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UNIVERSITY-INDUSTRY COOPERATION NETWORK IN ACADEMIC AND TECHNOLOGICAL PRODUCTIVITY

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Abstract

Knowing the gear of the triple-helix is fundamental to analyze the impact of public policies in the scenario of a country, especially when the variables linked to innovation refer to the chronological production of the facts. In this perspective, an analysis was assembled from intentional samples per regions of Brazil linked to the engineering areas, identifying indices that could demonstrate this evolutionary line, highlighting mainly in their numbers, the quantitative of patents of engineering deposited with and without the relation university-enterprise partnership (EU), with state mapping of the federation, public and private investments in P&D, patents with their respective classifications and scientific production of Engineering indexed to Scopus .It was concluded that from the years of 2005 with the Innovation Law there was a boost in these indices making It possible to understand that the numbers of articles began to scale a greater use for the production of patents, with emphasis on the South and Southeast universities of the country, although It is still a number that needs greater expressiveness for the country's future.

Keywords — engineering, innovation, patents, university-business

1. Introduction

Making efforts for innovation is the commitment that has been established over the years among Companies, Universities and Government, seeking the effective result to the Society in order to improve people's lives.

It is for this incessant search to improve, what this study aims to contribute with a technological mapping in network of cooperation between the entities promoting Education and Industry in the engineering sector, seeking the quantum of involvement in the correlation of inventors and scientific academies by states of federation, relation of these researchers and universities in isolation, the profile of patents given the size of the classifications produced by their respective actors, as well as the crossing of the chronological result of innovation growth and analysis of the academic production in Engineering as a reflection of the quantity of deposits.

In this way, It was sought to give greater knowledge among national institutions with data stratification on the evolution of innovation by a quantitative method with descriptive approaches of these variables, recognizing still a series of limitations to cover the whole scope, lacking even more a greater number of evaluations for the development and closing of the theme: university-industry cooperation network in academic and technological productivity.

2. Theories

Plonski (1992) defines university-enterprise cooperation as "a model of inter-institutional arrangement between organizations of a fundamentally distinct nature, which may have different purposes and adopt huge different formats", which according with Mota (1999) this process is a challenge that comes as a complement in the development of both members.

Etzkowitz (2002) presents a series of influences in the market with the mention of triple-helix (HT), demonstrating the evolution of knowledge with the participation of innovation actors: University, Enterprise and Government, highlighting the ascension of an entrepreneurial science.

It is also possible to highlight the role of open innovation with universities for the development of innovation, when It´s observed that this profile of innovation presents possibilities to generate a greater use in technological production, in the following words:

> More organizations fail to focus the entire innovation process on their internal teams and so, these organizations adopt an open innovation model, which similarly values both internal knowledge and external knowledge in the execution of R&D activities. One of the sources of knowledge outside the organization is the university, where research generates technologies that are increasingly being used by companies in the productive sector to develop innovations to be marketed in the market (BENEDETTI, 2011).

Ten years after the theory Etzkowitz (2002), studies by Carayannis and Campbell (2012) highlight an evolution of this model recognizing that although (HT) is the nucleus of formation for innovation, the insertion of a fourth and quintuple helix, with regard respectively to Civil Society, and the Environment can represent a new meaning for innovation.

In the study of Lopes (2015) It was possible to verify that the major barriers for the progress in the university-company relationship were mainly the bureaucratic aspects of the universities, while for the companies the index of the cultural differences was observable, although there is a relation fairly balanced in the demands for innovation between them.

Fabris (2016) points out in his model the Enterprise-University connection, listing 5 variables needed to be observed for the cooperative development of innovation, among which the following stand out: cooperation profiles, motivations, barriers, facilitators and satisfaction, "innovation from academic studies is seen as the best way to ensure the continuity of a business."

In the analysis of SOARES *et al.*, (2016) It was possible to emphasize that:

> [...] the increase in the number of patents required in Brazil (outputs) in recent years was mainly due to deposits made by non-residents. Among the deposits made by residents, the growth of requests by universities and research institutes stands out. This increase is largely the result of the creation of nuclei of technological innovation in these institutions, a direct consequence of the promulgation of the Technological Innovation Law (regulatory element), the main legal framework in the Brazilian academia-industry cooperation scenario (SOARES *et al.*, 2016).

