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Innovation roadmapping: science, technology and innovation to vacuum niche domain movements - Part I

Ciência, tecnologia e inovação para os movimentos de nicho no domínio de vácuo: parte I

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ABSTRACT

The methodology was conceived in a collection with two papers. The first paper contributes to the engineering field in research & development of products in the vacuum niche, while the second paper contributes to organizational management in the evaluation of the innovation system. **Purpose and importance:** The marketing requirements for the solution of smart cities for regular growth, economic development and job creation were specifically defined. **Methodology:** Through data mining scanning, hierarchical maps of the scientific literature were prepared in the state of the art, consolidating the most relevant results of 120 years. Roadmaps of commercial brands and roadmaps of technological patents in the broad vacuum niche domain were outcomes. **Result:** Convergence to a potential and emerging market for smart city solutions for the transition from modules to the digitalization society. **Originality:** It organizes and synthesizes, in an unprecedented roadmapping, the general knowledge fields of science, technology & innovation of the niche movements in the vacuum domain and traces possible technological frontiers for regular growth, economic development and job creation.

Keywords: Emerging Vacuum Technologies; Data Guidance, Digitalization.

RESUMO

A metodologia foi concebida em uma coleção com dois artigos. O primeiro artigo contribui para o campo de engenharia na pesquisa & desenvolvimento de produtos no nicho de vácuo, enquanto, o segundo artigo contribui para a gestão organizacional na avaliação de sistema de inovação. **Propósito e importância:** Definiu-se concretamente as exigências de marketing para solução de cidades inteligentes para crescimento regular, desenvolvimento econômico e geração de emprego. **Metodologia:** Por meio de mineração de dados, foram elaborados no estado da arte mapas hierárquicos da literatura científica consolidando resultados mais relevantes de 120 anos, mapas de marcas comerciais e mapas de patentes tecnológicas no amplo domínio de nicho de vácuo. **Resultado:** Convergência para um mercado potencial e emergente para soluções de cidades inteligentes para a transição de módulos para a sociedade da digitalização. **Originalidade:** Organiza e sintetiza, de forma inédita, os campos de conhecimento gerais de ciência, tecnologia e inovação dos movimentos de nicho do domínio de vácuo e traça possíveis fronteiras tecnológicas para crescimento regular, desenvolvimento econômico e geração de emprego.

Palavras-chave: Tecnologias Emergentes À Vácuo, Orientação Por Dados, Digitalização.

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INTRODUCTION

With the emergence of a knowledge-based society, innovation has become an increasingly important factor in the pursuit of development to achieve the welfare society. However, the pursuit of this goal is often hampered by an inadequate understanding of the extent to which innovation mechanisms are being transformed by the globalization of industry 4.0. The potential of uses of vacuum-tracking technologies is remarkably abroad, even for sectors that have been slow adapted for digitalization.

This study conducted a marketing query at institutional level to quickly detect if public researches and scientists perform refined patent research and science review in the state-of-art to trace trends and possible trajectories of knowledge field prior to behavioral research and technology development. The lack of operations involves data and analytics and common market to attend business problems.

Research background

How's life? The better life index is an initiative of the Organization for Economic Cooperation and Development (OECD)[1]. Since 2011, it is daily updated and is an interactive map that share the user information and well-being preferences, and count with more than 180 countries or territories. It has received more than 100,000 inputs per individuals under 11 categories such as: housing, income, jobs, community, education, environment, civic engagement, health, life satisfaction, safety and work-life balance.

Brazil has seen a road record of inclusive growth and poverty reduction over the past 10 years. According to OECD's How's life index[1], Brazil ranks above the average in civic engagement and social connections, but it is below average in personal security, income, education and housing. Nearly 71% of men are in paid work compared to 51% of women. In Brazil, 7% of employees work very long periods, less than the OECD average of 11%, with 9% of men working very long periods compared to 5% of women.

The digital transformation, how it affects science, technology and innovation (S,T&I) and the effects on how people work and live are remarkable. Integrative technology provides new insights and help to align quality metrics integrity, identifying limits as well touch direction for potential future. The OECD Micro-data Lab Intellectual Property Database provides a broad overview in knowledge economy and digital transformation that interacts with high-tech innovation and how trends change rapidly over the years 2000 to 2014[2].

