

Proposal for a technology vigilance system for a Technology License Office

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Abstract—To search for new technologies and to map new scientific and technological developments capable of significantly influencing a scientific and technological institution, is the main role of technological prospecting. Technological prospecting can be a useful tool for the provision of subsidies to finance R&D activities. In this context, using technological prospecting techniques in a Technology License Office is relevant to leverage R&D&I activities in an institution. Thus, the purpose of this task is to present a proposal for the application of technological prospecting tools to a Technology License Office, to support R&D&I activities. This task was conducted through bibliographic research and observation of activities. After the studies, it was verified that for technological prospecting, different methods should be used, since prospecting technology requires systemic vision, through monitoring, forecasting and future vision, guiding the decision making relevant to the positioning of R&D teams in conducting their research.

Keywords—*technological innovation, technology license office, technological prospecting, technological vigilance.*

I. INTRODUCTION

Science and Technology are essential tools in the great pursuit of the development and progress of a Country. For Martens and Monteiro (2016), Pope, Annandale and Morrison-Sauders (2004) and Wilkins (2003), current social, economic and environmental scenarios have forced organizations to innovate, manage change, and generate new activities and new products. Thus, according to Ikenami, Garnica and Ringer (2016), an organization's capacity for innovation is not only a differential, but an essential factor for its survival. Thus, for Bruno-Faria and Fonseca (2014), innovation has become a goal for different types of organization, that is, in each reality, aspects must be observed to the purpose of fostering it or to eliminate the barriers that may hinder -over there. This

context, according to Pope, Annandale and Morrison-Sauders (2004) and Wilkins (2003), presents new challenges for organizations, which present themselves in a more complex way and require greater speed for their treatment and management.

Brasil (2005) defines that technological innovation is the conception of a new product or process of manufacture, as well as the aggregation of new functionalities or characteristics to the product or process, which implies in incremental improvements and in the effective gain of quality or productivity, resulting in greater competitiveness in the market. For the OCDE (2003), technological innovation activities are the set of scientific, technological, organizational, financial and commercial steps, including investments in new knowledge, which lead to or try to lead to the implementation of new or improved products and processes.

For Andrade, Soto Urbina and Torkomian (2016), Kon (2016), Marzall, Santos and Godoy (2016), Pacheco and Gomes (2016), Festa (2015), Macedo, Miguel and Casarotto Filho (2015), Reichert, Camboim and Zawislak (2015), Sousa et al. (2015), Tres e Ferreti (2015), Dias e Cabral (2014), Gomes et al. (2014), Martins et al. (2014), Pereira et al. (2014) and Chimendes (2011), innovation is essential for improving the performance of an organization, and concerns the outcome of an organization's ability to articulate its specific sets of resources, competencies, and the interactions and relationships among the various actors impact of the organization's activities, in order to constitute a strategic mechanism, with the objective of achieving superior performance, creating a sustainable competitive advantage, and thus, generating added value and growth of the organization, besides remaining competitive in the market, which is constantly changing, and, ultimately, to promote economic development.

In other words, according to Andrade (2016), Marzall, Santos and Godoy (2016), Minguela-Rata et al. (2014),

Persico; Manca and Pozzi (2014), Bruce and Birchall (2011), Nieto and Santamaria (2010), Coral, Ogliari and Abreu (2009), it is possible to understand that innovation is the commercial exploitation of an invention, that is, of turning an invention into results. One can still think of product innovation or process innovation.

Andrade (2016), Frezatti et al. (2005), Froehlich and Bitencourt (2015), Selan (2009), Coral, Ogliari and Abreu (2008) and Al-Ali (2003) argue that there is an important relationship between strategy and innovation, and the effective innovation involves changes in the strategies, tactics and operational actions of the organization, that is, the alignment of innovation practices with organizational strategies. If the organization does not view innovation as a preponderant factor and does not have a well-defined strategy, it will not be able to efficiently and effectively manage all the factors involved in promoting innovation.

In a dynamic environment and surrounded by complex systems, such as the environment of action of the Scientific and Technological Institutions (ICT), a tool that can help in the direction of Research and Development (R & D) strategies is Technological Prospecting.

Technological prospecting can be defined as a systematic means of mapping scientific and technological developments that can significantly influence an organization, an industry, a specific product or process, or the economy or society as a whole.