Rosa e Frega (2017) investigate the actors in the technological transfer relationship, observing the so-called government stimuli to support innovation and partnerships with other institutions, while being able to identify barriers to researchers in the innovation process, such as: activities, lack of knowledge and lack of interest of researchers, deficiencies in the process of writing the patent and lack of human capital in the activities of the agency, bureaucracy and lack of support by the university.

In the current phase, Cornel, Insead e Wipo (2017) present the global picture of interaction between University and Company in the world scenario, standing out Brazil in the position of ranking 84 and a score of 37.4 points in front of the other countries. Of course, even 84 positions or at least 74 positions to be among the 10+ of a ranking of innovation will require an even greater effort in these U-E relations, requiring a lot of lubrication so that the gears of innovation can work with greater productive intensity.

(Federation of Industries of the State of Rio de Janeiro (FIRJAN), 2016) highlights the challenges for industry 4.0, pointing out the importance of training highly qualified professionals by academic institutions and research, strengthening relations with industry by focusing on issues such as smart strategic policies, government investments alongside industrial investors who carry vision and proactivity.

Taking an approach on the power of relation with networks of work or cooperation, It can be mentioned that:

> Network Science is a new and emerging scientific discipline that examines the interconnections among diverse physical, informational, biological, cognitive, and social networks. This field of science seeks to discover common principles, algorithms and tools that govern network behavior. (MATHIEU, 2017)

A clear view of the need for studies on the University-Company relationship from the point of view of innovation generation is present when Chang (2018) points out that:

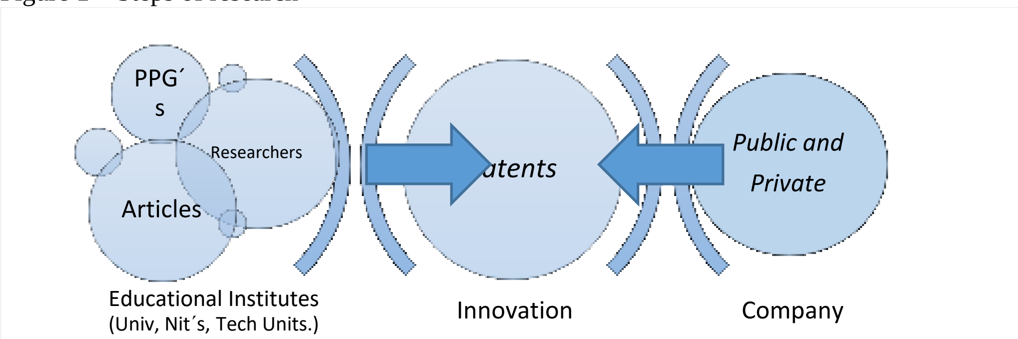
> Methods to link academic research achievements with innovative industries have gained considerable awareness worldwide in recent years. Subsequently, responding to industries' demand to reinforce the linkage between scientific research and industries is an issue awaiting urgent resolution for the government. Previous scientific pertaining to the linkage between scientific fields and (academic papers) technological fields (technology patents) primarily focus on non-patent research or university–industry collaboration. (CHANG, 2018)

3. Methodology

This study is part of an ongoing research project approved by CNPq, on the analysis of the technological production of researchers from federal universities in Brazil in the area of Engineering. For the data collection, a search was made in the Espacenet of all patents deposited in Brazil by title from 1976 to 2017. The university chosen for analysis was the federal university that had the highest number of patents per state, that is, chose a single university per state. Among the chosen universities, there were 3945 patents filed, selecting the patents in the areas of Engineering, which resulted in 1564 patents under analysis.

The research followed the selection stages of indexed articles and journals, information from researchers, graduate programs, private and state companies; which together form the pillars for the production of a patent, Figure 1.

Figure 1 – Steps of research



Sources: INPI (2018), OMPI (2018), Google Patents (2018), Capes Periodics (2018)

The data was organized, processed and tabulated with MS Excel Student 2013 support, as well as the software Vantage Point version 10 build 23603 (CEF3.2840.1518) and Gephi version 0.9.2.

