL CORP	26%	17%	21%	9%	30%	19%	18%	20%	17%	25%	28%	23%	22%	27%	25%
468	22%	MIT	6%	32%	18%	24%	23%	15%	22%	20%	34%	39%	17%	7%	17%	23%	30%
446	18%	GEORGIA INST TECHNOL	5%	10%	16%	15%	29%	12%	10%	17%	18%	16%	29%	23%	22%	19%	23%
503	19%	PURDUE UNIV	13%	26%	17%	9%	6%	19%	29%	21%	18%	19%	21%	28%	14%	21%	22%
499	29%	UNIV CALIF BERKELEY	33%	31%	29%	31%	24%	23%	25%	28%	18%	33%	26%	29%	39%	23%	43%
429	26%	CHINESE ACAD SCI	100%	33%	50%	10%	9%	11%	15%	29%	30%	17%	39%	29%	33%	34%	29%
460	21%	CARNEGIE MELLON UNIV	10%	5%	20%	13%	10%	22%	19%	7%	28%	14%	42%	41%	27%	28%	28%
442	28%	STANFORD UNIV	19%	27%	18%	29%	23%	30%	13%	23%	36%	31%	34%	20%	23%	33%	50%
369	33%	INDIAN INST TECHNOL	9%	20%	40%	40%	45%	38%	30%	43%	24%	60%	41%	27%	30%	14%	21%
377	20%	NATL TAIWAN UNIV	8%	6%	0%	13%	11%	17%	29%	19%	33%	12%	24%	21%	16%	29%	31%
394	20%	UNIV MARYLAND	32%	10%	53%	11%	32%	20%	15%	27%	19%	9%	14%	11%	25%	23%	18%
432	27%	UNIV CALIF SAN DIEGO	22%	27%	18%	42%	34%	19%	20%	22%	21%	36%	27%	29%	27%	35%	38%
396	23%	UNIV SO CALIF	13%	23%	17%	12%	20%	10%	26%	15%	23%	26%	42%	28%	27%	38%	26%
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 121: Computer application research centres specific output, evaluation of Col (%) for 1 year for Hardware Architecture WOS category.

Description: Sample of computer application output for Col (%) percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another research institution and the total documents published, total 15-year interval are divided in to 1 year interval; table showing output from computer application:19/11694 records.

Mean	Research centre	Year	2,3	2,5	2,7	2,8	2,7	2,8	2,9	3	3	3	3,1	3,3	3,3	3,2	3,3
		Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		Country	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A	N _A
4,7	IBM CORP	USA	3,1	4	4	3,6	4,5	4,4	4,7	3,7	6,1	4,8	4,8	8,2	5	4,9	7
3,4	UNIV ILLINOIS	USA	2,7	2,9	3,4	3,2	3,4	3,2	3,4	3,5	2,9	3,6	3,3	3,6	3	4	3,9
3,1	UNIV TEXAS	USA	2,5	2,9	2,5	2,8	3,1	3,3	3	3,7	3,3	3,2	3,3	-	-	-	-
2,9	NANYANG TECHNOL UNIV	SINGAPORE	2,4	2,5	2,6	2,8	2,9	2,4	2,8	2,7	2,9	2,8	2,9	3,2	2,9	3,2	3,2
3	TOKYO INST TECHNOL	JAPAN	2,9	2,8	2,4	2,9	2,6	3,2	2,8	2,9	3,2	2,6	2,9	2,9	3,5	3,3	3,6
2,9	NATL CHIAO TUNG UNIV	TAIWAN	2,3	2,5	2,1	2,9	2,8	2,9	3,1	2,9	3,2	3,2	3,3	3,5	3,3	3,2	3
3,6	INTEL CORP	USA	3,7	3,2	2,8	3,1	3,6	4,5	3,3	3,3	3,4	3,3	4,7	3,8	3,9	3,8	3,9
3,3	MIT	USA	3,4	3,1	2,8	3	2,8	3,7	3,5	3,1	3,8	3,2	3,5	3,7	3,6	3,4	3,5
3	GEORGIA INST TECHNOL	USA	2,6	2,4	2,9	3,1	2,8	3	2,7	3,1	2,8	2,9	3	3,2	3,3	3,6	3,4
3,2	PURDUE UNIV	USA	3	2,9	3	2,5	3	3	3,3	3	3,4	3	3,4	3,7	3,5	3,2	2,9
3,6	UNIV CALIF BERKELEY	USA	3,6	3,7	3	3,6	3,3	3,8	3,2	3,7	3,3	4	3,6	3,7	4,7	3,9	2,9
3,5	CHINESE ACAD SCI	PEOPLES R CHINA	2,5	2,3	3,5	3	3	3,1	3,3	3,1	3,4	3,2	3,6	3,8	3,8	4,5	3,8
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 122: Computer application research centres specific output, evaluation of N_A for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the research institution published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 12/11694 records.

