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EXTRACTION AND ON LINE AVAILABILITY OF INDICATORS RELATED TO SOCIAL RESPONSIBILITY, POPULARIZATION AND RESULT PROSPECTION OF RESEARCH IN NANOTECHNOLOGY IN BRAZIL

EXTRAÇÃO E DISPONIBILIZAÇÃO ON LINE DE INDICADORES DE RELACIONADOS À RESPONSABILIDADE SOCIAL, POPULARIZAÇÃO E PROSPECÇÃO DOS RESULTADOS DAS PESQUISAS EM NANOTECNOLOGIA NO BRASIL

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Abstract: *Scriptlattes* computational tool was used for extraction of performance indicators related to social responsibility, popularization and result prospection of research in nanotechnology in Brazil using as data source Plataforma Lattes and the CNPq Research Group Directory. Besides allowing for a quantitative evaluation of the bibliographic production on the matter, which used as base the number of published papers and book chapters, amongst other productions, the extractions have also allowed for the evaluation of indicators such as technological products, processes and techniques, related to the social responsibility in research, such as magazines and newspaper articles, linked to the popularization of Scientific results. Yet, the observation of indicators such as thesis and current research projects allowed the observation of prospective future results of current research in nanotechnology. Apart from the results related to the bibliographic productions, which can be found in several data basis, the tool makes available indicators in circular basis, which on turn, permit the prospect evaluation of future research results, as well as the evaluation of social responsibility and the popularization of research on the theme. The presented results may be replicated for any subject of interest, and may be used to guide future scientific research in the country.

Keywords: Scriptlattes, Social Responsibility, Popularization of Science, Prospective Analysis.

Resumo: O presente trabalho utilizou a ferramenta computacional *Scriptlattes* para extração de indicadores de desempenho relacionados à responsabilidade social, popularização e prospecção dos resultados das pesquisas em nanotecnologia no Brasil,

utilizando como fonte de dados a Plataforma Lattes e o Diretório de Grupos de Pesquisa do CNPq. Além de permitir avaliar quantitativamente a produção bibliográfica sobre o assunto, as extrações permitiram também avaliar indicadores como produtos tecnológicos, processos e técnicas, relacionados à responsabilidade social da pesquisa, assim como artigos em jornais de notícias e revistas, vinculados à popularização dos resultados da Ciência. Ainda, a observação de indicadores como dissertações, teses, supervisões de pós-doutorado e projetos de pesquisa em vigência, possibilitaram avaliar prospectivamente os futuros resultados das atuais pesquisas em nanotecnologia. Além dos resultados relacionados às produções bibliográficas, que podem ser encontrados em diversas bases de dados, a ferramenta disponibiliza indicadores disponíveis apenas em bases curriculares, que permitem avaliar prospectivamente os futuros resultados das pesquisas em andamento, além de avaliar a responsabilidade social e a popularização das pesquisas sobre o tema. Os resultados apresentados podem ser replicados para qualquer assunto de interesse, que por sua vez poderão ser utilizados para nortear o futuro da pesquisa científica no país.

Palavras-chave: Scriptlattes , Responsabilidade Social, Popularização da Ciência, Análise Prospectiva.

1. Introduction

Mapping of scientific activity in nanotechnology is relevant for the comprehension of the past, present and future research agenda. A considerable amount of scientific production on this theme may be found in the national and international bibliographic basis. However, the information on doctoral thesis and masters' dissertations, as well as post-doc supervisions and research projects under current supervision (which allow for a prospect evaluation of future results of the current research), apart from information on technological products, processes and developed techniques (that are indicators related to social responsibility in research), and the material published on newspapers and magazines (indicators associated to popularization of Science) cannot be found in bibliographic basis, they can only be found in the CV of researchers. As the web users is growing exponentially, the development of fast and accurate search tools proves to be extremely necessary

Based on the problem exposed above, some questions arise: Has the production of research groups in nanotechnology, particularly of those publically funded, been enough to leverage the research on this theme in the country? Have the developed research projects, registered research groups, thesis, dissertations and supervisions, as well as the originated publications been qualitative and quantitative compatible with Brazilian needs? Can the return on nanotechnology research be considered enough? Can the actual research on nanotechnology effectively fulfil future needs of the country around this theme? Apart from the questions here exposed, the advances in nanotechnology represent a great concern for many countries, especially Brazil. Hence, it is necessary to identify and organize the scientific production about this theme in the past decades, with the main objective of evaluating if the efforts in research done in recent years, especially that made with public funds, has produced the expected return for the understanding of a priority subject for the nation. In this sense, the aim of present paper is to make use of the

computational tool *Scriptlattes* for the extraction and *on line* availability of performance indicators related to social responsibility, popularization and result prospection of research in nanotechnology in Brazil.

2. Literature Review

2.1 Nanotechnology

Nanotechnology may be understood as the comprehension, control, processing and characterization of matter of dimension typically of 0.1 to 100 nanometres (nm), which constitutes an area of great interest in the context of science and engineering, with great potential of promoting innovation of impact to society (KOSTOFF; KOYTCHIEFF; LAU, 2007).

Different segments, such as agribusiness, energy and medicine have already benefited from the technology of manipulation at a molecular level. Due to the importance of the theme, the Brazilian government has previewed investments of the order of 1.5 trillion dollars until 2015. Already in 2013, a program of investment of 440 million reais (144 million dollars, approximately) was launched by the Ministry of Science, Technology and Innovation with the goal of stimulating Brazilian research on the matter, which constitutes priority for the country (CRISTALDO, 2013). Thus, knowing the main research groups of research in nanotechnology, identifying its components, understanding the evolution of publications on this issue in the past decades, evaluating the return to society, as well as predicting what the next results will be, will allow for the elaboration of a complete profile of the current panorama of research in nanotechnology, allowing, on turn, for the creation and reformulation of strategies that aim at leveraging research on this theme.

