Integrated analysis of indicators for relationship studies between science and technology: co-activities between papers and patents

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Abstract: Presents results of research that had as main objective test the proposed integrated analysis of the distinct Science and Technology outputs (papers and patents) and simultaneously investigate the potential contribution of co-occurrences indicators - co-activity - between different actors in the innovation system of countries organizations and their typologies to better understand the contexts of generation and use of both productions, as well as the dynamic relationship between Science and Technology. It was used as empirical object, the Scientific and Technological Production in the biodiesel field. It was identified 885 published papers and 612 patents. It was found that 80% of the countries that produced patent also produce papers, with strong positive correlation (0.832). A number of organizations that have published papers in the period were 547 and the number of registered patents that was the total of 319. There is co-occurrence in 7% of organizations, which have 25% of total papers and 22% of patents. These co-active organizations are more productive than others (non co-active). With respect to the registration of patents, Companies and Private Research Institutes, co-active registered 7% and Educational Institutes and Public Research Institutes 15%, proving to be more productive.

Keywords: relationship between science and technology; bibliometrics; scientometrics; papers; patents; biodiesel.

Resumo: Apresenta resultados de pesquisa que teve objetivo testar análise integrada de diferentes produções científicas (artigos e patentes) e investigar a potencialidade da contribuição de indicadores de coocorrência -ou coatividade- de diferentes atores de um Sistema Nacional de Inovação (países, organizações e suas tipologias) visando compreender melhor o contexto de geração e uso dessas produções e, dessa forma, a dinâmica das relações entre a Ciência e a Tecnologia. Para isso, foi utilizado, como objeto empírico a produção de artigos e patentes da área de biodiesel. Foram encontrados 885 artigos publicados e 612 patentes. Verificou-se que 80% dos países que produziram patentes também produziram artigos, com uma correlação positiva forte (0.832). O número de organizações que publicaram artigos no período foi 547 e o número de organizações que registraram patentes totalizou 319. Identificou-se coocorrência em 7% das organizações, sendo encontrado nestas, 25% do total de artigos e 22% de patentes. Assim, as organizações coativas são mais produtivas do que as demais (não coativas). Com relação ao registro de patentes desse grupo coativo, as empresas e institutos privados de pesquisa registraram de 7% e as instituições de ensino e institutos públicos de pesquisa 15%, sendo, portanto, mais produtivas que as primeiras.

Keywords: relações entre ciência e tecnologia; bibliometria; cientometria; artigos; patentes; biodiesel.

1. INTRODUCTION

Comprehension of the dynamics of development of scientific and technological activities and their relationships has been discussed for decades. There are several areas of knowledge that are of potential investigative interest to propose solutions and provide advances for the understanding of this issue. There are, therefore, the most diverse theoretical and methodological approaches to do it. In the context of Information Science, there is great emphasis on methods and techniques; both bibliometric and scientometric, whose applications and developments are achieved through the construction and analysis of indicators of scientific and technical publications.

Papers and patents are, respectively, the main sources of information for the generation of indicators aiming to investigate the relationship between Science and Technology. The quality (relative) of documents, the accessibility, the availability of databases, the ease of recovery, and the possibility of importing, among other factors, are what influences the use of papers and patents over other informational resources. Furthermore, patent documents and papers have descriptive elements and standardized bibliographic data that facilitate their comparisons.

Despite the differences and particularities between these documents, this research started with the assumption that it is possible to perform an integrated analysis of indicators of scientific productivity (papers) and technological productivity (patents) of countries and organizations through the investigation of co-occurrences, or co-activities, of countries, organizations and their typologies: Companies and Private Research Institutes (CPRIS) or Education Institutions and Public Research Institutes (EIPRIS). Using methods and techniques, both bibliometric and scientometric, a better understanding of the dynamics and relationships between S&T can be achieved.

The research aimed simultaneously to test a new method of integrated analysis of the different productions (papers and patents) and to investigate the potential contribution of co-occurrence or coactivity indicators between different actors and countries in the innovation system. The goal was to better understand the contexts dynamics of the connection between science and technology. Was used as the empirical object for the productions about biodiesel, because it is a subject of widespread scientific, technological, and economical interest for government, research institutions, and different industries.

2 STUDIES OF RELATIONS AND INTERACTIONS BETWEEN SCIENCE AND TECHNOLOGY

The methods and techniques used to construct the bibliometric and scientometric indicators of S&T are quite diverse. In the literature, one can find isolated (vertical) approaches that focus on only one document or another and horizontal approaches that focus on relationships or connections between documents.

From the analysis of isolated Scientific Production (SP) or Technology Production (TP), the occurrence or co-occurrence of organizations related to science (especially universities) and technology (industries) can be investigated in particular. The main approaches refer to: citation of scientific papers by patents, occurrences of organizations (mainly universities) registering patents, occurrences of organizations (especially industries) publishing articles, and co-occurrence / collaboration between different types of organizations and their researchers in either production.