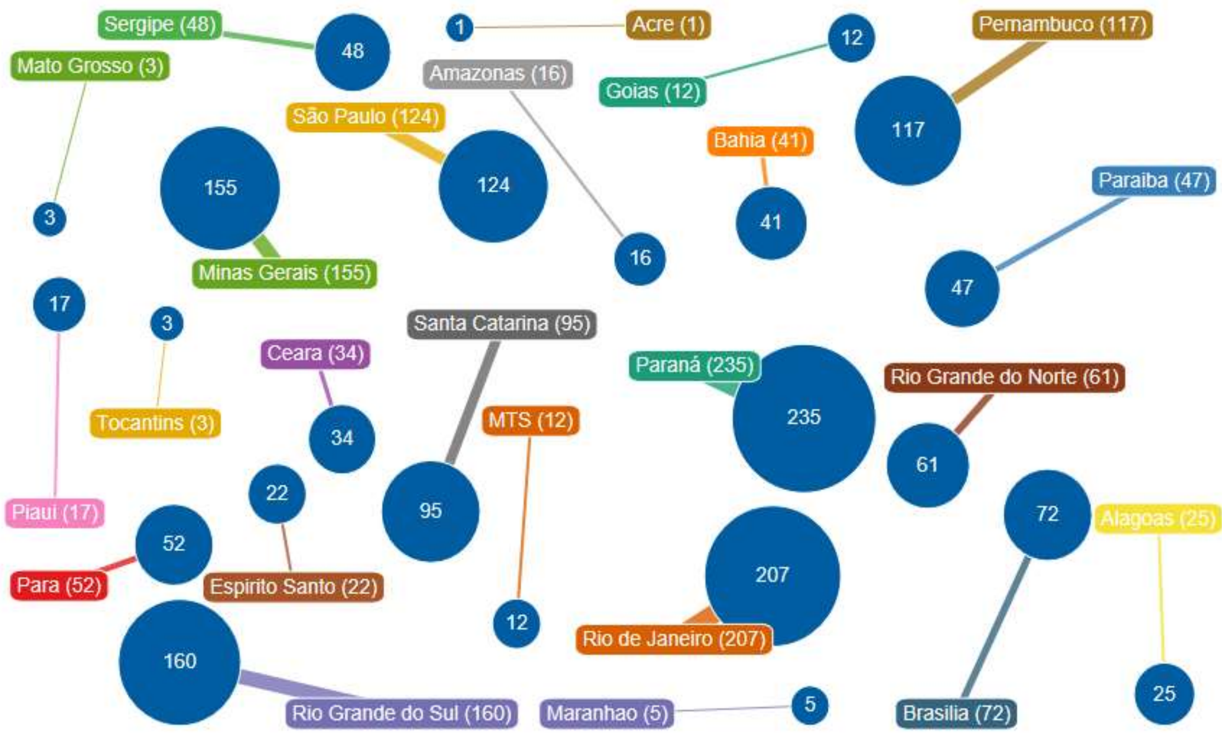
Evaluating the several variables related to the University-Company to the engineering, It was dimensioned as follows: a) Mapping of production of patents with or without partnership produced in Brazil in the period (Figure 2); b) Quantitative patents deposited and granted in the relationship with and without partnerships U-E. (Figure 3); c) Distribution of the type of partnership with federal universities (Figure 4); d) Applicants' relationship with the inventors generated in the Gephi software (Figure 5); e) Relation between inventors (Figure 6); f) Sizing of the main patent classifications found (Figure 7); g) Expenditure on innovation investments by both the public and corporate sectors (Figure 8); h) Number of scientific journals in engineering by period with percentage index in relation to world production (Figure 9).

4. OUTCOMES

a) Mapping of production of patents with or without partnership produced in Brazil in the period

In Figure 2, the universities with the highest number of engineering deposits are presented. Paraná was the university that most deposited in the country (235 patents), followed by Rio de Janeiro (207), Rio Grande do Sul (160), Minas Gerais (155) and São Paulo (124). These 5 states represent 56.34% of the total deposited. The university of Pernambuco (117) stands out in the Northeast and Brasília (79) in the Center-West. As for the North, Pará stands out with 52 patents, followed by the state of Amazonas with (16).