2.2 Universities, research and funding

In Brazil, the research brought about universities are the main responsible of scientific and technological development, as well as in countries such as the USA, where 73% of the information that fundament patent requests come from publications in the academic sector, against 27% of researchers from industrial background (NARIN; HAMILTON; OLIVASTRO, 1997). In this sense, the scientific and technological development of a country may be measured by the approval of patents and publication of scientific papers highly cited. The National Post-graduate Programme (SNPG *in Portuguese*) needs to form competent teachers and excellence researchers in all areas of knowledge, which assumes a permanent commitment to scientific rigour and to ethical, social, economic and cultural results. SNPG may be considered a strategic axis to scientific and technological development by the Federal Government, and the evaluation of the Coordination of Betterment of People in

Higher Education (CAPES *in Portuguese*), a mean of policy formulation that allows for objectives towards the whole society.

Despite the work of CAPES and SNPG, some inquiries become evident: is it possible to measure how much intellectual production of research in Brazil has contributed to the decrease of social inequality and the betterment of the quality of life of the population, as well as economic development in the country? Items such as personal, methodological / commercial, international, political and institutional interest influenced the path of Brazilian research? Have the research projects supported by public funds been distributed in order to contemplate subjects and regions in more need in terms of results? Have the research on important issues such as nanotechnology been accomplished and fomented according to the needs of the country? Which would be the source of information that allow for the search of answers to this questions?

2.3 Data and information sources

To answer the last of the questions proposed above, one must consider that Brazil possesses a depositary of Brazilian scientific production that also registers foreign researchers that collaborate with Brazil. This system is, until now, used mainly for individual, research group evaluation and management of researchers. With its own characteristics, this system constitutes a *big data, open data* depositary, which belongs to *deep web*. Amongst the several components of this system one may highlight Plataforma Lattes and the Directory of Research Groups of CNPq.

2.3.1 Lattes Platform

This is a circular basis, created by CNPq, which consists of an aggregation of informational systems, databases, portals and knowledge systems used towards mapping the national competences in research and funded actions in C, T & I (Science, Technology and Information *in Portuguese*). Plataforma Lattes represents the experience of CNPq in the integration of the dataset of curricula, of Research Groups and Institutions in one unique Informational System. Its current dimension does not only extent to planning, management and operations of funding of CNPq actions, but also includes other agencies of federal and regional funding devoted to science and technology, of higher education and research institutes. Furthermore, it has become strategic not only for the activities of planning and management, but also the formulation of policy of the Ministry of Science and Technology and of other governmental bodies in the area of C, T & I (MCTI, 2014). In 2012, Plataforma Lattes had approximately 2 million registered curricula (ALVES; YANASSE; SOMA, 2012). Currently, it is believed that the number spins around 2.4 million curricula between undergraduates, graduate and PhD holders, adding up to more than 19 million scientific productions. Data offered

by the Plataforma itself inform the presence of 119.402 PhD holders registered, half of them in the southeast region of the country (<http://estatistico.cnpq.br/painelLattes/mapa/>).

2.3.2 Directory of Research Groups of CNPq

The Directory of Research Groups of CNPq constitutes a data source that contains information on the activities of research groups in the country. The Directory maintains an actual base, in which the information is updated continually by the research group leaders, researchers, students and directors of the participating institutions. CNPq, on its turn, performs biannual census that are a photograph of the current basis. The inventoried research groups are localized in universities, isolated higher institutions, scientific research institutions, technological institutes and research and development laboratories of State-owned or previously State-owned enterprises, not including the groups localized in companies of the productive sector (<http://lattes.cnpq.br/web/dgp>).

2.4 Automation tools in the search of curricula and scientific production

The major available web searchers are generic, often disregarding more specific interests of its users (MA; PANT; SHENG, 2007). In this sense, as the amount of information available on the web is growing exponentially, the development of fast and accurate search tools now has become an important priority (MOURA et al., 2008). Plataforma Lattes and the Directory of Research Groups of CNPq store the information deposited in the environment *deep web*, a “region” of the *internet* that cannot be accessed by natural searchers used to navigate the surface of the *web*, which makes it difficult the extraction and organization of the information present in both platforms. They are Sucupira (ALVES; YANASSE; SOMA, 2011), *Lattes Extrator*, *Lattes Miner* (ALVES; YANASSE; SOMA, 2012), and *Scriptlattes* (MENA-CHALCO; JUNIOR; MARCONDES, 2009).

The *software* Sucupira constitutes a computational system that performs the extraction of the information in Plataforma Lattes, with the main goal of offering the Coordination of Betterment of People in Higher Education (CAPES in Portuguese) information on scientific production of *Stricto Sensu* Graduate Programmes (ALVES; YANASSE; SOMA, 2011). *Lattes Extrator* is a tool developed by CNPq itself in which previously enrolled institutions may extract from Plataforma *Extraction and on line availability of indicators related to social responsibility, popularization and result prospection of research in nanotechnology in Brazil*.

Lattes information relative to its faculty, student body and other collaborators, characterizing, therefore, a tool restricted to certain institutions. *Lattes Miner* consists of an automated tool, of public domain, that may be used to extract information from Plataforma Lattes

with regards to indicators of performance of faculty members, researchers, students and Post-Graduate Programmes (ALVES; YANASSE; SOMA, 2012). Lastly

Scriptlattes, besides being of public domain and allowing for the extraction of the academic production of a certain group of researchers, is also capable of organizing such information, eliminating production redundancy, generating reports and charts associated to the different kinds of scientific production, creating graphs of geolocalization, building networks of collaboration between researchers, among other functionalities, making such information available in the format of files that may be sent to a server and accessed as *web* pages, which may be consulted by any individual interested in accompanying the evolution of a Post-Graduate Programme, a course, a research line or the career of a particular researcher, or even the evolution of research on a certain subject, which becomes organized and easy to understand, contributing strongly to transparency in research (MENA-CHALCO; JUNIOR; MARCONDES, 2009).