A few examples of studies conducted by means of individualized approaches deserve to be highlighted. Sun, Negishi and Nishizawa (2007) analyzed the dynamics of scientific collaboration between universities and industries in Japan by measuring the level of co-authorship of scientific articles. Looy and contributors (2003) conducted a study about the interactions between S&T in 10 different scientific areas in countries of the European Union, through the analysis of citations made by patent documents and scientific papers. Owen-Smith and contributors (2002) studied relationships between public research organizations (universities, government laboratories, research institutes, non-profit research hospitals) and companies with activities in biotechnology and pharmaceutical multinational corporations by using patent documents to identify the structure and network configuration between them. Godin (1996), in order to study the potential of bibliometrics to understand the scientific activities of the industry, investigated the research and practice of publishing industry papers. The main aspects that the researcher sought to understand were the importance of industry publications, scientific fields privileged, the level of utility of science to industry, and the relationship between science and technology.

The indicators of relationships and interactions between different productions do not have the level of consolidation achieved by single analysis. Only a smaller number of authors have compared aspects of patent documents with scientific publications, but when this is done, newsworthy parallels can be discovered (Meyer, Bhattacharya 2004).

In this context, studies investigating the relationship between the S&T make use of bibliometric and scientometric methods and techniques of co-occurrence between documents.

For example, correlations or similar aspects between Scientific Production and Technology Production can be investigated. Noteworthy among these are the studies of co-occurrence of subjects (or co-classification) and co-occurrence of words. Another common method applied is the analysis of co-occurrence or coactivity between authors / co-authors (SP) and inventors / co-inventors (TP).

Studies of this nature are influenced by the fact that the patent documents have elements similar to those identified in papers. Walker (1995) (italicized), cited by Meyer and Bhattacharya (2004), established comparisons and identified correspondences between scientific papers and patent document specifications. Some studies that investigated the relationships and interactions between S&T by means of integrated analysis may be mentioned. Bhattacharya, Kretschmer and Meyer (2003) studied the citations of papers in patents and performed the analysis of co-occurrence of words between the productions. Meyer and Bhattacharya (2004) conducted a study that verified the similarities and differences between the two productions. They analyzed the collaborative networks and interactions between them by identifying coactivity (co-occurrence of the authors in papers and patents.

Some authors attempted to distinguish the relationships between the issues identified in the papers and patent documents in order to infer relationships between S & T. Bassecoulard and Zitt (2004) present, discuss, and perform experiments to verify the feasibility of a lexical approach, seeking correspondences between technical areas (International Patent Classification) and scientific specialties (ISI code/ Web of Knowledge).

Studies with similar approaches to the proposal of this research, investigating relationships of productivity between patent documents and papers from countries and organizations, have also been performed. Lin, Chem and Huang (2011) investigated the link between the production of patents and scientific papers of 20 electric-electronic companies. Zitt and collaborators (2003) examined the connection between S & T by geographical co-localization analysis of scientific and technological output of EU countries. The analysis was intended, among other aspects, to identify correlations between the geographical outputs of Science (papers) and Technology (patent). Ebato and Matsuura (2004) studied a variety of aspects of the relationship between papers and patents in the area of information security in four sectors (government organizations, universities, industry and non-governmental organizations). One aspect examined, was the correlation between the documents over the period of 1983 to 2003, concluding that they are related knowledge products.

Other research that investigates likeness between outputs, with the conjecture that there is a "disconnection" between the scientific and technological production, was presented

by Keys and Albuquerque (2006). For the authors, this "disconnection" – in Brazil's health area - is related to the strong presence of health-related patents among the non-resident patents in the country (a fact substantiated by a false pretense that there is already a connection between the different productions in the country).

3 METHODOLOGICAL PROCEDURES

3.1 database and the recovering of periodicals/papers and patents

This research was limited to patent documents and papers related to biodiesel that were published/registered between 2000 and 2007. The source of information for the recovery of the patent was the database Derwent Innovation Index (DII). Searches were conducted on October 20, 2007.

Science Citation Index (SCI) of Thomson Reuters and Scientific Electronic Library Online (SciELO) databases were used to identify the papers, thereby limiting the search to scientific magazines of technology, health sciences, hard sciences, and earth sciences. The investigation in Science Citation Index (SCI) was made on February 20, 2009 and the one in the SciELO database on April 30, 2009.

3.2 Search Strategies

The choice of terms for the search was set through the analysis of a patent document sample. A preliminary search was performed using the term "biodiesel" for the title and abstract, and from evaluation of the responses, the relevant terms were selected.