Mean			1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.8
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	Research Centre	Country	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}	N _{RI}
2.1	IBM CORP	USA	2	1.7	1.9	1.9	2.1	1.8	2	2.2	2.2	2.1	2.2	2.5	2.5	3.4	2.4
2.3	UNIV ILLINOIS	USA	2.3	1.7	1.9	2.2	2.2	2.5	2.4	2.3	1.8	2.3	2.2	2.4	2.3	2.4	2.6
2	UNIV TEXAS	SINGAPORE	1.8	2.2	1.8	2.2	2.2	2.1	1.9	2.3	2	2.1	2.1	-	-	-	-
1.6	NANYANG TECHNOL UNIV	JAPAN	1.3	1.2	1.6	1.4	1.2	1.4	1.8	1.3	1.4	1.4	1.6	1.6	2.1	2.1	1.8
1.6	TOKYO INST TECHNOL	TAIWAN	1.2	1.6	1.4	1.7	1.4	1.8	1.6	1.8	1.7	1.5	1.7	1.6	1.9	2	1.7
1.8	NATL CHIAO TUNG UNIV	USA	1.7	1.5	1.3	1.6	1.8	1.6	2	1.8	2.1	2	1.9	1.9	1.8	1.8	1.8
2.4	INTEL CORP	USA	2.7	2.3	2.2	1.9	2.7	2.8	2.2	2.2	2.1	2.2	2.6	2.5	2.5	2.8	2.6
2.2	MIT	USA	2.2	2.5	2	2	2.2	2.1	1.9	1.9	2.4	2.6	1.9	1.9	2	2.5	2.3
1.9	GEORGIA INST TECHNOL	USA	1.7	1.7	2	1.7	1.9	1.9	1.7	1.7	1.8	1.7	2.2	2.3	2.1	2.4	2.1
2.2	PURDUE UNIV	USA	2.2	2.2	1.9	1.7	1.9	2.3	2.4	2.1	2.1	2	2	2.7	2.2	2.3	2.2
2.4	UNIV CALIF BERKELEY	PEOPLES R CHINA	2.6	2.6	2.4	2.2	2.4	2.3	2.3	2.4	2.1	2.5	2.6	2.4	2.7	2.2	2.3
2	CHINESE ACAD SCI	USA	2	1.7	1.5	1.7	1.6	1.7	1.7	1.6	1.9	2	2.3	2.4	2.1	2.1	2.1
2.2	CARNEGIE MELLON UNIV	USA	2.1	2.2	1.8	2	1.8	2	2.5	2.1	2.1	2.1	2.3	2.5	2.6	2.4	2.5
2.2	STANFORD UNIV	INDIA	2.6	2.2	2.2	2.1	1.9	2	1.8	2.1	2.2	2.2	3	2.4	2	2.3	2.7
1.8	INDIAN INST TECHNOL	TAIWAN	1.5	1.7	1.8	2.1	1.9	1.8	1.6	1.9	1.7	2	1.8	1.5	1.7	1.6	1.5
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 123: Computer application research centres specific output, evaluation of N_{RI} for 1 year for Hardware Architecture WOS category.

Description: Computer application output for $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the research institution published during this said period, and $N_{RI,i}$, the number of research centres (of any nationality) participants in each item "i", total 15-year interval are divided in to 1 year interval; table showing output from computer application: 15/11694 records.