Figure 2- Mapping of required Engineering patents grouped by Federation State

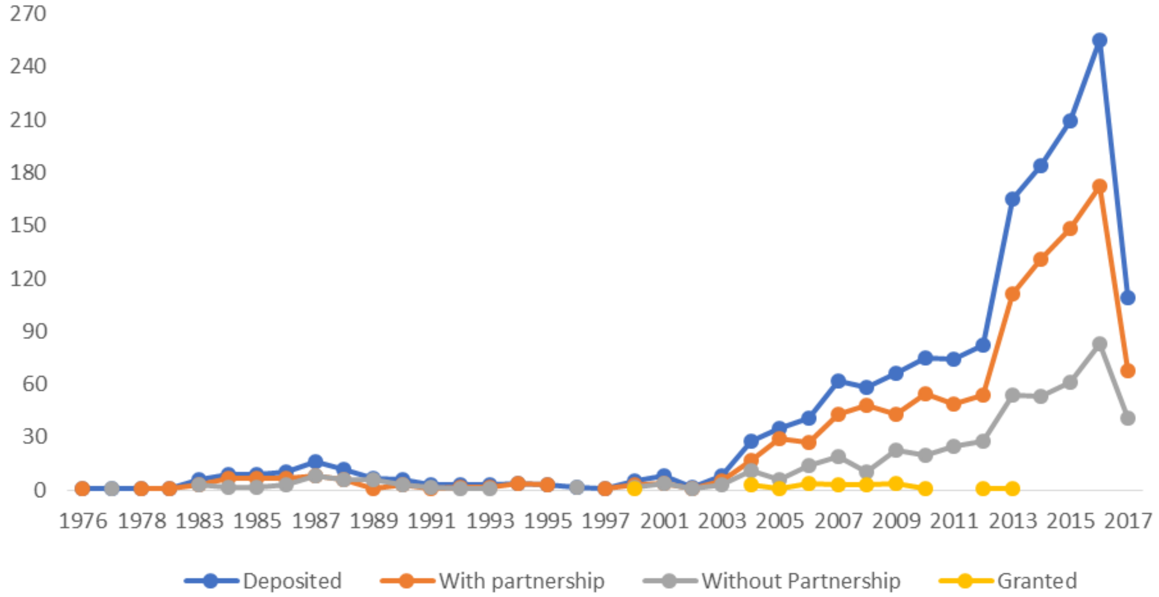


Source: Espacenet (2017); generation of image: Vantage Point.

b) Quantitative patents deposited and granted in the relationship with and without partnerships U-E.

According to Figure 3, the number of patents deposited reached its peak in 2016 (255 patents). Analyzing the 1976-2004 period, an average of 6.20 patents / year was registered, already in the period 2005-2017, the average was 108.8 patents / year. As for joint ownership, 61 patents were developed with partnerships in the period 1976-2004 and 437 in the period 2005-2013. In the period 1976-2017 a total of 22 patents were granted, 9 of them with co-ownership, or 40% of the total.

Figure 3 - Series of patents Deposited, Granted, Non-joint and with joint ownership

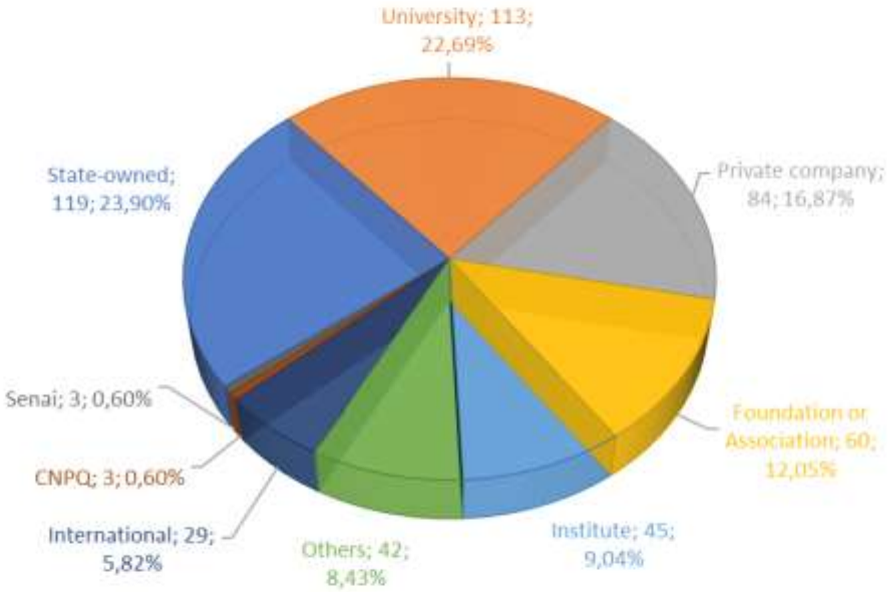


Source: Espacenet (2017); generation of image: MS Excel

c) Distribution of the type of partnership with federal universities

According to Figure 4, among the institutions that most deposited patents with joint ownership, the state companies had the largest share (23.90%), followed by other universities (22.69%) and private companies (16.87%). One can highlight Petrobrás and Embrapa among the state-owned companies that have signed the most partnerships.