From the selection of terms, the search strategy was defined. Thus, the search expression and the terms used for the recovery of patent documents were:

TS = (biofuel * AND fat) OR TS = (* AND biofuel oil) OR TS = (biofuel AND * fat *) OR TS = (bio-diesel) OR TS = (biodiesel) OR TS = (animal fat * AND * AND diesel *) OR TS = (animal oil * AND * AND * diesel) OR TS = (vegetation fat * AND * AND * diesel) OR TS = (vegeta * AND * AND diesel oil *) OR TS = (bio diesel)

After the search procedure using broad terms produced a number of patents related to biodiesel, the titles and abstracts were read and scrutinized to determine the real relevance of each document. After this preliminary step, it was possible to choose terms and define a more specific search strategy for the retrieval of papers. The terms chosen and the search strategy developed for the SCI database (later considered for recovery of articles in SciELO), was:

TS = (biological diesel *) OR TS = (biologic diesel *) OR TS = (vegetable diesel *) OR TS = (animal AND * diesel *) OR TS = (biodiesel *) OR TS = (bio diesel *) OR TS = (bio-diesel *) OR TS = (vegetable fuel * AND *) OR TS = (animal AND * fuel *) OR TS = (fatty acid biofuel AND * AND diesel)

3.3 Identification and characterization of countries and organizations

Patent´s documents. The organizational analysis was performed to identify and group the types of organizations (companies, universities, research institutes, public and private, etc.) that registered patents in the period of 2000-2007. The information was collected from the field Patent Assignee Name (s) and Code (s) (name of the applicants of the patent). In cases where a patent had more than one owner, a patent was computed for each.

The date used for graphing, drafting tables, and the analysis of countries and organizations was the priority year.

Journals/scientific papers. The analysis considered the organization in which the authors were affiliated at the time of the work's publication; the country of their connection, not their nationality. In cases where an article's authors were affiliated with different countries or organizations, an paper was computed for each country and organization.

a) Delimitation of the countries analyzed

On account of coverage limitations imposed by the DII database, the geographic focus of the analysis of biodiesel SP needed to be restricted. Thus, the indicators generated and analyzed include only countries whose patent office patents were indexed in the database at the time of the survey. In cases where countries were not mentioned, it was decided to exclude their data from analysis.

b) Identification of the country of origin of the organizations

Patent documents. The identification of the country of origin of the organizations was made by consulting the database *Sp@cenet*[2] *by the European Patent Office* (EPO). All documents were sought out by registration number, which was initially recovered through the DII database.

The information about organization's origin is easily recognized on the front page of Sp@cenet documents, but in some cases the data were not available, so the file needed to be opened to check the patent documents and identify them. In other cases, when the document

was not available in full text (in databases IBD and Sp@cenet), searches were carried out directly on the site of the country's patent office to confirm the origin of the organizations.

There have been rare occurrences of unavailability or difficulty identifying the names and/or countries of organizations/owners. In these cases, the priority country of the patent document was used.

Journals/scientific articles. The identification of the author's affiliation (organization and country binding) required no specific search procedures since the information is easily imported from databases. In cases of authors belonging to two or more organizations, it was decided to consider only their first affiliation.

For the identification of the country's productivity, the paper is computed only once per country. For example, a work that has five authors from the same country and another one from a second country, it would be counted as one product per country.

c) Standardization of organization's names

The standardization was performed by fist recovering the organization's websites, found through the Google search engine, between the months of October and December 2009. The full name of the company was collected from each page. It was decided to use the organization's name in English, except for those organizations whose original language was Portuguese. When the English name could not be located, the name remained in the original language of the organization. The name of the most important organization, hierarchically, was used.

If the company's web page was not found, but it had often been cited by other pages and documents, its nomenclature was completed. In other cases, where any website or mention about the business was not found, the original nomenclature presented in the databases (DII, SCI or SciELO) remained. Also, when it was observed that a certain organization changed its name or merged with another organization, the nomenclature was updated.

d) Standardization of countries

Country names have been standardized, opting to use the names in Portuguese. In the case of patents, the name UK (United Kingdom) correspond to a group of countries including Northern Ireland, Wales, England and Scotland. Concerning papers there's no sorting alike. Given this fact, we chose to group all items from the aforementioned countries as from Britain or the UK.

e) Typology of organization and sorting

To make comparisons between patent documents and scientific articles, it was considered essential to identify and sort the type of organization responsible for the documents. This information is not provided in the documents, therefore requiring more accurate research using other information sources. This information was retrieved from the web pages of each organization in the period between September 2009 and January 2010. When the webpage of the organization could not be found, but the name tag or abbreviation of it made its typology (commercial, industrial, educational, etc.) clear enough for identification, it was used.

The organizations were sorted into two categories: Education Institutions and Public Research Institutes (EIPRISs) and Companies and Private Research Institutes (CPRISs). Second reasoning given in Maricato (2010):

- Education Institutions and Public Research Institutes (EIPRISs): Involves universities and institutions of education and research (public, private and mixed), institutes and public research labs, public agencies in general (municipal, regional, federal, international), military education and research institutes, etc.
- Businesses and Private Research Institutes (CPRISs): Includes business groups and industries (public, private and mixed), nonprofit organizations (cooperatives, associations, non-governmental organizations), institutes and private research laboratories, etc.

When the web page of the organization could not be found, and neither the extension nor abbreviation of it made its typology clear, it was framed as "Unidentified."

3.4 Treatment and data analysis

Patent documents and papers retrieved through databases DII and SCI were exported to Reference Manager Software to check for possible duplicated data. The same check was made "manually" in the case of papers from SciELO. Subsequently, the data was exported to the spreadsheet software Microsoft Office Excel 2007 for standardization, refinement, field selection, variables crossing, tables and graphs preparation/analysis, and statistical calculations.