The bubbles chartered funded in OECD Micro-data Lab: Intellectual Property Database indicate different technologies that start to burst at the same time. The "X" axis indicates the year in which technologies start to burst, and the "Y" axis displays the number of years after technologies have stopped to burst and continued their development at a very much slower pace. In the early 2000s, light guides and digital data processing were presented. At 2001, optical recording or reproduction and editing and indexing appeared. The frontier path of digital transformation was remarked in: wireless resource management, digital data transfer, payment protocols, connection management, image analysis, organic material devices, transmission and control arrangements and multi semi-conductor devices[2].

Downes and Nunes[3] performed a study entitled "Big-Bang Disruption" in which the authors refer to as an Everett Rogers model marketing segments to launch new products Downes and Nunes[3] named Big-Bang Disruption what they refer to as an Everett Rogers model marketing segments to launch new products because five distinct marketing segments distributed in a normal pattern curve: innovators, early adopters, early majority, late majority and laggard. The model is a contrast curve which is taller and compressed of a traditional technology adoption. Caching the wave is Big-Bang disruption: "In the fight against this kind of disruption, intangibles are your most valuable assets – and perhaps the only ones you'll want to take with you" (p.54).

Although the dynamics and transition interpolations, since the first application of technology roadmap in the late 1970 to support integrated product-technology planning, roadmapping concepts and techniques have been widely adopted at product, technology, company, sector and policy levels. A key benefit is the integrated communication align technology and commercial perspectives with little underpinning theory or conceptualization[4].

OBJECTIVES

To module roadmap in "vacuum" semantic rooted taxonomy as a potential boosting frontier in science & technology and market-driver key-trend to innovation. The specific-objectives lays on outlined scientific knowledge, technology and innovation to spanning trends.

METHODOLOGY

Aydogdu et al.[5] proposed a nanotechnology roadmap that would contribute to the preparation of the defense industry. The study is based on bibliometric analysis with the aim to arouse trends in the development nanotechnology. For this study the proxy's linkages rooted a "vaccum" taxonomy to roadmapping external trends in the knowledge field target in Web of Science (WoS) core collection search engine indexes in SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI to characterize science field.

For this study, the bibliometric roadmapping was formulated in vacuum domain. To characterize the search engine a (*electric* *vac?um*) was set up, which returned only 6 results. Because of this, like a general strategic roadmapping, this case was recorded in (*device* *vac?um*) or (*machine* *vac?um*) and (*electr* *environment*) and (*product* *innova* *servic*). The search

engine included title, abstract, author keywords, and Keywords Plus. Time spanning available covered 1900-2019.

To aggregate the technological view for this study, the Patentscope data mining was applied to characterize technology path trends. Patentscope is maintained by the World Intellectual Property Organization (WIPO), which provides access to activities and services relating to the Patent Cooperation Treaty (PCT)6. This portal allows graphing of search results and provides access to a database containing patent applications filed via PCT, as well as collections from more than 40 countries, including filings filed in Brazil.

The analysis empathies with Sveiby7 dealt with traditional law stories in apply ontology to analyses collective leadership models developed by forager people: hierarchy and power-symmetric model. This may require exploration of alternatives outside the mainstream both in terms of ontology and study cases, in which this article efforts to show the original value in doing so.

In order to quickly diagnosis local S,T&I system, an electronic questionnaire was conducted and delivered via email with a voluntary participation beyond a question: Have you registered patent(s)?

The target was civil servants of IPEN-CNEN/SP with Master or/and a Ph.D., which totalized a valid population of 266 researchers and technologists. More than 30 days later, 61 responses were reached, reaching a fiscal response of 22.93%, in which it gives a 95% confidence interval, with a margin of error of 11%.

The general plan methodology scheme can be visualized in the Fig. 1 in which the results spanning dimensional maps in S,T&I.

RESULTS AND ANALYSES

The WoS engine search count 23,607 inputs in with top 10 research categories displayed in Fig. 2. Applied physics and electrical and electronic engineering were identified with almost 70% of total research category.