Figure 4 - Institutions that have joint ownership of patents with the Brazilian Universities

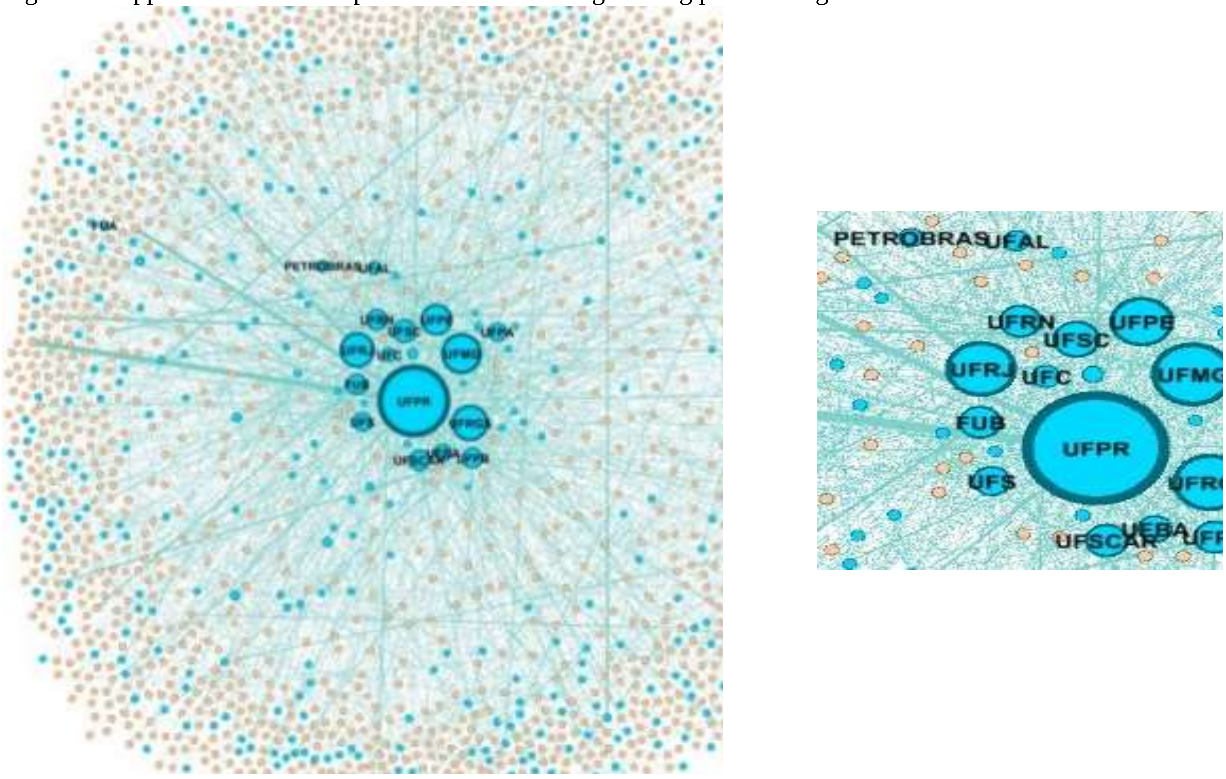


Fonte: Espacenet (2017); generation of image: MS Excel

d) Applicants' relationship with the inventors generated in Gephi software

With the aid of the Gephi software It was possible to make a list of the applicants with the inventors, in blue the applicants are and in orange, the inventors. In the center of the graph It is possible to observe the universities with the largest number of deposits, highlighting again for UFPR. Petrobrás appears as the main state applicant, Figure 5.

