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The effort of "Triple Helix" actors in disruptive technologies

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Abstract: Disruptive technologies are areas of technology capable of creating abrupt changes in the market, creating new economic arena and alter the way of life in our society. In this scope, it is of great importance to perform an investigation related to the technologies and its top players that will possibly play a protagonist role in the main evolutions and changes in our society in the next few years. Understand the dynamics of technology innovation in disruptive areas can bring light on current effort made by private and public sectors, and specially the timeframe for launching new products in market. In this context, this contribution seek to present and discuss the current conjuncture of R&D in a group of technologies considered currently as disruptive for the next two decades. The focus of the work is to analyse the distribution of technology production in these areas in a context of university-industry-government relation, using the concepts of "triple helix". For this purpose, we present statistical data of patents related to the investigated technology areas, and an analysis try to understand the motivation behind R&D in disruptive technologies, and what is the relationship among the triple helix actors in this innovative process.

Keywords: disruptive technologies, triple helix, technology plan, research and development.

1. Introduction

The bibliometric analysis of the most varied types of technology is of great importance in aiding strategic decision making, by both industry as well as universities and government agencies. Companies of the most varied sizes have a great interest in monitoring the activity of their competitors in order to use the collected data for strategic decision-making. However, besides the actors of the industry, this type of monitoring and analysis can also be done by universities and government bodies, in order to define R&D guidelines that are concordant with the current global and local conjuncture of the technologies of interest. In this context, the very distribution of investments in technologies by these three major players (Universities, Industry and Government), and the way in which they interrelate, is an indicative of the current situation involving these technologies in question and also serves as data source to assist in decision-making.

One of the approaches to perform bibliometric analysis is by the use of patent data. In this way, the analysis of patent related to the specific technology areas in a global context is a good source of quantitative and objective reasoning to obtain information that can be used to gain strategic advantage (MOGEE, 1994; MOGEE, 1991). In previous works, Mogee showed how is possible to identify new technologies using patent data (MOGEE; KOLAR, 1992), the differences among analysis using different patent offices (MOGEE, 2007), and the various business conditions were patent analysis are useful (BREITZMAN; MOGEE, 2002). Porter presented methods of research with the objective of finding the most relevant patent data to some studied case (MA; PORTER, 2015) and a hybrid methodology to analyse patent portfolios, considering a categorical approach together with a semantic approach (ZHANG et al., 2016). Milanez performed an analysis of a macro-indicator with the objective of forecasting technology trends (MILANEZ et al., 2014). Guan and Liu (2016) present an analysis of patents related to nano-energy, and Grupp and Schmoch (1999) present different ways to analyse statistical patent data. These works were very motivating for this article.

With regard to the "triple helix" model, Leydesdorff helped to define these concepts in several works, where he sought to elucidate the relations between University-Industry-Government (LEYDESDORFF, 2000; ETZKOWITZ; LEYDESDORFF, 1998; LEYDESDORFF, 2003; IVANOVA; LEYDESDORFF, 2014). Besides these, other works that approached the "triple helix" model were also great motivators for this article (ROBIN; SCHUBERT, 2013; AN; AHN, 2016; CUI et al., 2016).

In this article, we seek to bring statistical information about patents related to areas of technology considered as disruptive for the next two decades, and we analyse the current situation of such technologies in order to understand how the main actors relate among themselves during the innovative process of such areas. To do so, we use the concepts of "triple helix", dividing the patents coming from industry, universities or government.

2. Disruptive technologies

Christensen (1997) created the concept of disruptive technology when studying recurrent revolutions in the personal computer industry. The author also analysed heavy machinery industry and other economic sectors. Disruptive technologies are what implement the classical concept of creative destruction originated from Schumpeter (1942). In general, disruptive technologies are the areas of technological development that present the ability to modify the way our society lives and change significantly the market in which they are inserted. The Internet is an example of technology that has been identified as a disruptive technology in the past, and today is part of the daily life of our society. This technology was accessible to a very restricted group of people and organizations until the mid-1980s, but today is present in the life of a large part of the world's population, and governs the way we carry out basic day-to-day activities. Another example of Disruptive Technology is the use of motor vehicles in the early 20th century, which turned the usage of horse-drawn carts almost inexistent in the biggest cities of that time.

In the current global context, there are a number of technology areas with disruptive potential for the year 2025 (MCKINSEY GLOBAL INSTITUTE, 2013). The analysis of the current conjuncture of these technologies is of great value for the creation of R&D guidelines, and for understanding how its main actors and financiers relate among them.