The organization forms competences settled-up remain in academies and universities. The Chinese University of Science and the Massachusetts Institute of Technology (MIT) leading the basic knowledge in Fig. 3.

The funding agencies that promote financial supporting relay on government steins. Figure 4 covers the top 10 funding agencies. The National Natural Science Foundation of China and National Science Foundation (NSF) as well as the United States Department of Energy (DOE) and the Ministry of Education Culture Sports Science and Technology of Japan.

The Organization-Enhanced listed in Fig. 5 displayed a selected preferred organization name and/or their variants. All records feature searches the following fields within the index: Organization Name, Other Names, Relationships, and Name Variants. Search

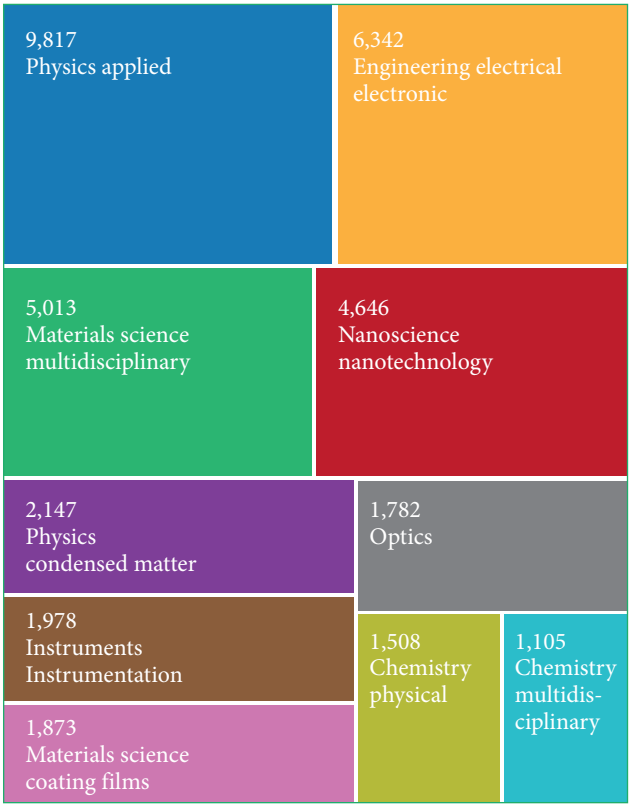

Figure 2: Research categories.

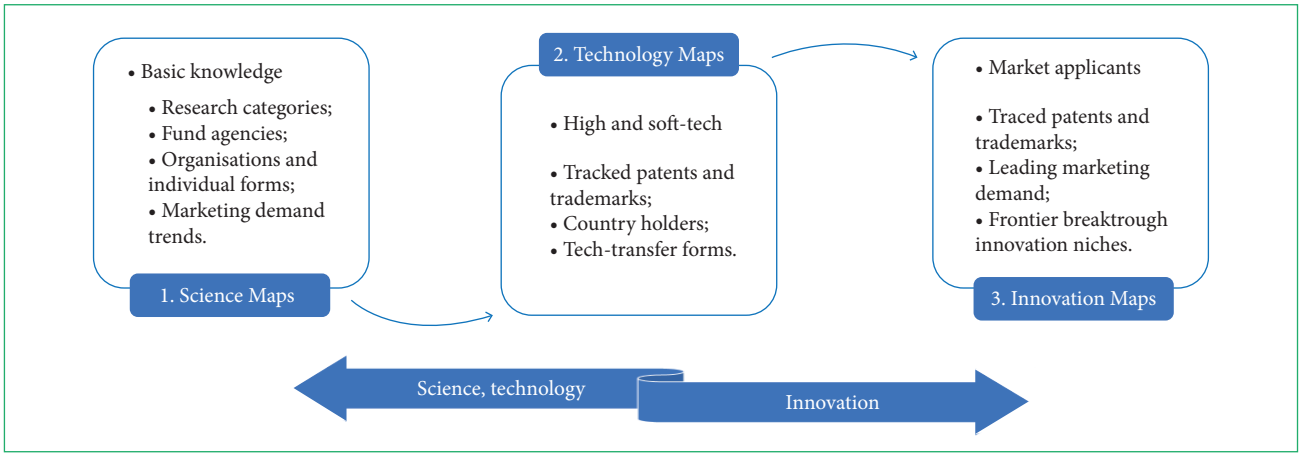

Figure 1: General plan methodology scheme.