Figure 5 - Applicants' relationship with inventors of Engineering patent filing

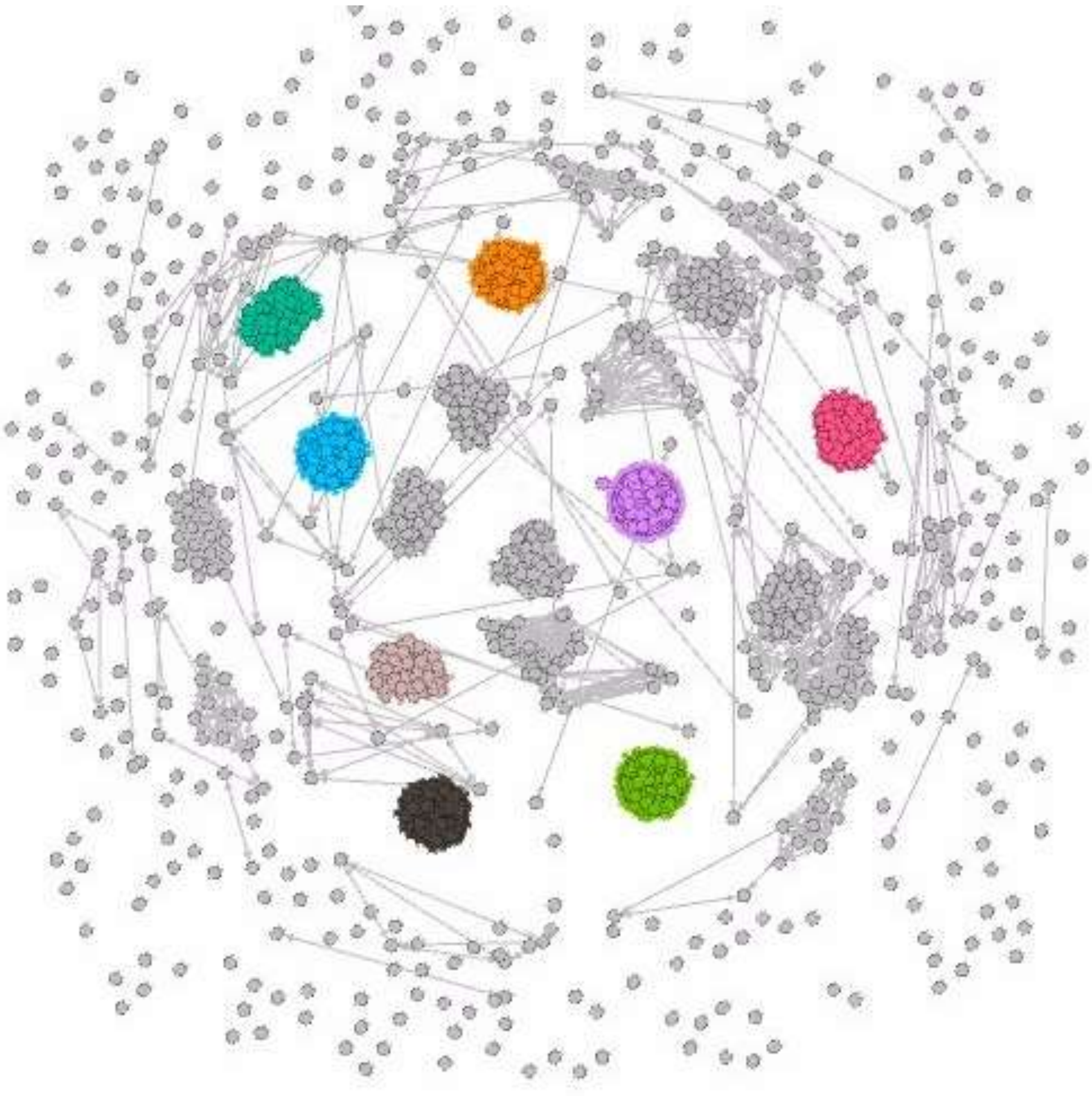


Source: Espacenet (2017); generation of images: Gephi

e) Relation between inventors

Again with the aid of Vantage Point (generation of the autocorrelation table) and Gephi, Figure 6 was generated, which represents the relation between the inventors. The larger circles represent a greater interaction among the inventors, being possible to verify several cluster of inventors. Elaborating a ranking of the 10 researchers with the largest number of deposits, 7 of them are from UFPR.