Graphical representations and interconnections patent index, articles, and its variables (countries, organizations, and types) were prepared using the UCINET software (version 6) and NETDRAW.

In order to study the relations between the SP and TP the Pearson product-moment correlation coefficient was used. According to Costa, "The term correlation means two-way

relationship (co + ratio) and is used in statistics to describe the force that keeps ´united´ two sets of values." (2005, p. 255) we usually put the citation after the quotation. The coefficient of determination (R2), which is closely related to the correlation coefficient of Pearson, was also used.

4 RESULTS AND DISCUSSIONS

4.1 Relation between country's paper and patent production

The number of papers published between 2000 and 2007 was 885 and the number of patents registered was 612. Therefore, the average number of articles per patent is 1.4. It is important to clarify that the coverage of patent databases and paper databases has different dynamics. While the DII base indexes all the patents registered by a country, the databases of journals/papers, in general, index just a relatively small number of journals and prioritizes those of the English language. Therefore, the proportions presented here cannot be misinterpreted.

The number of countries that published papers was 33 and those who registered patents 30, a difference of only 5%. The total number of countries with any kind of production was 35. Twenty eight countries, 80% of the total, had both patents and papers occurrences.

When investigating the correlation of production by countries, drawn from the rankings of each of the products (Table 1), there is a strong positive correlation coefficient (0.832) with a 69% index of determination. In addition to most countries being the same, there is a quantitative correlation between the production of papers and patents by countries.

Figure 1 gives a visualization of the displayed dynamic. The countries and their connections between the Scientific Production and Technology Production are represented. The productions are arranged in the center of Figure 1 by the red (patents) and blue (papers) squares. States are represented by circles, and the color green shows the ones with both products (co-occurrence). The countries shown in blue, on the right of Figure 1, are those that have only published papers. Countries on the left, in red, are those that have only registered patents. The thick line represents the quantity of productions (the thicker, the greater the number of papers published and/or patents by country).

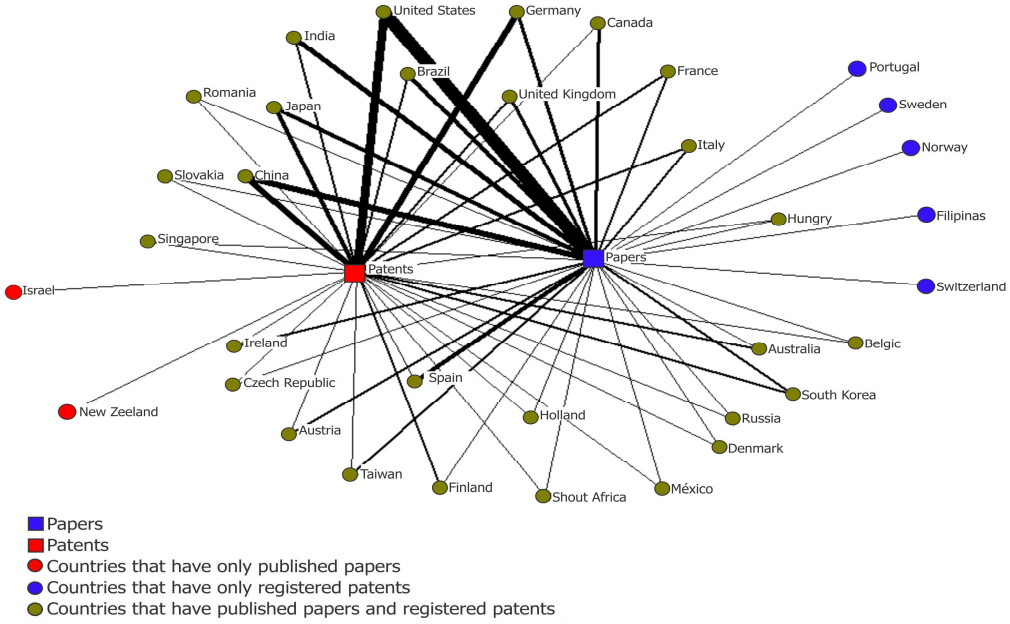

Figure 1: Developing countries of patents and papers in biodiesel and its relations.

The distribution of the SP and TP is more concentrated in countries that have both papers and patents (Table 1). The 28 countries with published papers and patents have a combined 937 papers (98% of published papers) and 616 patents (99% of all patents registered in the period).

When comparing proportions of papers and patents from countries that have both productions, the difference becomes even more evident. The average of published papers by co-active countries is about 33.5 and the average of patents is 22. The countries that have only published papers have an average of 3.4 (paper/country), and those who have only registered patents have an even lower average of 2 patents per country.

The number of papers is generally higher than the number of patents; the proportion is approximately 1.5 papers/patent (Table 1). There are some different cases. Among those who have higher quantities of patents, Germany deserves to be highlighted. It has approximately 2 patents/paper. China and Japan are two countries that also have more patents than articles. The average number of articles per patent in both countries is approximately 0.9 (1.1 patents/article).