For this article, we defined a list of technology areas considered as disruptive by McKinsey Associates Inc., in 2013 (MCKINSEY GLOBAL INSTITUTE, 2013). The areas of technology chosen for analysis in this work are 3D Printing, Advanced Materials, Autonomous Vehicles, Cloud Technology, Digital Currency, Energy Storage, Mobile Internet, and Renewable Energy. Some of these areas of technology have a direct relationship each other, such as Mobile Internet and Cloud Technology, for example. Others, however, do not have an explicit direct connection, as in the case of Advanced Materials with Digital Currency. The choice of technology areas with these characteristics is justified by a joint analysis of several technologies we are performing, as an effort to find a pattern of behaviour in the innovative process that is common to all of them. Thus, using a group of technology segments that encompasses both interrelated areas and areas with no apparent direct relationship is a good strategy.

It is important to emphasize, however, that the areas of technology studied in this work are not the only ones in a current context of disruptive technologies. As an example, some other areas of great importance that have disruptive potential for the coming years are Advanced Robotics, Automation of Knowledge Work, Internet of Things, Next Generation Genomics, among several others. For this article, these technologies were not included for analysis because of convenience and to avoid a very large amount of data, which could hinder the reading and analysis of the results.

2.1. 3D printing

The 3D Printing segment has been growing a lot in recent years. Advances in additive manufacturing technologies have increasingly allowed the substitution of classical manufacturing techniques that are characterized by the subtraction of material. As a result, these new techniques allows a more efficient manufacturing. In addition, the characteristics of 3D printing techniques have allowed a rapid advance of simple and user-friendly mechanisms through low-skilled users, resulting in the possibility of low-cost 3D printers that can be used by ordinary people.

For the next few years, the evolutions in 3D printing techniques present exciting trends. Within the framework of civil construction, there are already houses and bridges being built using additive manufacturing techniques, allowing for quick and low cost construction. In the context of simplified use by the ordinary user, there is a great number of possibilities and uses of this technology for the future, ranging from the printing at home of a simple pair of shoes with custom dimensions, or even printing food. There are also possibilities for the additive manufacture of living organisms, such as organs that can be used in transplants. With this, the wide range of possibilities of applying 3D printing technologies indicates a promising future for the segment, making this an area with disruptive potential for the next years.

2.2. Advanced materials

Technologies linked to advanced materials also have great disruptive potential for years to come. Among the possibilities presented by this segment, we highlight nanotechnology and intelligent materials, which are the focus of this study for the area of advanced materials.

Nanotechnology stands out for using nanoscale materials applications. In these dimensions, some materials have surprising properties, such as high mechanical strength, high conductivity, high reactivity, etc (MCKINSEY GLOBAL INSTITUTE, 2013). The applications related to these technologies range from the possibility of creating batteries of greater capacity to the use of nanostructures for the application of medicines in a more efficient way and with fewer side effects to the patients, among several other possibilities.

So-called intelligent materials stand out through various forms of actuation, such as self-healing materials, which have the ability to regenerate automatically, or shape memory materials that are able to change their own shape depending on its temperature. Other alternatives in this segment are the so-called piezoelectric materials, which are capable of transforming applied pressure into electrical energy, resulting in a large number of possibilities for energy transformation and recovery. With this, the applications of advanced materials in their various possibilities can be considered as an important source of innovation for the next years.

2.3. Autonomous vehicles

Autonomous vehicles are not exactly new. For a long time, autonomous control technologies have been used in aircraft, ships and trains. However, advances in autonomous vehicle control technologies have led to great potential for innovation in the coming years. Large companies such as Google, Uber and Ford are already extensively testing autonomous cars and trucks, and they show themselves as an inevitable way to transport people in the near future.

The benefits of using autonomous vehicles go beyond the comfort of being transported without the need for someone to drive. The use of computer-controlled vehicles is a crucial factor in increasing transport safety, as most of the accidents in this sector occurs because of human error (MCKINSEY GLOBAL INSTITUTE, 2013). In addition, a considerable increase in the efficiency of the vehicles is possible with the autonomous control of acceleration and braking, making possible an optimization of the energy consumption during the operation of the cars. In addition, there is still the possibility of vehicles communicating with each other, so that they choose their most efficient routes based on the data of each car, thus creating a smart traffic network. These, among several other possibilities of application, put the segment of autonomous vehicles as a possible great source of innovation for the next years.

2.4. Cloud technology

Technologies of data storage and services using the cloud also have great potential for innovation in the near future, with increasing use of such applications. Through cloud technology, it is possible to perform tasks remotely, so that all computational effort is contained in a network of servers and the results are delivered online to the user. This may lead to a decrease in the demand for storage and processing capacity of personal devices.

There are already several known applications of cloud technology. Online search tools or data storage are an example of applications in this segment. Streaming services, such as Netflix, are one of several examples of cloud technology applications that have become very popular in recent years because of their versatility and ease of use. In this way, the high range of application possibilities of the cloud technologies, combined with the creativity of the developers in creating services that are increasingly innovative and relevant to society, makes this segment a great source of innovation for the next years.