Thus, the purpose of this task is to present a proposal for the application of technological prospecting tools for application in a Technology License Office (TLO), to support the R & D teams of an ICT.

Considering that this work was conducted through bibliographic research, patent research, observation of activities and possible comparisons between best practices, this research could be classified as a qualitative, explanatory, deductive and original research. For Godoy (1995), qualitative research is applied when researchers have broad interests that are defined as the research is developed. In this type of approach, the researcher has a particularly important role because he has direct contact with the problem studied and it is through the researcher that the problems are understood and the focus of the research can be altered or adjusted. According to Gil (1991; 2008), a research can be classified as explanatory when it aims to deepen the knowledge about a certain reality. According to Gil (1991, 2008), the deductive research comprises the analysis that starts from the general and then descends to the particular, that is, deductive reasoning starts from principles considered as true and indisputable to reach conclusions in a purely formal, that is, by virtue of its logic alone. An original scientific research is, according to Cervo et al (2007) and

Andrade (2009), of that research that contributes with new conquests for the evolution of knowledge.

Also, there was direct and continuous interaction with the TLO members of the ICT studied, as well as with their researchers. In this way, this research can also be considered as applied research, since it allowed to apply knowledge in a practical way. According to Kauark, Manhães and Medeiros (2010), applied research aims to generate knowledge for practical application, directed to the solution of specific problems. And yet, it can be considered as an action research. According to Thiollent (2009), Severino (2008), Tripp (2005), Coughlan and Coughlan (2002) and Kincheloe (1997), action research allows the researcher to understand a problem and intervene in real time, it is a methodology in which the target process of the research is improved through the practice, generating learning and knowledge about the process and the research during the resolution of the problem. For Tripp (2005), action research is applied through a 4-step cycle: planning an improvement, acting to implement planned improvement, monitoring and describing the effects of the improvement implemented, and evaluating action outcomes, feedback cycle.

This work is divided into 4 parts. The second concerns a review of the literature on technological prospecting, the third presents a proposal for applying the tool in a TLO, and finally the fourth part indicates the final considerations of this research.

II. LITERATURE REVIEW: TECHNOLOGICAL PROSPECTING

Corroborating the definition of technological prospecting presented in the introduction of this task, Almeida and Moraes (2014), Robinson et al. (2013), Georghiou et al. (2008), Coelho et al. (2003) and Cuhls and Grupp (2003; 2001), Slaughter (2001), describe that prospecting is a process that examines the long-term future of science (2005), UNIDVO (2005a; 2005b), Porter, technology, economics and society in order to interpret data, trends and signs of change and future events, with the objective of identifying areas of strategic research and emerging generic technologies that are likely to generate greater economic and social benefits. social policies.

In other words, for Horst et. al (2011), the technological prospecting is the survey of a relation of technologies and supporting activities for its development in order to meet the expectations and demands of a certain group.

For CTPETRO (2003), technological prospecting consists of: It is a process, not just a set of techniques; It focuses on creating and improving understanding of possible future developments and the forces that seem to shape them; It assumes that the future cannot be scientifically demonstrated from certain premises. The central point is

to discuss the chances of development and the options for action in the present; Passive behavior is not expected in the future, but an active positioning. The future will be created by the choices that are made today.

Coelho (2003) complements that technological prospecting is not the same thing as prognosis or foresight, since it implies an active participation in shaping the future. De Castro, Lima and Freitas Filho (1999) indicate that traditional forecasting builds the future in the image of the past, while technological prospecting focuses on futures with alternative possibilities of being different from the past. It is important to highlight that technological prospecting is aimed at guiding present decision making, based on the existence of turbulence that causes changes in the behavior of variables - critical factors - considered relevant.

For Jannuzzi et. Al (2004), technological prospecting is an instrument to know the possibilities and opportunities of investments in R & D, in areas that may be important for the economic and social development of the country. Technological prospecting has as one of its main objectives, the offer of subsidies for the financing of R & D activities, relating sets of technologies that will be important, according to society's expectations. The results of the technological prospect thus allow the indication of a list of topics (a R & D agenda) ordered by priorities, according to a panel of experts. In addition, the very process of consulting specialists, collecting information, processing and organizing these data provide support for those decision makers, and are also part of a prospective study.

Kupfer and Tigre (2004) describe that the technological prospecting is carried out with the following objective:

- Monitoring (monitoring the evolution of facts and signals and factors that bear change and future);
- Forecasting (making projections based on historical statistical series); and,
- Vision (anticipate future possibilities based on interaction with experts).