Table 1 – Scientific and technologic production in biodiesel per countries

Country	Paper	% Paper	Patents	% Patent	Average of Papers / Patents
United States	242	25	140	23	1,7
China	100	10	113	18	0,9
Germany	53	6	107	17	0,5
Japan	66	7	71	11	0,9
Brazil	68	7	35	6	1,9
India	83	9	16	3	5,2
Spain	61	6	5	1	12,2
United Kingdom	42	4	10	2	4,2
France	27	3	24	4	1,1
Canada	43	5	7	1	6,1
Italy	33	3	11	2	3,0
South Korea	14	1	18	3	0,8
Taiwan	20	2	8	1	2,5
Austria	14	1	6	1	2,3
Australia	6	1	11	2	0,5
Finland	6	1	10	2	0,6
Ireland	11	1	2	0	5,5
Belgic	7	1	3	0	2,3
Holland	8	1	2	0	4,0
Hungry	3	0	6	1	0,5
Slovakia	7	1	1	0	7,0
Czech Republic	7	1	1	0	7,0
Romania	6	1	1	0	6,0
Singapore	4	0	2	0	2,0
Filipinas	5	1	0	0	-
Portugal	5	1	0	0	-
Sweden	5	1	0	0	-
Denmark	3	0	1	0	3,0
Shout Africa	1	0	2	0	0,5
México	1	0	2	0	0,5
Israel	0	0	2	0	0,0
New Zeeland	0	0	2	0	0,0
Russia	1	0	1	0	1,0
Norway	1	0	0	0	-
Switzerland	1	0	0	0	-
Total	954	100	620	100	1,5

Some countries stand out by having a higher number of published papers compared to patents numbers. Spain has approximately 12 papers per patent. Other countries in the same situation are Canada (6.1 papers/patent), India (5.2), and Britain (4.2).

The productivity analysis of biodiesel paper/patent production by country, establishes a strong relationship between the different productions, as well as a strong link between Science and Technology. The results of this analysis defend the thesis that the SP directly or indirectly influences the TP, and vice-versa.

It is not possible to fully understand the complexity of the structural connection or how information flows between the actors in the system just by analyzing the production data alone. Zitt and associates (2003) believe that geographic proximity facilitates interactions

among actors, depending on the type of knowledge involved. A classical hypothesis states that codified knowledge allows easy circulation and lower costs, and that tacit forms of information are more interchangeable in a closer geographical context. The authors defend that positioning creates a potential for exchange, reinforced by proximity and thematic expertise, but of course, does not guarantee communication or exchanges between actors.

Certainly, it is not possible to infer the existence of relations in all countries analyzed given the small yields. However, one agrees with Abramo, D'Angelo and Pugini (2008) about the significant correlation between the production of patents and scientific literature, in countries with considerable scientific and technological productions. They state that Italy is a different case, but here it is proven that it is indeed in alignment with Abramo's statement, because the country has an average of 3 papers per patent.

With the same perspective, Mu-Hsuan, Wan-Yu and Dar-Zen (2010) investigated, among other aspects, the correlation between concentration and productivity of papers and patents by countries. The authors consider that there exists a link between the productivity of scientific articles and patents, stating that they are affected by countries' policy scenarios and economic growth. In this research, the dynamics presented by the authors could be somehow justified, since there is a direct relationship between the countries and the production of patents on biodiesel.

4.2 Relationship between organization's paper and patent production

The number of organizations that published papers between 2000 and 2007 was 547 and the number of registered patents was 319. The number of organizations that published articles is 26% higher than those with patent deposits. Facing the largest number of articles published, and the different dynamics of scientific collaboration from technological collaboration, it was expected a higher number of organizations would have published papers in the period.

The examination of SP and TP data, using the displayed data on the ranking of biodiesel paper and patent-producing organizations divided by country and type, show that there is no linear connection between these two kinds of production. It means there is no quantitative link between them, since the co-relation coefficient is close to zero (0). This is certainly influenced by the fact that there is a large dispersion of paper and patent-producing organizations, which is in no way similar to a core of organizations exhibiting great productivity. The low correlation does not mean that there are not connections between the amounts produced by organizations, but one does not cause the other. On the other hand, it is

possible to make use of co-occurrence analysis of organizations in order to verify the existence of one producing both paper and patents.

The amount of organizations producing papers and patents on biodiesel is 809. The group can be divided into three subgroups: 1 - organizations that have published only papers (490, 61%), 2 - organizations that have published only patents (262, 32) and 3 - organizations that have published papers and patents (57, 7%).

Although only a relatively small 7% of organizations produced both papers and patents, it is considered to be sufficiently expressive to make inferences about the direct horizontal relations between S & T. These relationships could not be captured by separate analysis of the different productions, so they, therefore, have symbolic and quantitative importance.

There are other aspects and indirect links to be analyzed in order to achieve a deeper comprehension about the connection between S & T. Each of the three organizational groups mentioned can be again subdivided according to their types: CPRISs, EIPRISs and "Unidentified."