2.5 The tool *Scriptlattes*

Scriptlattes is a computational tool, free to use, that works in personal computers equipped with *Linux* (once up to the present time *Windows*. does not have all the necessary libraries for its operation). The tool is capable of downloading Lattes CVs of a group of researchers enrolled in CNPq, extracting from this CVs academic and professional information judged necessary, excluding redundancies and creating reports by type of production, apart from generating collaboration and internationalization graphs relative to the list of researchers provided by the tool (MENA-CHALCO; JUNIOR; MARCONDES, 2009). Several experiments using *Scriptlattes* have already been performed for the referred extractions, for instance, aiming at identifying basic competences in nanotechnology (FERRAZ; QUONIAM, 2014a), in dengue fever (FERRAZ; QUONIAM, 2014b) and related to the *Stricto Sensu* Post-Graduate Programmes (FERRAZ et al., 2014; FERRAZ; QUONIAM, 2015; FERRAZ; QUONIAM; MACCARI, 2014).

This studies, conducted using the *Scriptlattes* computational tool, were important in the sense that allowed to know who were the principle investigators involved in the nanotechnologies and *Stricto sensu* management researches in the Brazilian territory. In this sense, the aim of the present study is to complement the previous studies, allowing to gain further insight regarding, essentially, the nanotechnology's Brazilian academic and technique productivity. To know the state of the art of nanotechnology academic and technique productivity will allow to measure how much investment will be needed if the results are not corresponding to the nation necessities.

3. Methods

The basis for the use of the computational tool *Scriptlattes* is described briefly in the next few paragraphs. It is a web crawler that works. In general, the tool creates *html* pages with *links* to access secondary pages containing information related to researchers existing on the lists that feed into *Scriptlattes* at the beginning of extractions. In this phase one may inform the program the type of production one wishes to extract, as well as define the evaluation period of the referred production. The internal mechanisms of processing of *Scriptlattes* are complex, require advanced knowledge of the *Python* programming language and, once outside the scope of this paper, were suppressed in the present work. However, any information regarding more detailed informatics, as well as the step-by-step for replication and adaptation of the methodology here proposed may be easily obtained in the original work of Mena-Chalco, Junior e Marcondes (2009).

Scriptlattes is based on the sequential execution of some computational module based on a list made manually (in the case of the analysis of specific curricula of individuals already known, such as of those belonging to a Post-Graduate Programme for which one wants to see the production indicators), or automated (when the list is made using as a basis the research on keywords of the search engines in Plataforma Lattes and the Directory of Research Groups in CNPq, method employed in the current experiment involving nanotechnology).

The first module of the tool extracts directly from Plataforma Lattes the curricula that one wishes to analyse. On a second stage, there is a pre-treatment of the data based on the analysis of redundancy of productions registered by researchers. Thirdly, collaboration charts between group members and bibliographic, technical and artistic production reports are made, as well as supervision academic reports. Such information may be used by *Scriptlattes* for the confection of files transformed into *html* pages (language of marking for hypertext used to produce webpages), and that can be made available under an address on the *internet*. Even though collecting data directly from the *Lattes* database is not possible, a series of computational procedures allow for the information from the CVs to be recovered, based upon public data issued by the Plataforma itself. Each researcher registered at the Lattes base has a unique 16-digit code, which provides straight access to a *web* page where the CV of that given researcher is stored. From there extractions are possible.

The results offered by the tool consist of a series of reports containing information related to the bibliographic, technical and artistic production, as well as supervisions, collaboration and geolocation maps of the members listed in the entry file, besides collaboration networks of researchers and analysis of the titles of produced publications. For the elaboration of entry lists specifically for *Scriptlattes* in this experiment, containing names and Lattes IDs of the researchers in nanotechnology in Brazil, an advanced search of the matter was performed, using the terms specified in the Y axis of Figure 1, while in the X we have the number of

selected curricula for each of the criteria. The recovery curve identified at this stage permitted the creation of an expression specific for the area.

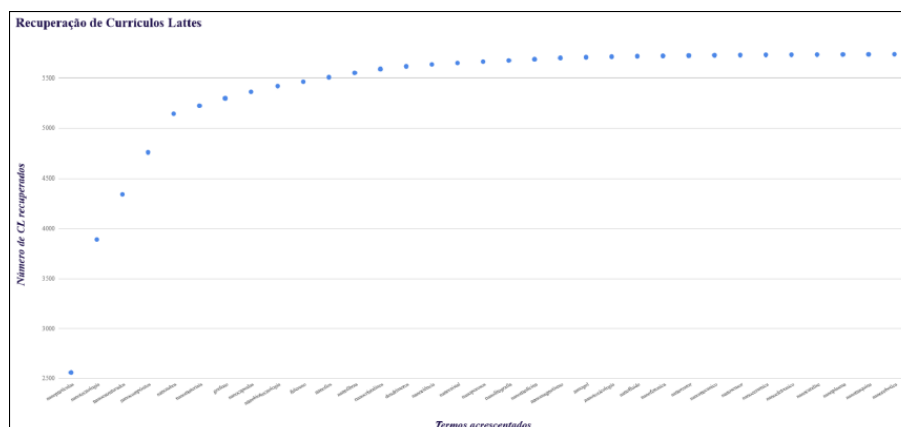


Figure 1

Results curve for retrieving IDs of researchers in nanotechnology in Brazil

Source: <http://vlab4u.info/nanotecnologias/>

In continuity, as exclusion criteria, the researcher had to hold a PhD, regardless of whether he or she is Brazilian or foreigner, belong to a research group with the descriptor “nanotechnology”, correctly registered in the National Directory of Research Groups of CNPq, which allowed for the extraction of a list with the so called “*core competences*” in nanotechnology in the country, that is, a list containing the researchers that possess some kind of descriptor existing in Figure 1 in their CV, as well as being registered in a CNPq research group that also had one of the descriptors. In a second phase, we have verified who were the researchers that had some type of partnership with researchers of the *core competences*, even if not enrolled at a research group registered in CNPq with one of the descriptors of Figure 1. To this group of researchers, one has named “collaborators level 1”, or *core competences* 1. Extractions would be possible until level 2, 3 or 4. However, due to the limited space for the presentation of results, we have opted to present the current experiment only with regards to the group of central researchers (*core competences*) and their direct collaborators (*core competences* 1). With the lists of names and Lattes IDs of the researchers, the processing of the information was brought about by the execution of sequential functioning modules. The first module *downloaded* the curricula, dedicating special attention to the publication of scientific publication in peer-review journals. Afterwards, the professional address and the remaining production, done and on-going supervisions, as well as photo collection (when present in CV Lattes) was performed, with the objective of treating for redundancy and exclusion of the redundant production. At a fourth stage of processing, several charts were generated; with special highlight to those which function was to demonstrate a network of collaboration between members in the entry list, taking into account the most relevant scientific production, beside presenting bar charts with the numeric evolution of the production of each kind through the past decades. In the fifth phase, a geo-location map based on the

address informed by researchers in Plataforma Lattes was generated. Lastly, several *html* pages were produced, according to the type and year of publication and sent to an *internet* server in order to be available for consultation.