In order to apply technological prospecting, according to Almeida and Moraes (2014), Millet (2006), Camarinha-Matos and Afsarmanesh (2004), Phaal et al. (2001; 2004), one of the most applied methods is the construction of technological and strategic roadmaps, considering the mapping and mobilization of specialists around the R & D topics in the area in focus, the definitions of objectives and the scope of the prospecting and the the most appropriate methods and prospecting tools.

Mayerhoff (2008) describes a four-phase model for the technological prospecting, being:

- Preparatory phase (definition of objectives, scope, approach and methodology);
- Pre-prospective phase (details of methodology and data collection);
- Prospective phase (collection, treatment and analysis of data); and
- Post-prospective phase (communication of results, implementation of actions and monitoring).

Regarding the prospective phase, Kupfer and Tigre (2004) and Caruso and Tigre (2004) indicate some techniques for collecting information: conducting experiments or tests; query database records (authors and titles); consultation of publications (papers and patents); conducting visits; conducting interviews; application of questionnaires; observation techniques.

According to Mayerhoff (2008), the historical information used in prospecting methods should be obtained through continuous and reliable series. The Technological Prospecting studies that need this information find in the Intellectual Property system, specifically in the Patents system, a valuable resource, since this system feeds a database that has been growing significantly in the last decades, due to the growing importance patents in the economy.

For Tomiaka, Lourenço and Facó (2010), Barroso, Quoniam and Pacheco (2009), De Castro, Lima and Freitas Filho (1999), Contant and Bottomley (1988), a patent is a document that contains numerous internationally standardized information. Therefore, it is a document of easy identification, such as: patent title, name of the depositor, inventors, prosecutors, date of filing, date of grant of the patent, classification of the patent according to the application, summary, complete descriptions, claims, quotes referenced, among other information. The information available in a patent is relevant and it is necessary to carry out collections and analyze large quantities of patents, through tools such as Data Mining, for decision making.

Also, for Tomiaka, Lourenço and Facó (2010), Barroso, Quoniam and Pacheco (2009), De Castro, Lima and Freitas Filho (1999), Contant and Bottomley (1988), based on patents, consequently a variety of information. Access to patent databases is relatively simple and can provide access to two types of databases: the free ones maintained by the offices of each country and the commercial ones maintained by companies that organize on a single server the vast majority of the world's databases. Here are some of the free bases: World Intellectual Property Office (WIPO); United States Patent and Trademark Office (USPTO); European Patent Office (EPO); National Center for Industrial Property Information and Training (NCIPIT).

Still in the prospective phase, after collecting information, these should be analyzed. Kupfer and Tigre (2004) and Caruso and Tigre (2004) present some methods for the analysis of the information, through the technological prospection: technological mapping; science and technology analysis; scenario analysis; Industry analysis; Patent analysis; delphi.

According to Kupfer and Tigre (2004) and Caruso and Tigre (2004), unlike classic prediction activities, which are dedicated to anticipating a supposed future as unique, prospecting exercises are constructed from the premise that there are several possible futures. These are typically the cases in which the present actions change the future, as with technological innovation. Future technological advances depend on the complex and unpredictable mode of allocative decisions taken in the present by a relatively large set of non-conclusive agents. Prospecting exercises serve as a means to achieve two objectives: The first is to prepare the actors in organizations to seize or face future opportunities or threats. The second goal is to trigger a process of building a desirable future.

In this sense, Tomioka, Lourenço and Facó (2010) describe that technological prospecting is of fundamental importance for the development of research, both in business and academic. Technological prospecting can be used to: anticipate technological changes; understand the course of change; support the decision-making process in research and development; support the technology protection process; support the technology commercialization process.

Also, according to Tomioka, Lourenço and Facó (2010), the information from the technological prospection are useful to: determine the state of the art or state of the art; identify alternative technologies; locate technological and commercial information that involves specific companies, owners, depositors or inventors; improvement of the quality of patents to be deposited, if this is the focus; identify alternative holders or exchange of technologies; research advancement in the inventive novelty of an invention; identify a member of a patent family; seek the country in which a patent has been deposited; locate the document that is written in a desired language; obtain a list of priority documents or references cited; to estimate the importance of the invention by the number of patents deposited; obtain information on the validity of a patent deposited or granted; patent infringement of third parties. According to Quintella et. al (2011a; 2011b; 2011c; 2011d), in order to carry out the technological prospection, tools and skills are usually not well detailed and not incorporated into vocational training. However, for De Castro, Lima and Freitas Filho (1999), the knowledge and tools for technological prospection are still limited, although there is great interest in expanding

them. Such a quote, made 18 years ago, is still a reality today.