Figure 6 - Relation between inventors of Engineering patents

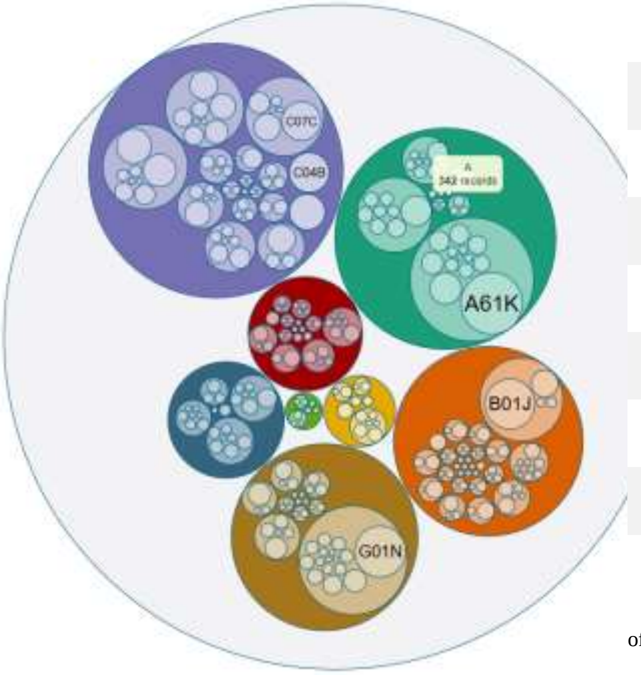


Source: Espacenet (2017); generation of image: Gephi

f) Sizing of the main patent classifications found

Amount of 1564 patents, the most prominent among patent classes, follow the respective quantifications: C (522), A (342), B (239), G (234), H (85), F (79), E 41, D (9) so that they stand out in their subclasses A61 - Medical or veterinary science or hygiene (214), G01 - Measuring and testing instruments (149), B01 - Physical or chemical processes or apparatus in general (99), C12 - biochemistry; beer; alcohol; wine; vinegar; microbiology; enzymology; genetic engineering or mutation (98), H01 - Electricity - basic electrical elements (28), E04 - Building (19), F16 - biochemistry; beer; alcohol; wine; vinegar; microbiology; enzymology; Genetic or mutational engineering (18), D21 - Paper manufacture; production of cellulose (4). See Figure 7.

Figure 7 - Circular diagram of patents by International Classification with emphasis on the greater quantitative of classes and subclasses



Classes	Sub classes	Main Items
A - 342	A61 - 214	A61K
B - 239	B01 - 99	B01J
C - 522	C12 - 98	C07C
D - 9	D21 - 4	D21H
E - 41	E04 - 19	E04C
F - 79	F16 - 18	F25B;F16L
G - 234	G01 - 149	G01N
H - 85	H01 - 28	H01M

* Classes - description of classes and the quantity of their respective patents;

** Subclasses - description of the subclasses with the highest quantitative among the subgroups;

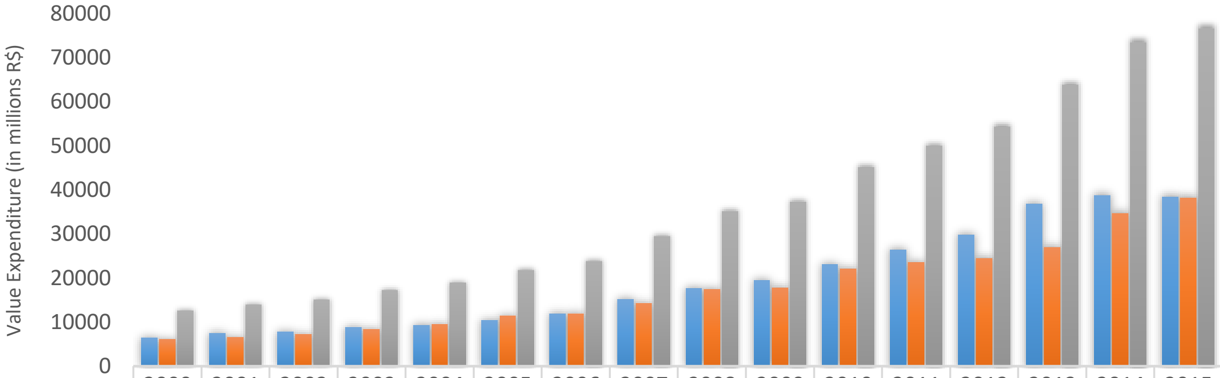
Main items represented within groups of sublcasses.

Source: Espacenet (2017); generation of image: Vantage Point

g) Expenditure on innovation investments by both the public and corporate sectors

In Figure 8, Public Expenditures (Federal and State) and Corporate Expenditures (private, state and postgraduate) (MCTIC, 2017). were measured. In 2015, Brazil recorded the highest R&D expenditure (R$ 76,531 million), an increase of 252% in relation to 2005, the graph also shows a similar growth of Public and Private expenditures over the years.