The research groups were selected according to the curricular *core competences* criteria, as proposed by (DE MAGALHÃES et al., 2014). The concept of *core competences* consists of the construction of a sample that unites essential competences of a given theme. The model of essential competences adopted was that of Prahalad e Hamel (PRAHALAD, 1990; PRAHALAD; HAMEL, 2006), which defines them as a group of abilities and technologies that enable a company to provide a certain benefit to its clients, more than an ability or technology. These essential competences come from organizational competences, which, on turn, are obtained through the existence of specialist individual personal competences (*core*). To certify that the researchers belonged to a research group related to nanotechnology registered in the Directory of Research Groups of CNPq, an auxiliary *Script* named *ScriptGP*, a *Script* in *Python* language that extracts Lattes IDs of all researchers belonging to these groups and that allows for a comparison between Lattes IDs existing in research groups and those recovered from the search engine of Plataforma Lattes. Thus, the researchers that existed in both lists composed the official final list used for the extraction of data from the curricula directly from Plataforma Lattes.

4. Results

4.1 General View

Figure 2 shows the main *html* page, where the links to several other *html* pages may be visualised. The latter contain total lists of the production indicators of researchers selected by *Scriptlattes* according to the criteria established for *core competences*. In this page, one may obtain access not only to the review presented in Figure 3 (by accessing the link “Review” in Figure 2), but also to technological products, processes and techniques (which refer to social responsibility in research, that is, the real return that research offers to society), to texts published in newspapers and magazines (that on an aggregate level determine what is called popularization of research), to on-going research products, post-doc, PhD and Masters supervisions (which allow for a prospective view of current research), apart from the geo-positioning of researchers and the networks of collaboration established between them. To have access to this information, one only needs to click on the link “collection and presentation of *Scriptlattes*”, or even the specific links for such, all available in Figure 2.



Figure 2

Access to production indicators of researchers in nanotechnology

Source: <http://vlab4u.info/nanotecnologias/>

To illustrate the analysis performed by *Scriptlattes*, Figure 3 brings the results from the extraction of the curricula deposited in Plataforma Lattes, which possess, at the time of the analysis, one of the descriptors presented in Figure 1 in any kind of production registered. In this figure, one may verify that, from the researchers included in the above-mentioned criteria, 12,237 held a PhD title, of which 1,521 possessed a Productivity in Research Scholarship, 1,438 had the scholarship and were inserted in a Research Group with one of the descriptors, and 1,915 only were in the Research Groups with the descriptors, being considered for the present experiment as members of *core competences* in nanotechnology.

Researchers that had the descriptors in their CVs, however, in a publication in partnership with researchers of the *core competence* were considered “*core competences* collaborators”, and composed *core competences* 1. To visualise the data described, also presented in Figure 3 below, one must click in the link “*Review*”, found in the upper part of Figure 2.

Nanotecnologias					
	Cr�terios Identificados	Curric�ulos	Curric�ulos sem GP	N�mero total de colaboradores	Grupos de pesquisa
	Doutores e demais Brasileiros e estrangeiros	12237	1473		
	Doutores Brasileiros e estrangeiros	5810	1185		
	Doutores Brasileiros e estrangeiros com grupo de pesquisa	5518			31070
	Doutores Brasileiros e estrangeiros com grupo de pesquisa "nano"	4673			
"Core competencies"	Doutores Brasileiros e estrangeiros com grupo de pesquisa "nano"	1915	NA	30316	691
	Doutores Brasileiros e estrangeiros com bolsa produtividade	1521			
	Doutores Brasileiros e estrangeiros com grupo de pesquisa e bolsa produtividade	1438			
"Core competencies 1"	"Core competencies" e colaboradores	4288	963		

Figure 3

Review of core competences and core competences 1 in nanotechnology in Brazil

Source: <http://vlab4u.info/nanotecnologias/>

By clicking on the link "*Collection and presentation of Scriptlattes*", present in Figure 2, gives access to the *html* page presented in Figure 4. On it, one may see new *links* that direct to the main production indicators in nanotechnology. Through the *links* indicated by number "1", one can access a series of indicators that constitute the bibliographic production of researchers, such as, a list of complete papers published in journals, published or organized books, chapters in books, newspaper and magazine pieces, complete papers and summaries published in conference proceedings, papers accepted for publication in journals, presentation in events, apart from prefaces, postscripts, monographs, guides, amongst others. Such results, which constitute the bibliographic production in nanotechnology in the country, as well as the collaboration networks between these authors, were already presented to the scientific community (Ferraz, Quoniam, & Alvares, 2014; Ferraz & Quoniam, 2014), and do not constitute the main focus of this paper.

The *links* presented as number "2" provide access to pages where one may evaluate the technical production, including technological products, processes and techniques, technical work, amongst others. On their turn, the links referred to as number "3" give access to pages of indicators related to supervision of different nature, both the on-going as well as the past, meanwhile, number "4" points the *links* to access pages containing indicators referring to research projects, prizes and awards, participation and organization of events and internationalization of research. Finally, number "5" indicates the geo-localization mapping of researchers in nanotechnology, using the informed address provided by them in Plataforma Lattes. Once the present experiment has focused on presenting the results related to social responsibility, popularization and prospection of research results in nanotechnology, the indicators on bibliographic production, some items shown in number "2", "3" and "4", as well as the geo-location map of the researchers and the past supervisions were not contemplated in the results section.