In this same sense, for Tomioka, Lourenço and Facó (2010), Barroso, Quoniam and Pacheco (2009), De Castro, Lima and Freitas Filho (1999), Contant and Bottomley (1988), in general, the use of technological prospecting is rare, to subsidize research projects, whether in academia or industry. However, the use of this type of tool is important, because in the industrial or technological field, about 70% of the information is described in patent databases and the rest, 30%, is in scientific publications or other forms of dissemination.

De Castro, Lima and Freitas Filho (1999) and Contant & Bottomley (1988) indicate that a number of reasons have hindered the practical implementation of more formal models of technological prospecting: a) The tradition within the scientific community to leave exclusively to the researcher the responsibility of choosing what to research; b) The fragmentation of the research structure between public and private sectors makes it difficult to construct a single set of priorities; c) Market forces, determining the lines of R & D to be followed by the private sector, impose biases on the priorities for those more profitable activities; d) The belief that the public sector should be responsible for the generation of basic science and the private sector for R & D contributes to the bias in establishing demands and priorities, since it is difficult to predict the impact to be generated by basic knowledge.

For Quintela et al. (2011), Technological Prospecting should be demystified, becoming a routine tool, influencing the decision-making processes, which may facilitate the appropriation of the technologies through Intellectual Property, and improve the management of innovation, while increasing the critical sense and to broaden the vision of technological bottlenecks and opportunities associated with them.

III. PROPOSAL FOR A TECHNOLOGY VIGILANCE SYSTEM, BASED ON TECHNOLOGICAL PROSPECTING, FOR A TLO

For Kupfer and Tigre (2004), prospecting exercises work as a means to achieve two main objectives: 1) prepare the actors in the industry to seize or face future opportunities or threats; and, 2) unleash a process of building a desirable future. Therefore, according to Jannuzzi et. al (2004), this exercise aims to indicate an agenda and prioritize R & D activities for a given time horizon.

For Freire, Guimarães and Jesus (2011), success in the competitive strategy of a given industry also depends on the prospection and monitoring of information about a particular process or technology. Through this prospecting study it is possible to establish a differential

in competitiveness, based on the mapping of fundamental information and knowledge sources.

In this way, one of the possible applications for technological prospecting is linked to the possibility of anticipating the technologies that can be applied and / or contributing to the R & D projects of an ICT. Therefore, it is necessary to establish a directive for the application of technological prospecting tools.

Reinforcing the above, Freire, Guimarães and Jesus (2011) describe that the marketing and technological monitoring needs to be carefully structured so that it can serve as an identification of new opportunities and signs of change in a given market.

Thus, in order to initiate technological prospecting, the technologies to be prospected should be prioritized, giving priority to those with the greatest impact and relevance on ongoing R & D projects, including, but not limited to, problems not yet solved by R & D areas. This prioritization should be done in conjunction with the researchers in the area in question.

After the prioritization of technologies, the search process begins, to identify technologies developed and protected through intellectual property. As previously described, prospecting may be carried out by searching national and international patent databases (example: INPI, USPTO, Sp@cenet, WIPO, among others). This search should be carried out by combining two distinct criteria: keywords and fields of the international patent classification. Keywords describe the technology of interest and the fields of international patent classification indicate the allocation of such technologies. In order, to perform this search, it will be necessary, firstly, to elaborate the search strategies, which begin with the determination of the databases to be used, then, together with other members of the research group, the identification of the keywords, both in Portuguese, and in English for use during searches.

Once the searches have been completed, data processing should be carried out to group similar technologies to analyze each technology individually, pointing out its strengths and weaknesses and its stage of development.

In addition to database searches, it will also be necessary, and of great importance, to promote a literature review on the technologies prioritized for prospecting. This review of the literature should point to the state of the art about the technologies used to solve the question or research problem that one wants to reach.