Research institution	Country	1997-1999		2000-2002		2003-2005		2006-2008		2009-2011	
		N _P	Rank	N _P	Rank	N _P	Rank	N _P	Rank	N _P	Rank
IBM CORP	USA	177	1	151	1	135	1	107	1	63	11
UNIV ILLINOIS	USA	79	4	60	7	88	3	88	2	73	5
UNIV TEXAS	USA	88	3	71	3	115	2	72	6	0	-
NANYANG TECHNOL UNIV	SINGAPORE	49	14	63	5	73	8	79	4	74	4
TOKYO INST TECHNOL	JAPAN	71	5	55	11	63	16	73	5	61	12
NATL CHIAO TUNG UNIV	TAIWAN	68	6	57	8	63	15	56	19	66	8
INTEL CORP	USA	37	21	50	14	84	4	68	8	50	20
MIT	USA	56	9	70	4	70	10	52	27	39	37
GEORGIA INST TECHNOL	USA	40	18	50	13	76	7	60	14	60	13
PURDUE UNIV	USA	30	35	42	20	65	13	80	3	68	6
UNIV CALIF BERKELEY	USA	53	12	56	9	70	11	56	18	43	28
CHINESE ACAD SCI	PEOPLES R CHINA	5	362	52	12	80	5	64	10	78	2
CARNEGIE MELLON UNIV	USA	56	10	61	6	54	21	62	12	45	23
STANFORD UNIV	USA	58	8	72	2	48	25	39	39	43	29
INDIAN INST TECHNOL	INDIA	51	13	34	28	68	12	57	16	48	21
NATL TAIWAN UNIV	TAIWAN	28	38	40	23	54	20	69	7	64	9
UNIV MARYLAND	USA	39	19	49	15	59	19	59	15	44	26
UNIV CALIF SAN DIEGO	USA	42	16	45	17	61	17	53	23	44	27
UNIV SO CALIF	USA	53	11	37	25	59	18	50	29	45	24
UNIV CALIF LOS ANGELES	USA	32	30	55	10	64	14	53	24	37	40
..	..	..	..	..	..	..	..	..	..	..	..

Table 124: Computer application research centres specific output, evaluation of N_P for 3 years along with Rank Info for Hardware Architecture WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and N_{RI,i} the number of participating research institutions in each document "i", total 15-year interval are divided in to 3-year interval. Rank: position of ranking drawn from the number of publications produced by the specific research centre during that period; table showing output from computer application: 20/11694 records.

Total		8861	8413	11506	11101	11588
	Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
Research centre	Country	N _P	N _P	N _P	N _P	N _P
IBM CORP	USA	177,42	150,72	134,78	106,8	63,11
UNIV ILLINOIS	USA	78,62	60,13	88,2	88,36	73,05
UNIV TEXAS	USA	88,21	70,71	115,22	71,9	0
NANYANG TECHNOL UNIV	SINGAPORE	49,28	62,67	73,17	78,62	74,01
TOKYO INST TECHNOL	JAPAN	71,08	55	63	73,23	60,89
NATL CHIAO TUNG UNIV	TAIWAN	67,83	57,33	63,28	55,7	66,12
INTEL CORP	USA	36,95	49,86	83,78	68,12	49,91
MIT	USA	55,72	70,47	70,41	51,91	38,72
GEORGIA INST TECHNOL	USA	40,37	50,25	75,75	60,34	60,4
PURDUE UNIV	USA	29,55	42,43	65,03	79,79	67,75
UNIV CALIF BERKELEY	USA	52,59	55,67	69,76	56,03	43,28
CHINESE ACAD SCI	PEOPLES R CHINA	4,5	51,52	79,85	63,5	77,84
CARNEGIE MELLON UNIV	USA	55,52	60,52	53,58	61,86	45,28
STANFORD UNIV	USA	58,44	71,67	48,25	38,95	42,72
INDIAN INST TECHNOL	INDIA	51,42	34,2	68,28	57,33	47,75
NATL TAIWAN UNIV	TAIWAN	28,33	39,58	53,62	68,87	64,47
UNIV MARYLAND	USA	39,49	48,52	59,04	59,45	44,09
UNIV CALIF SAN DIEGO	USA	41,99	45,08	61,12	53,48	43,67
UNIV SO CALIF	USA	53,32	37,13	59,47	49,81	45,07
UNIV CALIF LOS ANGELES	USA	31,86	55,02	64,22	53,23	37,18
..	..	..	..	..	..	..

Table 125: Computer application research centres specific output, evaluation of N_P for 3 years for Hardware Architecture WOS category.

Description: Computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/11694 records.

Figure 72: Computer application output, a triennium status graph N_p by research centre, Hardware Architecture WOS category.

Description: Computer output for selected WOS category, $N_p = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_p is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i", total 15-year interval is divided in to 3-year interval.