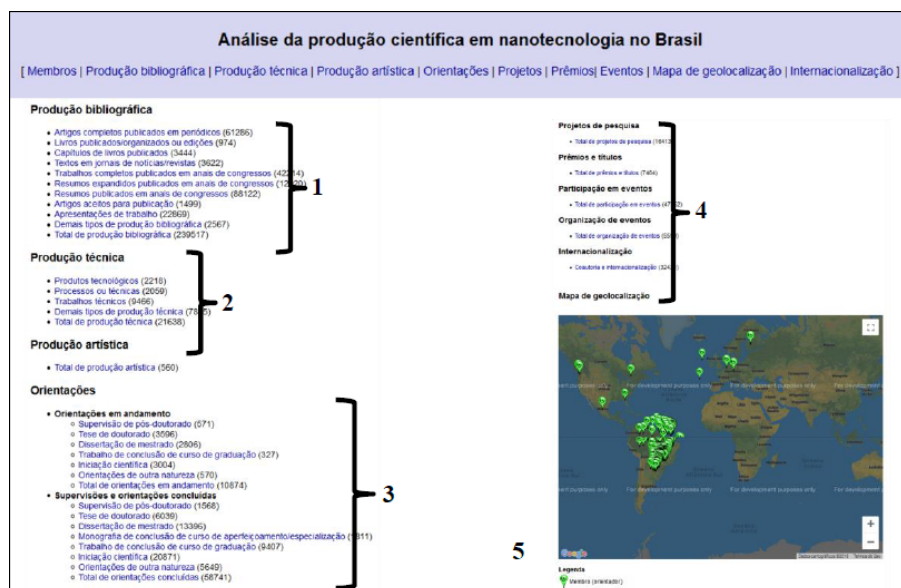


Figure 4
Collection and presentation of Scriptlattes
Source: <http://vlab4u.info/nanotecnologias/>

In spite of the possibilities made available by both *Scriptlattes* and *ScriptGP*, the central focus of the present work has been to demonstrate and organize information on the indicators of bibliographic production, which on its turn may be found in several databases, the tools also offer a series of other indicators present only in Plataforma Lattes (that is a circular basis) and in the Directory of Research Groups of CNPq (which, on turn, consists of a research group database). Thus, fulfilling the proposed objective, we will present in detail the indicators that permit the evaluation of social responsibility in research, the degree of popularization of the scientific results and, finally, those that allow for prospective analysis (*forecasting*) of the current research on nanotechnology, possibly previewing future results.

For Rasquinha (2008), social responsibility can be understood as a form of payback, that is, a need that the institutions have to justify themselves with the population, constituting a very relevant theme in actual organizational behaviour. As for popularization of scientific research results, one must take into consideration that the average citizen hardly has access to papers and other types of bibliographic production directed at the academic community, leaving only the publications of the great media, such as newspapers and magazines, for the dissemination of science advances. According to the American *Wikipedia*, the term *forecasting* refers to the possibility of predicting future results of current events. In Science, *forecasting* or *prospection* are important tools not only for foreseeing the future, but also the possibility of formulation of strategies to leverage the evolution of technology (<http://en.wikipedia.org/wiki/Forecasting>). Considering these three points of highlight in the present work, more detailed analysis on indicators especially related to bibliographic production in nanotechnology, as well as collaboration networks between authors on the theme may be

consulted in previously cited publications (Ferraz, Quoniam, & Alvares, 2014; Ferraz & Quoniam, 2014).

4.2 Social Responsibility of Research

Figures 5 and 6 can be accessed by clicking into the first two respective items indicated by number “2” in Figure 4, and demonstrate quantitatively the production in nanotechnology that effectively generated a technological product (Figure 5), or even some process or technique (Figure 6). These, on turn, may represent a practical application of the results derived from actual research in nanotechnology. In Figure 5, one sees that the years of least contribution with technological products for the country were 1976 and 1978, with only one production registered in each year, while the greatest technological production took place in 2007 and 2011, with 172 and 195 registrations, respectively. In the evaluation of processes and techniques resulting from research in nanotechnology, one might verify in Figure 6 that the years with the smallest contribution were 1950, 1969, 1973, 1976 and 1979, with only one registered production (although in the years 1951 to 1968, 1970 to 1972, 1974 and 1978 there is no registration of processes or techniques related to nanotechnology). On the other hand, the years of greatest production were 2007 and 2011, with 144 and 143 productions respectively.

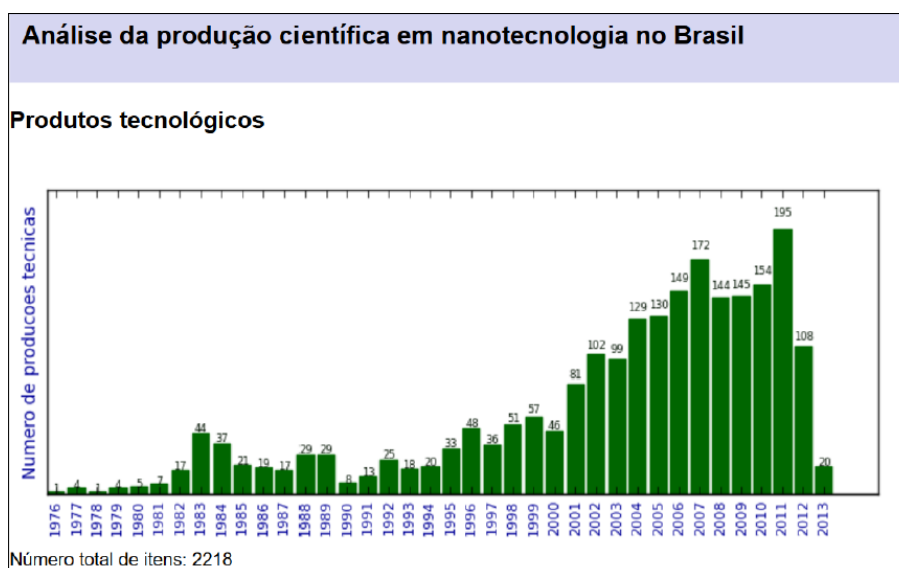


Figure 5
Technological production in nanotechnology in Brazil from 1976 to 2013.
Source: <http://vlab4u.info/nanotecnologias>