The number of papers and patents produced by each of these subgroups (CPRISs, EIPRISs and "Unidentified"), deserves to be presented. The data is shown in Figure 2. The egocentric network displays the relationship between the SP (paper) and the TP (patents) by type of organization.

In Figure 2, each circle represents an organization. The ones in red are the CPRISs and ones in blue are the EIPRISs. The green circles represent organizations categorized as "Unidentified". The productions are represented by squares, blue for papers and red for patents. The links between organizations (circles) and productions (squares) correspond to the type of production in which the organization has participated. These links are represented by lines, which also represent the amount of papers or patents issued/registered by the organizations. The thicker the line, the greater the number of papers/patents the organization has.

Therefore, the clusters formed correspond to organizations that have registered only patents in the top right corner, organizations that have published only papers in the bottom left corner, and organizations that have published both patents and papers (co-activity or co-occurrence) in the central cluster.

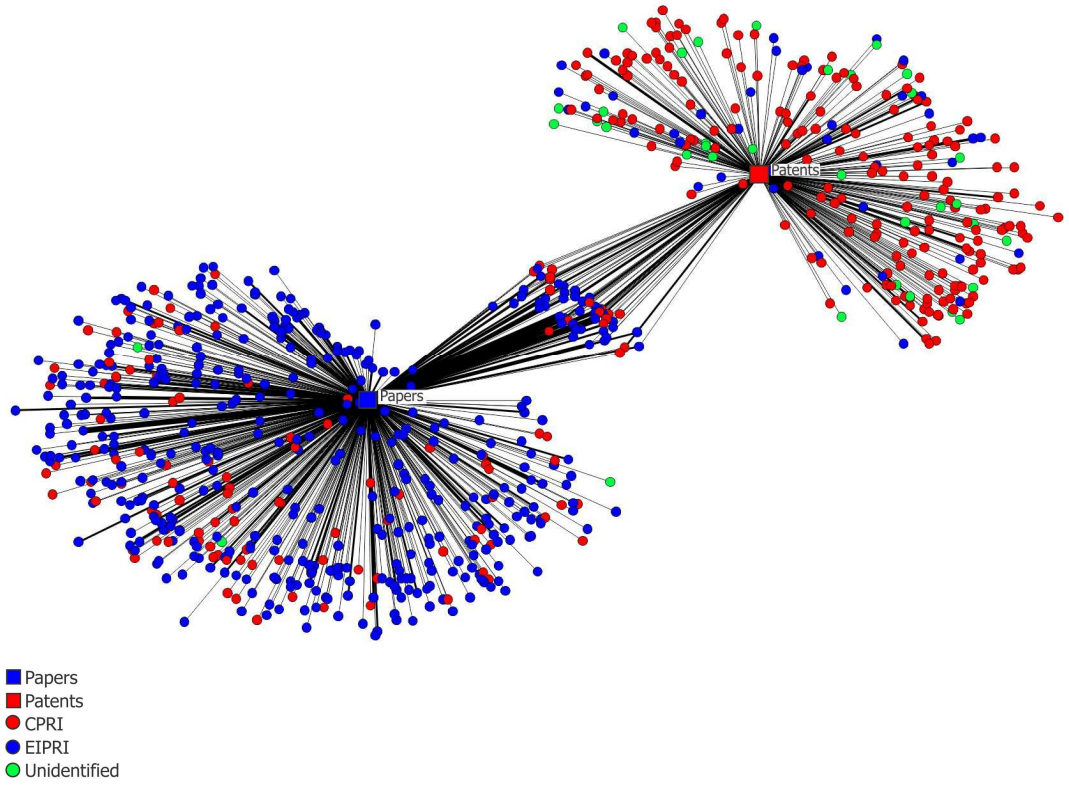

Figure 2: Biodiesel papers and patents producing organizations by types and their relations.

Figure 2 shows that organizations producing patents are predominantly CPRISs, organizations producing papers are predominantly EIPRISs, and organizations producing both articles and patents are distributed among CPRISs and EIPRISs, with apparent quantitative advantage for the second Another aspect that can be observed is that there are more patent producing organizations than paper in the “Unidentified” category. This scenario reflects the now widely-discussed problem of organization of databases, which is even more serious with patent documents than with scientific papers.

Although it is possible for there to exist a connection between the organizations and their paper and patent production on biodiesel, it is important to analyze it quantitatively, in order to have a better understanding of its dynamics.

Figure 3 shows the number of scientific and technological productions of each organizational group presented in Figure 2. Therefore, the data are sorted by kind of production (only patent, only paper, or both), and then by organization group (CPRI, EIPRI, unidentified).