Research centre	Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
	Country	YIF	YIF	YIF	YIF	YIF
IBM CORP	USA	0,97	1,73	1,5	2,01	1,85
UNIV ILLINOIS	USA	0,72	0,94	1,4	1,54	1,52
UNIV TEXAS	USA	0,78	1,01	1,28	1,22	-
NANYANG TECHNOL UNIV	SINGAPORE	0,36	0,5	0,86	1,31	1,56
TOKYO INST TECHNOL	JAPAN	0,27	0,37	0,47	0,52	0,57
NATL CHIAO TUNG UNIV	TAIWAN	0,64	0,77	0,91	1,08	1,07
INTEL CORP	USA	0,7	0,91	1,1	1,2	1,33
MIT	USA	1,04	1,2	1,54	1,66	1,82
GEORGIA INST TECHNOL	USA	0,85	1,07	1,37	1,35	1,52
PURDUE UNIV	USA	0,84	0,96	1,44	1,52	1,38
UNIV CALIF BERKELEY	USA	0,84	1,02	1,34	1,54	1,71
CHINESE ACAD SCI	PEOPLES R CHINA	0,59	0,27	0,46	0,74	1,21
CARNEGIE MELLON UNIV	USA	0,83	1,06	1,3	1,44	1,77
STANFORD UNIV	USA	0,96	0,98	1,52	1,77	2,03
INDIAN INST TECHNOL	INDIA	0,41	0,86	0,9	0,9	1,27
NATL TAIWAN UNIV	TAIWAN	0,38	0,65	0,9	1,51	1,09
UNIV MARYLAND	USA	0,8	1,02	1,37	1,41	1,42
UNIV CALIF SAN DIEGO	USA	0,91	1,06	1,16	1,23	1,37
UNIV SO CALIF	USA	0,73	0,87	1,37	1,46	1,44
UNIV CALIF LOS ANGELES	USA	0,73	0,97	1,21	1,29	1,28
..	..	..	..	..	..	..

Table 126: Computer application research centres specific output, evaluation of YIF for 3 years for Hardware Architecture WOS category.

Description: computer application output for $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/6197 records.

Figure 73: Computer application output, a triennium status graph YIF by research centre, Hardware Architecture WOS category.

Description: Computer output for selected WOS category, $YIF = (\sum_{i=1}^N YIF_i) / N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published", total 15-year interval are divided in to 3-year interval.

Research centre	Year	1997-1999	2000-2002	2003-2005	2006-2008	2009-2011
	Country	N _{CI}	N _{CI}	N _{CI}	N _{CI}	N _{CI}
IBM CORP	USA	27	34	19	17	3
UNIV ILLINOIS	USA	27	25	21	10	3
UNIV TEXAS	USA	19	19	14	10	-
NANYANG TECHNOL UNIV	SINGAPORE	12	14	12	9	5
TOKYO INST TECHNOL	JAPAN	4	4	4	2	1
NATL CHIAO TUNG UNIV	TAIWAN	12	14	11	7	2
INTEL CORP	USA	23	14	20	6	4
MIT	USA	47	47	43	16	6
GEORGIA INST TECHNOL	USA	38	66	28	26	4
PURDUE UNIV	USA	26	20	20	9	3
UNIV CALIF BERKELEY	USA	51	56	29	14	9
CHINESE ACAD SCI	PEOPLES R CHINA	10	5	5	8	3
CARNEGIE MELLON UNIV	USA	41	26	25	12	4
STANFORD UNIV	USA	45	37	29	19	5
INDIAN INST TECHNOL	INDIA	12	11	6	5	2
NATL TAIWAN UNIV	TAIWAN	13	45	9	8	2
UNIV MARYLAND	USA	27	24	25	8	3
UNIV CALIF SAN DIEGO	USA	24	31	13	9	2
UNIV SO CALIF	USA	40	61	28	13	3
UNIV CALIF LOS ANGELES	USA	31	48	31	8	3
..	..	..	..	..	..	..

Table 127: Computer application research centres specific output, evaluation of N_{CI} for 3 years for Hardware Architecture WOS category.

Description: Computer application output for $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval; table showing output from computer application: 20/6197 records.

Figure 74: Computer application output, a triennium status graph N_{Ci} by research centre, Hardware Architecture WOS category.

Description: Computer output for selected WOS category, $N_{Ci} = (\sum_{i=1}^N N_{Ci,i})/N$, where N is the total number of research papers of the country published during said period and $N_{Ci,i}$ is the number of citations received by each document "i" until downloaded data time, total 15-year interval are divided in to 3-year interval, total 15-year interval are divided in to 3-year interval.