Figure 3: Organization forms.

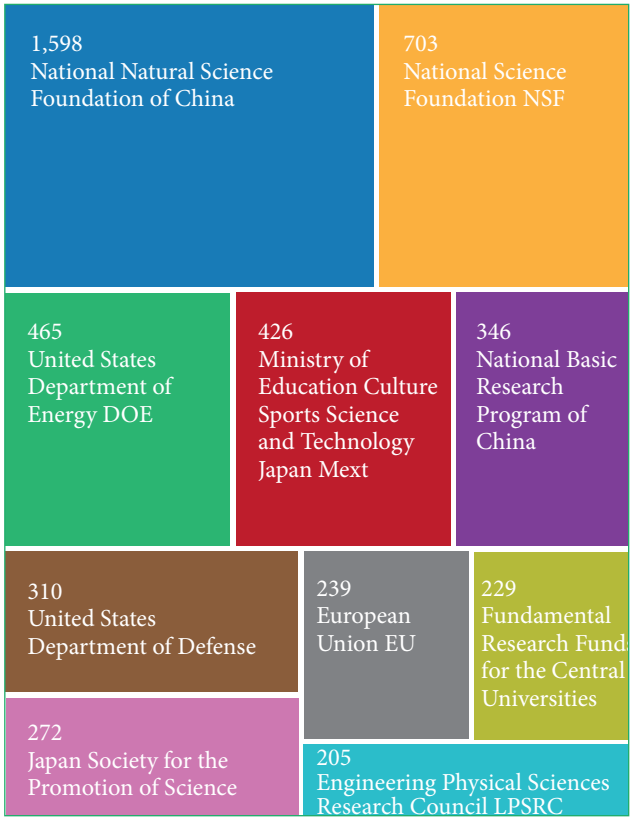

Figure 4: Funding agencies.

Field *versus* Search Aid Fund Results was different recognizes by the search engine machine. In this example, the search aid finds outline the preferred names that display an aid result. The four most specialized organizations that stood out came from the United States Department of Energy (DOE), 765 from Chinese Academy of Sciences, 622 from University of California System

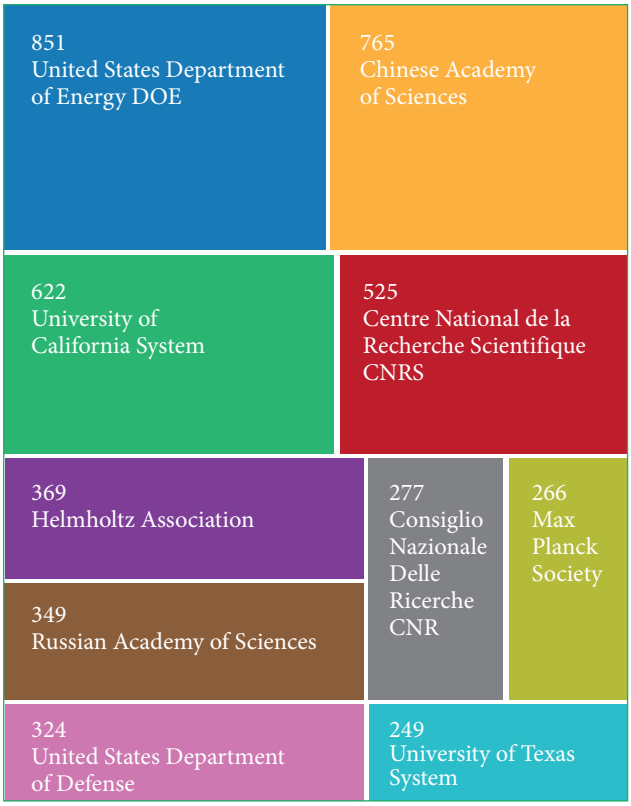

Figure 5: Organizations – enhanced aid fund results.

and 522 from Centre National de la Recherche Scientifique (CNRS), according to Fig. 5.