After the collection and treatment of the prospecting data, complemented with a review of the literature, it will be possible to evaluate how the prospected technologies can collaborate with the R & D projects, now in progress, that is, it will be possible to identify if there are technologies that can be used or applied to solve problems not yet

solved by the research team. Also, it will be possible to indicate the possible improvements to be made in the developed processes or the possible needs of the development of new technologies, or the improvement of the already developed, to incorporate the processes.

However, before applying or using the prospected technologies, it is important to assess your maturity level so as not to use technologies that are still mature enough to actually solve the problem. Considering Silva Neto (2015), Jochem, Geers and Heinze (2011) and Fraser, Moultrie and Gregory (2002), technological maturity can be observed as a competency model that points to different degrees of maturity, from an initial stage to an advanced stage, going through several intermediate stages, being necessary to fulfill specific criteria for each stage.

In this way, it was created by NASA in the 1970s, according to Jesus and Chagas Júnior (2017) and Lemos and Chagas Júnior (2016), a tool called Technology Readiness Level (TRL), whose objective is to measure or estimate the level of maturity of a particular technology. The application of TRL is standardized through ISO-16290: 2013 (Space systems - Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment).

According to Jesus and Chagas Júnior (2017) and Lemos and Chagas Júnior (2016), each technology is evaluated according to the parameters for each technology level, and then the TRL of the critical elements of the technology can be estimated.

Thus, TRL can be applied to assess the level of maturity of the technologies being prospected, that is, to identify the technological risk of each technology, prior to its application in R & D projects, as already described. According to Mankins (2009) and Almeida (2008), the application of TRL can contribute to reduce the risk in the development of new technologies, since it represents an important tool or metric that evaluates the anticipated uncertainty in research and development activities.

The application can be performed using TRL Calculator, which consists of a tool developed using MS-Excel worksheets, which allows the selection of several descriptive items related to the various levels of TRL, related to the current stage of the analyzed technology. This tool was developed, according to Almeida (2008), by the Air Force Research Laboratory of the United States of America. It should be emphasized that the data and information necessary for the application of this evaluation should be collected and discussed through the interaction with the other researchers that compose the research team.

The evaluation of technological maturity, through TRL, is important to indicate the necessary effort to be undertaken

in the research and development of each technology, under study, giving subsidy to the researchers to conduct their projects, as well as opening new fronts of studies and research.

Based on the above information collected and addressed, an information framework for technologies should be created, describing each technology, pointing out its strengths and weaknesses and its level of technological maturity. Based on this framework, the research team can carry out a comparison between technologies.

With the comparison made, an important point is to know effectively the technologies that are compared, through contact with the ICT or team that created the technology. Also, in this contact, you can be asked to demonstrate the use of the technology and, especially, to carry out tests, during a certain period.

Based on the tests, the technology to be incorporated into the technology that is in development may be chosen. For those technologies with a similar profile, priority should be given to those with the highest level of maturity, since the chances of failure are lower.

Having made the choice, a relevant issue is the negotiation of technology transfer and intellectual property rights.

Concluding this item, different technological prospecting methods should be used simultaneously, because none of them, in isolation, meet the needs of the research team, that is, the application of technological prospecting with a systemic view. And, according to Castro, Lima and Cristo (2002), without a good mapping of the important forces and events that have determined the past and shape the present, it is impossible to draw good visions of plausible futures, with enough robustness to guide the formulation of strategies. Vision of future without knowledge of the occurrences and past and present occurrences is exercise of divination and fiction, it is magical knowledge. It may even be confirmed, but the way to reach this vision can hardly be incorporated into scientific and managerial methodology.

IV. CONCLUSION

As stated by Chimendes (2011), the leverage of economic and social growth is linked to the role of knowledge and technology in the performance of production, distribution, economy and social performance. Therefore, scientific research, technological development plays a key role in this scenario.

Moreover, the importance of technological innovation in economic development was widely studied by Schumpeter (1982) in the first half of the century. Knowing the impact of scientific and technological research and its applications and discussing the results are fundamental to the development of a nation.

In this way, technological prospecting contributes directly to the strengthening of the R & D & I activities of a science and technology institution, and its techniques applied from a TLO, has a significant result in the promotion of research.

Aiming to present a study for the application of technological prospecting tools to a TLO innovation, considering that this work was conducted through bibliographical research, observation of activities and possible comparisons, it is understood, finally, that the objective was made effective.

It is concluded that "if" the organization does not commit itself to stimulating innovation, it will be in the near future, doomed to failure, since science and technology are really eminent elements for economic and social advancement.

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