Research institution	Country	1997-2011						
		N _P	N _P (%)	Col (%)	IF	N _{CI}	N _A	N _{RI}
IBM CORP	USA	633	1,20%	22,60%	1,55	22	4,7	2,1
UNIV ILLINOIS	USA	388	0,80%	22,40%	1,26	17	3,4	2,3
UNIV TEXAS	USA	346	0,70%	19,50%	1,09	15	3,1	2
NANYANG TECHNOL UNIV	SINGAPORE	338	0,70%	29,80%	1,02	10	2,9	1,6
TOKYO INST TECHNOL	JAPAN	323	0,60%	8,90%	0,45	3	3	1,6
NATL CHIAO TUNG UNIV	TAIWAN	310	0,60%	13,00%	0,9	9	2,9	1,8
INTEL CORP	USA	289	0,60%	21,50%	1,08	13	3,6	2,4
MIT	USA	287	0,60%	21,60%	1,42	35	3,3	2,2
GEORGIA INST TECHNOL	USA	287	0,60%	18,40%	1,28	30	3	1,9
PURDUE UNIV	USA	285	0,60%	19,50%	1,32	13	3,2	2,2
UNIV CALIF BERKELEY	USA	277	0,50%	28,70%	1,29	32	3,6	2,4
CHINESE ACAD SCI	PEOPLES R CHINA	277	0,50%	25,60%	0,77	5	3,5	2
CARNEGIE MELLON UNIV	USA	277	0,50%	20,90%	1,3	21	3,4	2,2
STANFORD UNIV	USA	260	0,50%	27,60%	1,39	29	3,5	2,2
INDIAN INST TECHNOL	INDIA	259	0,50%	33,10%	0,87	7	3	1,8
..	..	..	..	..	..	..	..	..

Table 128: Computer application output, evaluation of N_P , $N_{P\%}$, $Col\%$, YIF , N_{CI} , N_A , N_{RI} for 15 years for Cybernetics WOS category.

Description: Sample of computer application output for $N_P = \sum_{i=1}^N \frac{1}{N_{RI,i}}$, where N_P is the total number of research papers published by the research centre during said period, and $N_{RI,i}$ the number of participating research institutions in each document "i"; $N_P (\%) = \frac{N_P}{N_W}$ is the contribution of each research centre to the world production, where N_W is the total number of published research papers of "Selected WOS category" at global level; $Col (\%)$ percentage of international collaboration is ratio of the research papers published in collaboration with at least one centre of another research centre and the total documents published; $YIF = (\sum_{i=1}^N YIF_i)/N$, where N is the total number of research papers of the research centre published during said period, and YIF is the IF to the journal of the year when each document "i" was published"; $N_{CI} = (\sum_{i=1}^N N_{CI,i})/N$, where N is the total number of research papers of the research centre published during said period and $N_{CI,i}$ is the number of citations received by each document "i" until downloaded data time; $N_A = (\sum_{i=1}^N N_{A,i})/N$, where N is the total number of research papers of the research centre published during this said period, and $N_{A,i}$ is the number of authors (of any nationality or institution) participants in each item "i"; $N_{RI} = (\sum_{i=1}^N N_{RI,i})/N$, where N is the total number of research papers of the research centre published during this said period, and $N_{RI,i}$ the number of research centres (of any nationality) participants in each item "i", total 15 years' time; table showing output from computer application: 15/11693 records.

7.4.5. Evaluation of the diffusion and internationalization of the worldwide research journals

Abbreviated Journal	Mean IF	N° papers	5315 USA	1656 JAPAN	1793 PEOPLES R CHINA	1168 TAIWAN	904 SOUTH KOREA	715 UNITED KINGDOM	845 CANADA	618 ITALY	472 GERMANY	633 SPAIN	..
VLDB J	3,83	222	40	1	11	3	1	2	5	3	6	1	..
IBM J RES DEV	3,02	301		2	4	0	0	3	1	0	7	0	..
IEEE T NEURAL NETWORK	2,99	883	17	3	28	3	2	8	4	4	2	4	..
J ACM	2,78	150	49	1	1	0	0	5	4	3	5	1	..
IEEE WIREL COMMUN	2,39	310	28	2	8	4	2	4	10	6	5	5	..
IEEE MICRO	2,36	204		5	3	1	1	1	0	1	1	4	..
IEEE NETWORK	2,2	190	30	1	6	4	4	3	12	4	5	6	..
COMMUN ACM	2,17	741		1	2	1	1	6	3	2	2	1	..
IEEE ACM T NETWORK	2,16	679		1	5	2	2	1	4	4	2	0	..
COMPUTER	1,79	447		1	2	0	1	7	2	1	2	2	..
IEEE T COMPUT	1,76	685	40	3	5	8	5	4	6	5	1	5	..
IEEE T DEPEND SECURE	1,58	170	45	1	4	4	1	2	5	6	3	2	..
J OPT COMMUN NETW	1,5	295	22	8	7	3	3	4	10	6	2	5	..
IEEE DES TEST COMPUT	1,45	215		1	1	9	1	1	4	4	3	1	..
IEEE MULTIMEDIA	1,32	152	25	2	10	5	3	3	5	4	4	5	..
IEEE T RELIAB	1,3	359	26	3	12	13	3	3	8	2	1	3	..
J COMPUT SYST SCI	1,3	311	26	1	3	3	1	11	6	4	8	3	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 129: Computer application research centres specific output, Percentage of total number of weighted research papers published by each journal for Hardware Architecture WOS category.