The technology record Patentscope search engine settle-up fund the total amount of 592,794 results[6]. Table 1 shows that China, USA, Japan, UK and Korea have a house domain of registered patents. The inventor's funds in personnel were Russian first and second position while the candidates are essentiality organizations such as Matsushita Electric Ind Co Ltd., LG Electric Inc, Toshiba Corp and Samsung Electronics Co. Ltda.

Under IPC code, the 10 mainly families: H01L, A47L, C23C, H01J, B01D, B29C, A23L, G01N, B65D and H01H was discovery and are shown Table 2, which presented the labels of IPC Class and subclass in order of the most vacuum patents:

In the latest 10 years the growth of 100% of the publication of vacuum patents is remarkable. The phenomenon can be observed in Fig. 6 due to mostly of the lasts three years, 2017, 2018 and 2019.

Source filter tab enumerated the original data source private for the records matching search *vac?um* in WIPO register trademark(s)

Table 1: Vacuum sort domain patents: inventors and applicants' bench.

Countries		Applicants		Inventors		IPC code	
Name	No	Name	No	Name	No	Name	No
China	206,758	MATSUSHITA ELECTRIC IND CO LTD	3,427	Kvasenkov Oleg Ivanovich (RU)	1,695	H01L	43,301
USA	94,600	LG ELECT INC.	2,547	Квасенков Олег Иванович (RU)	1,695	A47L	40,874
Japan	62,119	TOSHIBA CORP	2,260	The inventor has waived the right to be mentioned	1,007	C23C	36,735
UK	42,295	SAMSUNG ELECTRONICS CO., LTD.	2,246	Wang wei	524	H01J	28,046
Korea	41,280	SOCONY VACUUM OIL CO INC	1,884	Dai Changhong	433	B01D	24,115
PCT	31,790	HITACHI LTD	1,844	Zhang Wei	424	B29C	21,649
European Patent Office	30,726	MITSUBISHI ELECTRIC CORP	1,481	Li Wei	416	A23L	18,092
Canada	16,392	LG Electronics Co., Ltd.	1,456	Wang Jun	403	G01N	16,025
Russian	16,075	TIGER VACUUM BOTTLE CO LTD	1,310	Kvasenkov O.I.	387	B65D	13,405
Germany	13,098	Samsung Electronics Co., Ltd.	1,310	Квасенков О.И.	387	H01H	12,147

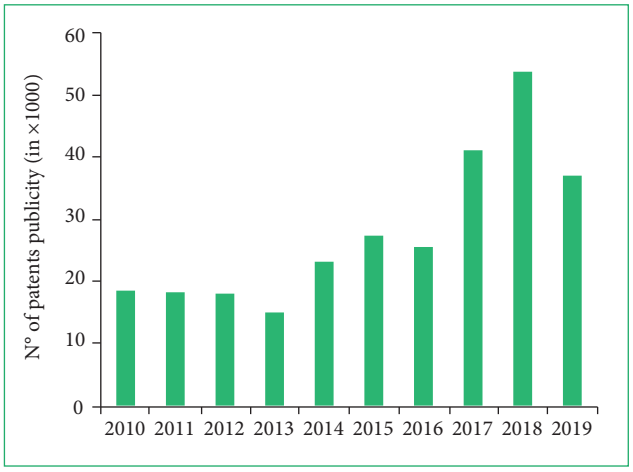

Figure 6: Publicity of number *vacu?m* patents of the latest 10 years.

for global brands record in text and/or image. The search of global trademark(s) registered in Madrid system records 3,040 global brands of which 1,185 are active; 1,720 are inactive and 135 remain pending. When the use in strategic concept intent related: 156 units were typed in verbal matches, 47 in nonverbal; 679 combined and 17 unknow. Table 3 categorizes the 10 most relevant active global brands.

Figure 7 demonstrated quickly diagnosis of IPEN-CNEN/SP, 69% of total 266 civil servant researches and technologists with Master or Ph.D. have not register patents. Almost half of people with patent, 15% of the total, affirmed that they usually search for anteriority of the patent(s) in contrast of 13% that have patent, but not usually search prior. Only 3% of people with registered patents say they don't usually search refined patent.