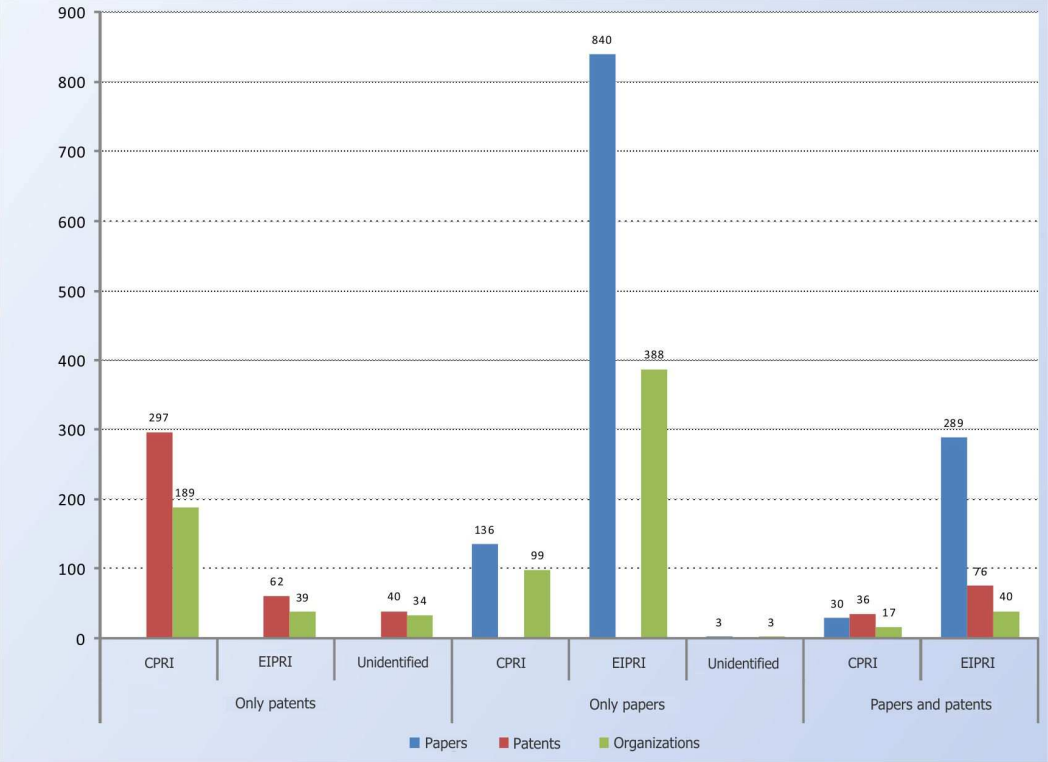

Figure 3: Organizations by type and their productions (only patents, only papers and both papers and patents).

The dynamics of organizations that have productions in both categories can be appreciated in Table 2, with a total number of 57 (7%). However, they have 319 (25%) published papers, which is more than the organizations that published only papers. This group had an average of 5.7 (papers/ organization), while the organizations that produced only papers had an average of 2.

Table 2 – Organizations which have papers and patents in biodiesel

Organization	Country	Paper	Patent	Category
United States Department of Agriculture	United States	58	1	EIPRI
Indian Institute of Technology	India	37	1	EIPRI
Iowa State University of Science and Technology	United States	17	1	EIPRI
Council of Scientific and Industrial Research	India	9	7	EIPRI
IFP - Innovation, Énergie, Environnement (Institut Français de Petrol)	France	1	13	EIPRI
Chinese Academy of Sciences	China	9	3	EIPRI
Mississippi State University	United States	10	2	EIPRI
Universidade de Brasília	Brazil	11	1	EIPRI
Beijing University of Chemical Technology	China	8	3	EIPRI
Complutense University of Madrid	Spain	10	1	EIPRI
Kyoto University	Japan	9	2	EIPRI
South China University of Technology	China	4	6	EIPRI
University of Saskatchewan	Canada	9	1	EIPRI
China Petroleum & Chemical Corporation	China	5	4	CPRI
National Research Council	Italy	8	1	EIPRI
Universidade Estadual de Campinas	Brazil	8	1	EIPRI