Description: Computer application output, $JL_j (\%) = N_{PJ} / N_j$ shows the influence of each country in the existing journals, $JL_j (\%) = N_{PJ} / N_j$, where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_j is the total number of research papers published by this journal, $JL_j (\%)$ is percentage of the total number of papers published by a journal due to researchers of a specific country (the sum of each row is 100%, representing the total number of papers published by each journal); table showing output from computer application: 17/116 records

Abbreviated Journal	Mean IF	N° papers	5315 USA	1656 JAPAN	1793 PEOPLES R CHINA	1168 TAIWAN	904 SOUTH KOREA	715 UNITED KINGDOM	845 CANADA	618 ITALY	472 GERMANY	633 SPAIN	..
VLDB J	3,83	222	1,7	0,1	1,4	0,6	0,4	0,6	1,4	1	3	0,3	..
IBM J RES DEV	3,02	301	3,6	0,4	0,6	0	0	1,4	0,4	0	4,7	0,2	..
IEEE T NEURAL NETWORK	2,99	883	2,8	1,6	13,9	2,3	2	9,4	3,9	6,1	3,3	5,2	..
J ACM	2,78	150	1,4	0,1	0,1	0	0	1	0,7	0,7	1,5	0,2	..
IEEE WIREL COMMUN	2,39	310	1,6	0,4	1,4	1,2	0,6	1,9	3,7	3	3	2,3	..
IEEE MICRO	2,36	204	2,5	0,6	0,4	0,2	0,3	0,2	0,1	0,2	0,4	1,2	..
IEEE NETWORK	2,2	190	1,1	0,1	0,7	0,7	0,9	0,8	2,6	1,3	2	1,7	..
COMMUN ACM	2,17	741	8,7	0,5	0,8	0,4	0,9	5,8	2,4	1,9	2,8	0,7	..
IEEE ACM T NETWORK	2,16	679	7,8	0,3	2	1	1,3	1,4	3,5	4,7	2,9	0,5	..
COMPUTER	1,79	447	4,5	0,3	0,5	0,2	0,5	4,2	1	1	2,3	1,7	..
IEEE T COMPUT	1,76	685	5,2	1,1	2,1	4,5	4,1	3,4	5	5,2	1,4	5	..
IEEE T DEPEND SECURE	1,58	170	1,4	0,1	0,4	0,6	0,2	0,6	1	1,7	1,2	0,6	..
J OPT COMMUN NETW	1,5	295	1,2	1,5	1,1	0,7	0,9	1,7	3,4	3	1,5	2,2	..
IEEE DES TEST COMPUT	1,45	215	2,2	0,2	0,1	1,6	0,3	0,3	1,1	1,2	1,5	0,4	..
IEEE MULTIMEDIA	1,32	152	0,7	0,2	0,8	0,6	0,5	0,6	1	0,9	1,2	1,1	..
IEEE T RELIAB	1,3	359	1,8	0,6	2,5	4	1	1,7	3,4	0,9	0,9	1,6	..
J COMPUT SYST SCI	1,3	311	1,5	0,2	0,5	0,8	0,4	4,6	2,1	2	5,4	1,5	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..

Table 130: Computer application research centres specific output, Percentage of total number of weighted research papers published by each country for Hardware Architecture WOS category.

Description: Computer application output, $Jl_c(\%) = N_{PJ} / N_P$ shows the dissemination of the papers of each country in the different journals of the field, where N_{PJ} is the total number of weighted research papers of a country published during a period in a specific journal, and N_P is the total number of weighted research papers published by the country (in every journal), ($Jl_c(\%)$) is percentage of the total number of weighted papers of one country published in a specific journal (the sum of each column is 100%, representing the total number of papers published by each country); table showing output from computer application: 17/116 records.