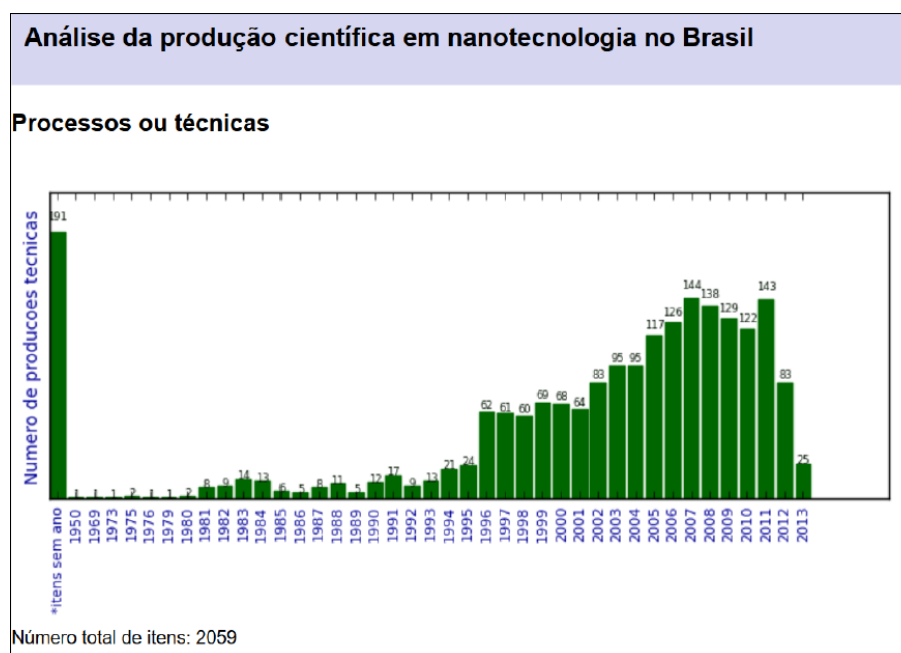


Figure 6

Processes and techniques applied to nanotechnology developed in Brazil from 1950 to 2013.

Source: <http://vlab4u.info/nanotecnologias/>

4.3 Popularization of results of scientific research

When one performs a quantitative analysis of the research results in nanotechnology developed in Brazil and that effectively were, somehow, made available for the population in general, excluded obviously the *websites* of popular content (which until now do not have an appropriate place of registration in Plataforma Lattes), one observes that only in the 1980s, starting in 1987, some few results were popularly published. A gradual increase of the indicator from the 1990s can be observed, culminating in the peak of production in 2007, with 288 productions.

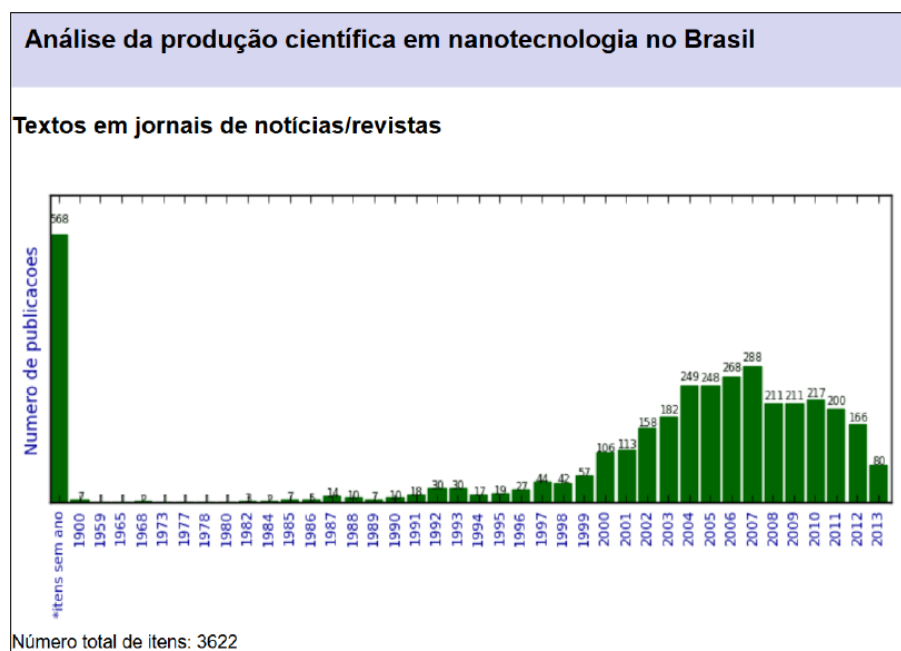


Figure 7
Published texts in newspapers and magazines on nanotechnology
Source: <http://vlab4u.info/nanotecnologias/>

4.4 Prospective Analysis

4.4.1 Research Projects

Figure 8, which access is obtained by the first *link* indicated by number “4” in Figure 4, permits the evaluation of the temporal evolution of research projects indicated in Lattes curricula by the researchers in nanotechnology in the nation. On it, one can identify that the greatest number of projects enrolled was 2010, with 1,658 projects, followed by 2008, with 1,626 projects. The years with smallest productivity in this indicator were those between 1962 and 1982, varying between 1 and 8 projects per year. Nonetheless, the focus of this evaluation is specifically to design a profile of future results of the on-going projects, excluding the past projects. Therefore, the projects deposited after 2013, lasting longer than 2 years become more relevant, once they will probably finish by 2015. In the lower part of Figure 8, one may identify the last five projects enrolled about the theme, all in 2013, and that up until the moment of the extractions were considered on going. Based on their titles and project descriptions (data not available in the present study), it is possible in a certain way to preview their results, and bring about a predictive evaluation on the future contributions on nanotechnology in Brazil. It is worth remembering that long lasting projects deposited before 2013, and that by any instance are still current, may be evaluated in detail in the *forecasting* in nanotechnology.