University of Nebraska	United States	8	1	EIPRI
Laser S.r.l.	Italy	4	4	CPRI
National Institute of Advanced Industrial Science and Technology	Japan	5	3	EIPRI
Ottawa University	Canada	7	1	EIPRI
Universidade Federal do Rio de Janeiro	Brazil	6	2	EIPRI
Ecole des Mines de Nantes	France	6	1	EIPRI
Petrobrás - Petróleo Brasileiro S.A.	Brazil	1	6	CPRI
Tohoku University	Japan	6	1	EIPRI
Cargill Inc.	United States	3	3	CPRI
East China University of Science and Technology	China	5	1	EIPRI
Universidade de São Paulo	Brazil	5	1	EIPRI
BASF	Germany	1	4	CPRI
Carnegie Mellon University	United States	2	3	EIPRI
University of Minnesota	United States	4	1	EIPRI
Dalian University Of Technology	China	3	1	EIPRI
Huazhong University of Science & Technology	China	3	1	EIPRI
Instituto de Tecnologia do Paraná	Brazil	3	1	EIPRI
Japan Energy Corporation	Japan	2	2	CPRI
Michigan State University	United States	3	1	EIPRI
Zhejiang University	China	1	3	EIPRI
Empresa Brasileira de Pesquisa Agropecuária	Brazil	2	1	EIPRI
Eni Spa	Italy	2	1	CPRI
Evonik Industries AG	Germany	1	2	CPRI
Fraunhofer-Gesellschaft	Germany	1	2	CPRI
Hitachi Zosen Corporation	Japan	2	1	CPRI
Indian Institute of Science	India	2	1	EIPRI
Tohoku Electric Power Co., Inc.	Japan	2	1	CPRI
Universidade Regional Integrada do Alto Uruguai e das Missões	Brazil	2	1	EIPRI
University of the State of Baden-Württemberg and National Large-scale Research Center of the Helmholtz Association	Germany	2	1	EIPRI
Agriculture and Agri-Food Canada	Canada	1	1	EIPRI
AkzoNobel N.V.	Holland	1	1	CPRI
BioPlastic Polymers & Composites LLC	United States	1	1	CPRI
Doshisha University	Japan	1	1	EIPRI
ExxonMobil	United States	1	1	CPRI
Indian Oil Corporation Ltd	India	1	1	CPRI
National Taiwan Normal University	Taiwan	1	1	EIPRI
Queen's University Belfast	United Kingdom	1	1	EIPRI
Research and Development Center in Transport & Energy	Japan	1	1	CPRI
Runyon Industries, Inc.	United States	1	1	CPRI
Universidad Nacional Autónoma de México	México	1	1	EIPRI
University of Delaware	United States	1	1	EIPRI
Total		**319**	**112**	

Comparing the data of the organizations with both productions to those with only patents, it can be observed that the co-actives also registered more patents than the latter. The 57 organizations are responsible for 112 patents (22%) and the 262 organizations that had only patents have 399 patents (78%). The proportion of patents per organization is slightly higher in the case of co-active organizations (an average of 2, while the other group had 1.5).

These results are consistent with the perspective presented in the work of Adams and Griliches (2000), and also Lach and Shankerman (2003), that according to Abramo, D'angelo and Pugini (2008), concludes that universities with the highest intensity of publication also have the highest intensity of patenting. From the percentages and ratios presented, it is possible to infer that there are stronger connections between S & T among these organizations, having interactions and mutual stimulation between the different productions.

The co-active organizations are divided into CPRIS and EIPRIS, with 17 from the former (2% of total) and 40 from the latter (5% of total). Besides having more organizations on EIPRIS, they are also more productive than the CPRIS ones. Organizations categorized as CPRIS published 30 papers (2%) and the EIPRIS published 289 (22% of total). The proportion of papers per organization of CPRIS is 1.8 and 7.2 for EIPRIS.

Regarding patent numbers, the dynamics are as follows: while the co-active CPRIS registered 36 patents (7%), the EIPRISs registered 76 (15%). The proportions are similar with both groups at approximately 2 patents/organization.

Data about organizations (CPRISs and EIPRISs) that have papers and patents on biodiesel show that there are direct and two-way connections between them and, therefore, a horizontal relationship between the S & T. However, observing the numbers, it becomes clear that EIPRISs have greater importance under the quantitative point of view.

Organizations that have co-occurrence of papers and patents on biodiesel are described in Table 2. The Pearson correlation analysis of these co-active organizations was performed in order to infer the cause-effect relation between paper and patent registration production and vice versa, and it proved to be practically nonexistent. In a similar analysis, Moura and Caregnato (2011) identified a significant correlation between papers and patents of authors/inventors and institutions.

5 CONCLUSIONS

The objective of the analysis of relations and interactions between the scientific and technological production was to investigate horizontal relationships (between patent documents and papers) between S & T. The analysis allows the expansion of the analytical scope when compared with the analysis of isolated productions (vertical). Vertical analysis provides basic results about the intersection of organizational types (CPRIS and EIPRIS), while horizontal analysis allows for the study of occurrences and co-occurrences between

documents and their variables. In this study we explored countries, organizations, and organization types.

Given the dynamic and presented correlations and co-occurrences, with greater or lesser degree among the variables (countries, organizations, and their types), it was found that there is a relationship between biodiesel scientific and technological production.

It is important to highlight that the interaction between science and technology can vary by area of knowledge, and that there are possible differences between the proportion of paper/patents among these areas. Accordingly, Meyer (2000) states that in statistical terms, it can be assumed that the health sector is an area where the proportion of papers/patents is high. As illustrated, it is compared with areas characterized as "low-tech", in which a patent may arise without any scientific publication to support it. Thus, it is deemed appropriate to conduct studies in other areas of knowledge and also using other approaches, so that we can better understand the relationship between S & T.

From the data presented throughout this study, it is concluded that the use of bibliometric and scientometric indicators can be useful to investigate the relationship between science and technology, with the establishment of comparisons between indicators of PS and PT regarding countries, organizations, and their typologies.

Finally, it is considered that Information Science, an interdisciplinary area, has the potential to contribute (without losing its disciplinary aspects inherent to the processes of searching, organizing and disseminating information) to discussions and studies, both theoretical and pragmatic, concerning the existing PS and PT information, as well as their relations and interactions.

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