DISCUSSION

The threshold search fund that vacuum niche domain lays on competences in science, technology and potential market to innovation spanning. The evidences came from WoS data (Fig. 2 and 4) that remarks the long-term relationship that matter enlaces academia, industry and funds. In terms of volume, data discovered in institutional and organizational forms, evidences that academia and universities leading science knowledge was remarkable. Also, it is noteworthy that basic knowledge science category has movements for science applications.

When organizations were focused on improving, the data fund evidenced on the same path in mappers new universities, with two exceptions: Government issues in the US Departments of Energy and Defense and government research institutes in France and Italy. The mapping in Fig. 3 suggests that vacuum science has been funded by government agency funds, lacking private fund in vacuum basic science.

Performed by scientists and researchers, the data showed in Fig. 1 evidences that applied physics, electrical and electronic engineering, multidisciplinary material science, nanoscience and nanotechnology, physics condensed

Table 2: Patent classification, class and subclass rooted vacuum.

IPC Class	Label	Subclass
H01L	Basic electric elements. Semiconductor devices; electric solid-state devices.	Resistors; magnets, inductors, transformers; capacitors; electrolytic devices; batteries, accumulators; waveguides, resonators, or lines of the waveguide, connectors, current collectors; stimulated-emission devices; electromechanical resonators; loudspeakers, microphones, gramophone pick-ups or like acoustic electromechanical transducers; electric light sources; printed circuits, hybrid circuits, details of electrical apparatus, use of semiconductor devices in circuits.
A47L	Human necessities; furniture; domestic articles or appliances.	Coffee mills; spice mills; suction cleaners in general Domestic washing or cleaning; suction cleaners in general health; life-saving; amusement.
C23C	Chemistry; metallurgy; coating metallic material.	Coating material with metallic material; surface treatment of metallic material by diffusion into the surface, by chemical conversion or substitution; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapor deposition.
H01J	Basic electric elements; electric discharge tubes or discharge lamps.	Spark-gaps; arc lamps with consumable electrodes; particle accelerators.
B01D	Performing operations; transporting separating; mixing; physical or chemical processes or apparatus in general.	Separating solids from solids by wet methods, by pneumatic jigs or tables by other dry methods; magnetic or electrostatic separation of solid materials from solid materials or fluids, separation by high-voltage electric fields; centrifuges; vortex apparatus; presses per se for squeezing-out liquid from liquid-containing material.
B29C	Performing operations; transporting separating; mixing; working of plastics; working of substances in a plastic state in general.	Shaping or joining of plastics; shaping of material in a plastic state, not otherwise provided for; after-treatment of the shaped products, repairing.
A23L	Human necessities; foods or foodstuffs; their treatment, not covered by other classes.	Foods, foodstuffs, or non-alcoholic beverages, not covered by subclasses or; their preparation or treatment, cooking, modification of nutritive qualities, physical treatment; preservation of foods or foodstuffs.
G01N	Physics; instruments; measuring; testing; investigating or analyzing materials by determining their chemical or physical properties.	Measuring or testing processes other than immunoassay, involving enzymes or microorganisms; investigation of foundation soil; sensing humidity changes for compensating measurements. Measuring or investigating electric or magnetic properties of materials; using reception or emission of radio waves or; measuring degree of ionization of ionized gases, i.e. plasma; testing electrographic developer properties.
B65D	Performing operations; transporting separating; mixing.	Containers for storage or transport of articles or materials, e.g. bags, barrels, bottles, boxes, cans, cartons, crates, drums, jars, tanks, hoppers, forwarding containers; accessories, closures, or fittings therefor; packaging elements; packages.
H01H	Basic electric elements; electric switches; relays; selectors; emergency protective devices.	Contact cables; overvoltage protection resistors, resistive arresters; electrolytic self-interrupters; switching devices of the waveguide type; devices for interrupted current collection; overvoltage arresters using spark gaps; emergency protective circuit arrangements; switching by electronic means without contact-making.

Table 3: The most 10 vacuum global brands records in text and/or image.