Figure 8 - Public, Business and National Total R&D Expenditures, 2000-2015



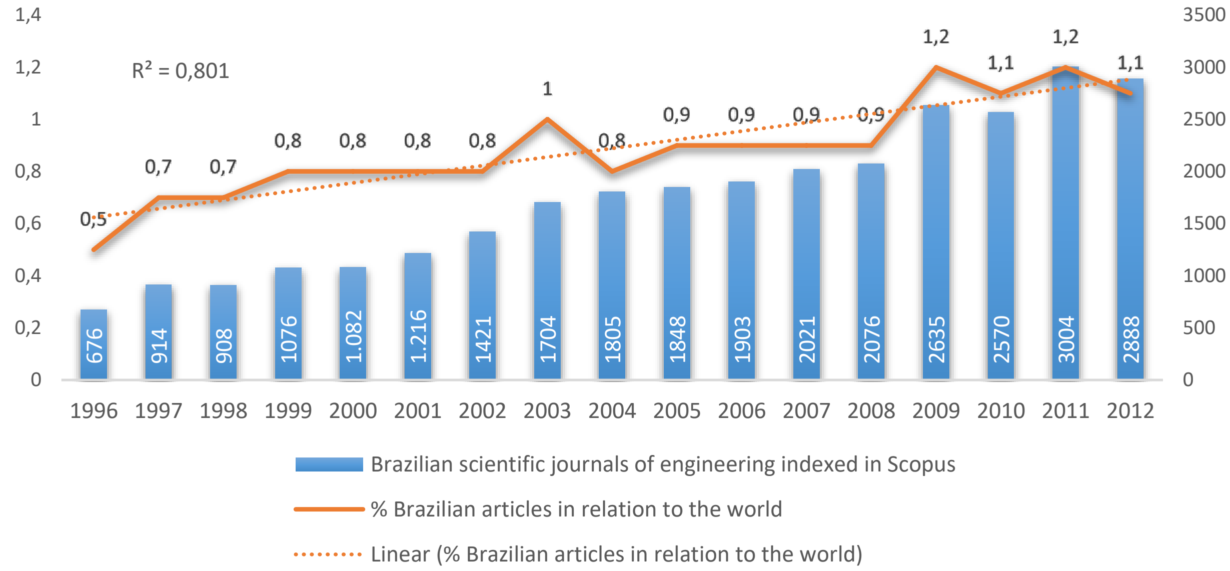
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
D.P	6494	7448	7761	8826	9335	10371	11911	15185	17681	19498	23039	26383	29803	36784	38743	38394
D.E	6067	6525	7271	8343	9526	11388	11896	14232	17430	17787	22034	23493	24452	26965	34645	38137
Total	12561	13973	15032	17169	18862	21759	23807	29416	35111	37285	45073	49876	54255	63749	73388	76532

Source: Ministério da Ciência, Tecnologia, Inovação e Comunicação (2017); generation of image: MS Excel.

h) Number of scientific journals in engineering by period with percentage index in relation to world production

As for the production of scientific journals in Engineering indexed to Scopus, the trend line, with $R^2 = 0,801$, shows a growth of national productions in relation to the world, as well as a 52% increase in scientific production between 2005- 2012. See Figure 9.

Figure 9 - Scientific Periodicals of Engineering indexed to Scopus



Source: Ministério da Ciência, Tecnologia, Inovação e Comunicação (2017); generation of image: MS Excel

5. Final considerations

The university-industry linkage in the field of engineering has made It possible to understand that there has been a massive effort by the EU together with the support of the Government, resulting in a general improvement with the support of the 2005 Innovation Law, generating a series of results with the increase proportional to the investments made, both for public and business expenditures, reaching:

- The South and Southeast were the leaders in patent development in Brazil, but with growth after 2005 proportional to the other regions;

- Average increase of patents with approximately 17 times the amount prior to the innovation law;

- Greater share of patent production by partnerships formed between universities, state-owned companies and private companies;

- In the list of applicants with inventors, Petrobras occupies a prominent position within the scope of co-ownership;

- The researchers from Paraná have 7 of the 10 largest developers of Engineering patents in the country;

- As for the patent profiles produced in these partnerships, It was understood that there was a prominence in biochemical production and genetic engineering and mutation;

- The total expenditure between the formed partnerships tripled, generating a growth of 252% in relation to the period of the Innovation Law (2005);

- The scientific production in engineering evolved significantly when analyzing its tendency in the regressive analysis with an index above 0.8.

Therefore, the formation framework of the triple-helix partnerships resulted in a national gain for innovation.

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