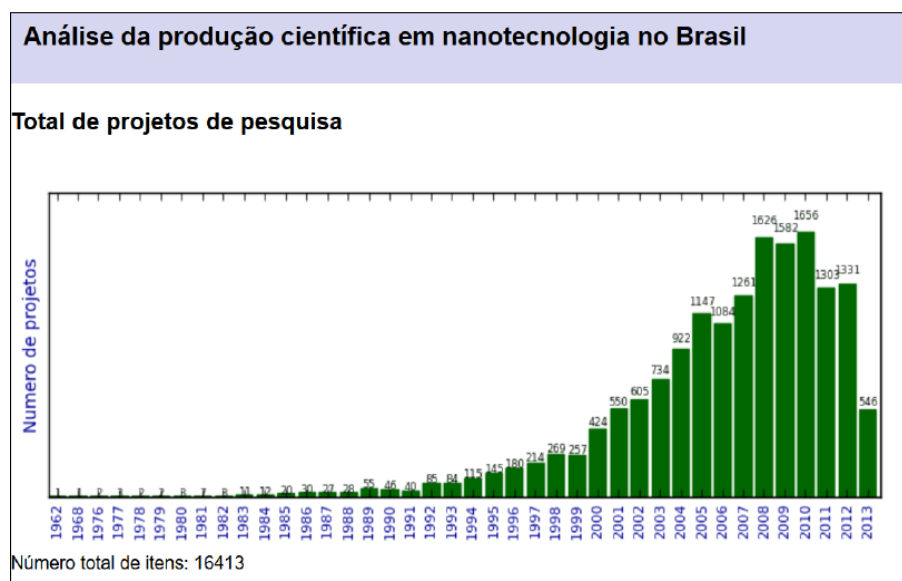


Figure 8
Research projects registered in Lattes curricula of researchers in nanotechnology in Brazil between 1962 and 2013.

Source: <http://vlab4u.info/nanotecnologias/>

4.4.2 Dissertations, thesis and current supervisions

Figures 9, 10 and 11 bring respectively the metrics of production related to the Masters' dissertations, doctoral thesis and post-doc supervisions conducted by researchers in nanotechnology. In Figure 9, one may see that 852 dissertations were deposited. Considering that on average a Master's Program lasts two years, a deeper evaluation of the titles of these dissertations permits the prospection of future results, which may become available throughout 2015, for instance.

Figure 10 presents quantitative data related to doctoral thesis written about nanotechnology. As the PhD courses in Brazil normally last four years, an evaluation of the titles of the thesis registered after 2012 (which will probably be finished by 2015) allows for the prediction of their results, as was the case of dissertations. Finally, also for post-doc supervisions, that like the Master Programs have an average length of two years, the evaluation of the 171 titles of supervisions registered in 2013 (Figure 11) allows for some speculation of up-coming results related to nanotechnology. The lower part of each figure displays a list in inverse chronological order, where the Lattes CV of each supervisor may also be accessed by clicking on the *link* of their name.

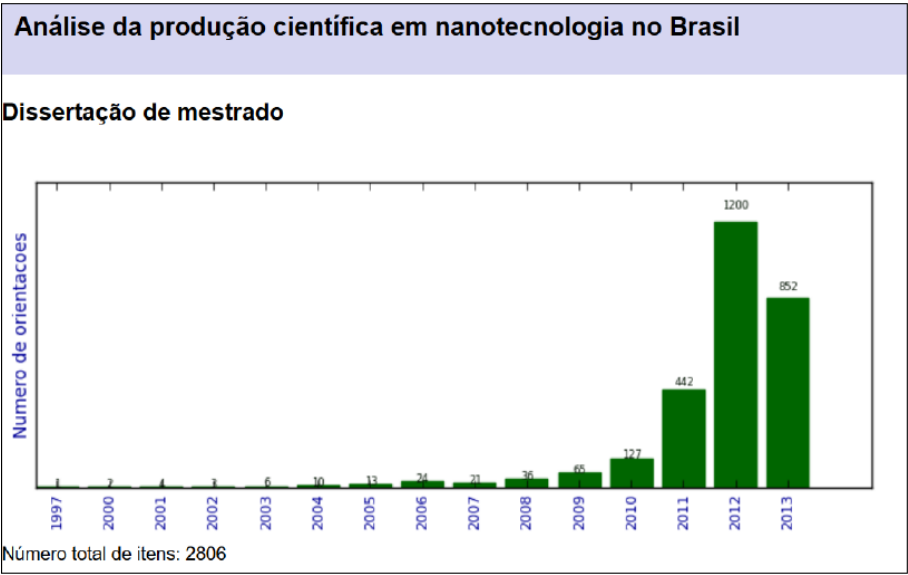


Figure 9
Dissertations registered by researchers in nanotechnology in Brazil since 1997
Source: <http://vlab4u.info/nanotecnologias/>

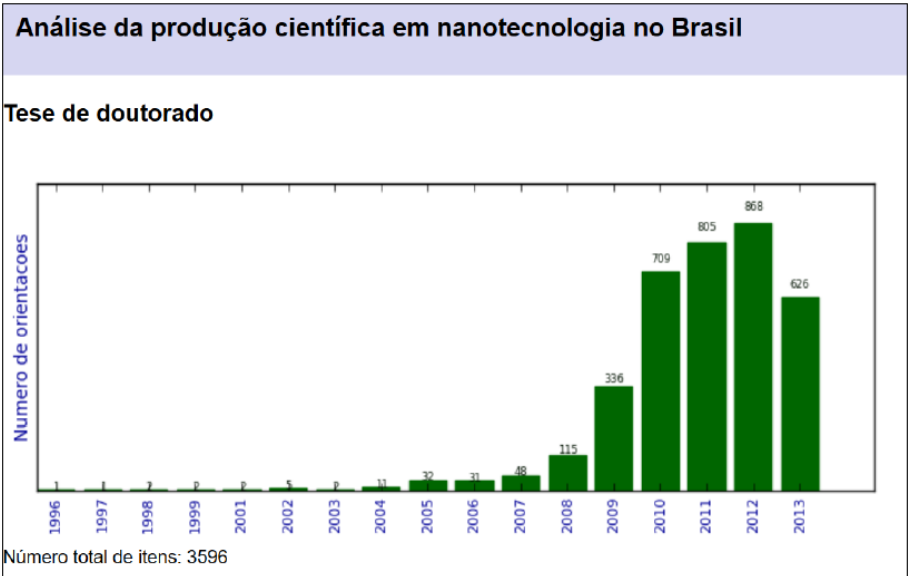


Figure 10
PhD thesis registered by researchers in nanotechnology in Brazil since 1996
Source: <http://vlab4u.info/nanotecnologias/>