#	Brand	Holder	Nice Cl.	Country holder
1	Vacuum Fusion	Evolve Lifewares PTY Limited	6, 20, 21, 35	AU
2	DVP Vacuum Technology	D.V.P. Vacuum Technology S.P.A.	7	IT
3	FONDAREX SWISS Vacuum Technology	Fondarex S.A.	7	CH
4	TERRAVAC Vacuum Excavation	TerraVac Pty Ltd	37, 39	AU
5	VAC Vacuumschmelze	Vacuumschmelze GmbH & Co. KG	6, 9	DE
6	Best Lock Vacuum Pro-Hooks	CIE europe	6, 20, 21	FR
7	DVP Vacuum Technology	D.V.P. Vacuum Technology s.p.a.	7	IT
8	VIKING Vacuum Systems	Adrian Mead	7	AU
9	TANVAC Vacuum Excavator	STG global PTY LTD	7, 12	AU
10	Vacuumarator	Jets AS	7, 11	NO

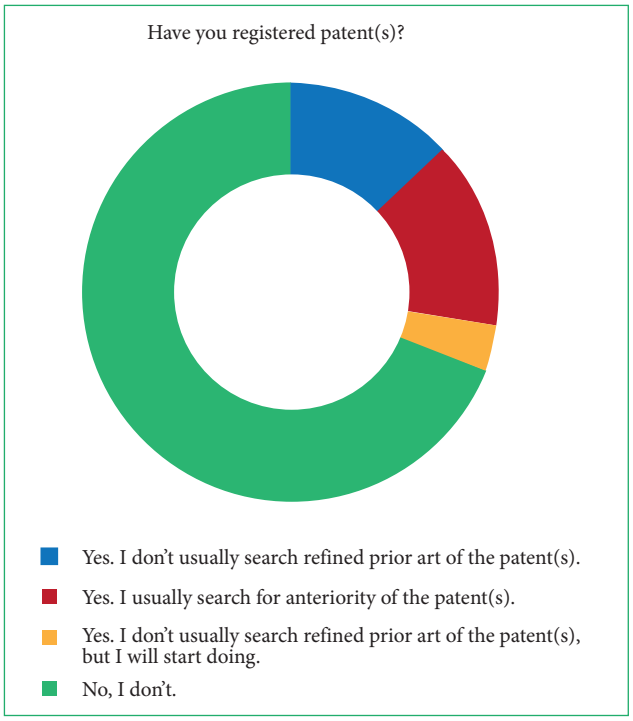

Figure 7: Quickly diagnosis from public researchers and scientists at Nuclear and Energy Research Institute about patents.

matter, instruments and instrumentation, material science coating films, optics competences, physical chemistry and multidisciplinary chemistry accompanies the researcher categories inputs.

CONCLUSION

Regarding 10 years of analysis, vacuum patents almost achieve a double record in the past 5 years. Although inventors were personal, the innovation applicants were organizational forms. This study remarks the relevance of marketing trace and trends into patents and trademarks to attach business model.

Registering a patent is not a cultural behavior, although more than 50% of IPEN-CNEN/SP scientists that have registered patents used to course a pre-trial analysis or starting doing. It's a marketing opportunity path for supporting decision making at research and institutional strategic to public policies for developing countries. Data and analytics in the age of knowledge may alter the dynamic in intellectual properties compliance.

Fast-tracking traced integrated reports propitiated breakthrough technologies in digital transformation, however, women lack as authors, inventors or vacuum applicants as individuals, especially in technological patents traces. This may be a gap to be filled by political science actors in labor market equality income insertion, soft-skills development for analytics and big-data-driven age.

The technological potential trend was remarked in: connectedness, wireless resource management, digital data transfer, payment protocols, connection management, image analysis, organic material devices, transmission and control arrangements and multi semi-conductor devices, safe and security, housing machines, and applications.

Road spamming traced for S,T&I as a core competence for smart specialization must encompass marketing trends and traces to better comprehend innovation dynamics, forms, actors and agents along interplay in order to response the marketing demands of smart cities in social determinants in developing countries to regular growth, economic development and yield employment for individuals, and organizational forms.

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