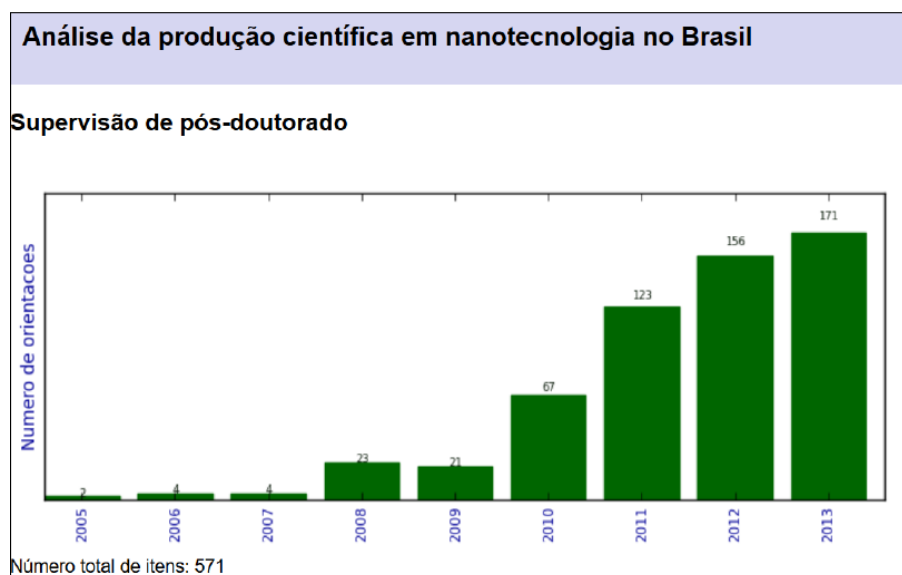


Figure 11

Post-doc supervision registered by researchers in nanotechnology in Brazil since 2005

Source: <http://vlab4u.info/nanotecnologias/>

5. Final considerations

In the present study, the computational tool *Scriptlattes* was used to extract, organize and make easily available through the *internet* academic, technical and technological productions, besides presenting indicators related to the popularization of Science results and prediction of future results, from researchers in nanotechnology registered in Plataforma Lattes and belonging to a research group with the descriptor “nanotechnology” properly enrolled in the Directory of Research Groups of CNPq, which characterized them as *core competences* in nanotechnology. The results presented, apart from allowing for a quantitative evaluation of the bibliographic production of a given theme, by making use of the number of papers, chapters or books published, papers in conference proceedings, amongst others, permits a qualitative analysis of the referred indicators, given that the data may be studied in detail with the full use of the tool (*full text or text mining*), which can specifically look at the titles of the above-mentioned production. Such information can be used by the competent organs, especially the research fomenting agencies in order to verify whether the bibliographic production on a certain theme fulfils the demand, thus, providing ideas for new research grants, especially in regions of the country where the production on that theme is still incipient.

For Dantas (2011), valuing production indicators that allow for the evaluation of the social impact of scientific research is as important as valuing the metrics used to measure intellectual production on a theme of priority interest. Hence, by analysing the return that research on nanotechnology has given back to society in the past few decades, which may be defined as “social responsibility in research” (RASQUINHA,

2008), one can conclude that the extraction, organization and presentation of indicators such as technological products and processes and techniques that effectively allow to measure how much researchers in nanotechnology have contributed to the betterment of living standards. It is worth noting that such production indicators are not available in most datasets, which mostly host scientific papers, thesis, dissertations, and papers in conference proceedings, among other productions, all registered in Lattes CV of the researchers. Thus, once again Plataforma Lattes appears to be a unique circular basis where the indicators related to social responsibility may be automatically extracted, simply by using the computational tool described in this experiment.

According to Candotti (2002): *“Writing for all, when we are studying nature, human beings or society, requires the will to represent what we imagine, understand or believe to be with words and images. We are used to write for the specialist reader, we do not do it as naturally for the lay, common public”*. In this statement, the author emphasizes the importance of popularization of scientific knowledge by means of great access media, given that, with few exceptions, these individuals do not look for information in scientific journals. In the present study, the quantitative evaluation of the text published in newspapers and magazines permits, at least preliminary, measuring the degree of popularization reached by scientific research in nanotechnology. It is beyond the scope of this work evaluating whether this index is (or is not) in accordance to the expect index. However, just as for indicators in social responsibility, this type of production is only available in the curricula registered in Plataforma Lattes, being this, the only basis for extraction and evaluation of data. The formulation of campaigns about the importance of the popularization of Science among the academic environment could, perhaps, contribute for the future betterment of the indicators of popularization based on the indices here presented.

The tool *Scriptlattes* has proved to be very effective with regards to the accomplishment of a prospective analysis of future results from current research in nanotechnology, when considering the quantitative indices of Master dissertations, PhD thesis and Post-doc supervision, as well as on-going research projects. The results offered by the tool permit the compilation of a quantitative analysis, just as performed for social responsibility, using only the tool that analyses titles and descriptions of the above mentioned indicators. Even though outside the scope of this work, it is possible to say that the referred analysis will permit a safe evaluation of whether up-coming results will supply the need related to the research on the theme in the country. One may highlight that the Lattes basis is currently the only available source for prospective evaluation of current research in any given subject. Still, the forecasting of results regarding technological changes can be greatly useful to many different groups of professionals (ORLIKOWSKI, 2000).

The computational tool *Scriptlattes* has proved to be very effective with regards to the extraction, organization and availability of several performance indicators derived from research in nanotechnology,

a priority subject in Brazil. Besides the results derived from the bibliographic production, which may be found both in Lattes curricula as well as specific databases, the tool makes available indices that allow for the evaluation of social responsibility and the degree of popularization of research in nanotechnology, as well as the prospective analysis of future results of current research, information not easily available on the *web*, unless computational tools that aim at extracting and presenting them similarly, like Scriptlattes, are in place. The results here presented can be replicated for any subject of interest, and, thus, may provide a guideline for future research in the country.

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