2.5. Digital currency

Interest in cryptocurrency has been growing continuously. The simplicity of making transactions in digital form has attracted a large number of people and companies, and the evidence indicates that in the future, much of the monetary transactions will be done digitally. This possibility opened a range of options and allowed some currencies to be created with the only option of serving through a digital way and using *blockchain* technologies. Today, the most famous and most valuable digital currency is Bitcoin, but the possibilities of using digital currencies are not restricted to the most famous of them. Other digital currency options have been appearing every year, such as Ethereum, Litecoin, Monero, Ripple, among others.

Banks and governments have been showing interest in the digital currency market. The use of *blockchain* technologies for monetary transactions is seen as a possibility of cost reduction and alternative to the bureaucratic processes currently used. In addition, trends that point to an increasing interest in the use of digital currencies have led some governments to act quickly to fit the new reality, so that there are already discussions among government agents regarding crypto-coins regulations and their commercial use.

2.6. Energy storage

The methods of energy storage have been attracting great interest from researchers and developers in recent decades. The increasing evolution of other areas of technology is increasing the need to supply energy and its forms of storage, which makes this segment an important actor that can influence the progress of other areas. Technologies such as hybrid or fully electric vehicles, drones, mobile phone, and others, are extremely dependent on energy storage technologies, making this an area of great innovative importance for years to come.

The main advances currently are related to lithium-ion batteries, which are commonly used in computers, tablets, cell phones, etc. However, there are other potential alternatives such as technologies related to molten salt, supercapacitors, flywheels, and several others. With this, the great possibilities of alternatives for energy storage, together with the constant increase in the demand for technologies of this area, has made this one of the great protagonists among the technologies with disruptive potential for the next years.

2.7. Mobile internet

Another area of great innovative potential for the coming years is the Mobile Internet, which can be defined as the set of mobile devices with high-speed connection and applications (MCKINSEY GLOBAL INSTITUTE, 2013). Thanks to the Mobile Internet segment, today it is possible for a user to call a ride through Uber, or use his smartphone to buy food that will arrive at the door of his house in a few minutes. The user can also control his bank account and make transactions in a simple and easy way. These are just a few examples of the Mobile Internet application options that are now being used on a large scale.

However, the applicability are not limited to the possibilities of using the Mobile Internet through smartphone and tablet applications. Wearable devices are already quite common and offer the most varied services. Some examples are rings that make payments only by the proximity of the device to the paying machine. Others are the bracelets that calculate the user's running pace and heart rate, assisting with health care and quality of life through data collected in real time and transmitted to the user by the application. These examples, along with several other possibilities, make the Mobile Internet a segment that has the capacity to modify significantly the way we consume and perform services in the very near future.

2.8. Renewable energy

Renewable energy sources also present themselves as an important segment with disruptive potential for the coming decades. These sources of energy are related to the continuous resources found on our planet, such as the sun, rivers, winds, etc. (MCKINSEY GLOBAL INSTITUTE, 2013). Growing concern about how our society throws toxic waste into the atmosphere has put renewable energy production options increasingly on the agenda.

Within the context of renewable energies, two stand out with disruptive potential for the coming years: solar and wind energy. Other renewable sources, such as rivers supporting hydroelectric power plants, are already well exploited and represent much of the energy produced in the world, but do not present great disruptive potential for the near future and appear to be already at a mature level of technology. In addition to these, renewable energy options through biofuels, ocean thermal energy, geothermal energy, and nuclear energy are also present. These, however, although presenting a very great potential in terms of innovation for energy production, present themselves as options still very new and without the capacity to act as protagonists in the next years (MCKINSEY GLOBAL INSTITUTE, 2013). In this way, the renewable sources of solar and wind energy stand as the great disruptive possibilities of this segment for a near future, and for that reason, they are placed as the focus of study of this area.

3. Methodology

The general objective of this article is to analyse the distribution of patents related to several areas of technology considered as disruptive for the next years among their applicants, classifying them as University, Industry or Government, in a global context. The discussion aims to understand how these three types of institutions interrelate throughout the innovative process of these technologies. To do this a complete map of the amount of patents by countries and institutions was performed.

The general steps of this research were: (1) identify the set of patents related to each technology area; (2) define the top players in each segment; (3) classify the top players of each segment among University, Industry or Government; (4) identify the countries where most patents are produced related to each technology area; and (5) analyze the results and understand the way of acting of the main actors in the process of these technological innovation.

In order to carry out the searches on the patent platform, a methodology was defined for the definition of keywords in order to use only the terms that were relevant to the disruptive context of the technologies. This methodology is an adaptation of the Huang and Porter method (HUANG et al., 2015), and consists of three distinct parts: The first is the definition of the main terms related to the area analysed, based on basic studies on the theme. The second is an analysis of frequency of occurrence of keywords using the formula of "Hit Ratio" presented by Huang and Porter in their article. The two parts, together, results in a list of keywords considered for search. With this list, the third part is carried out, which consists of a final revision for the addition or exclusion of some terms. Table 1 presents the final terms considered for each technology area analysed in the study.

Some terms given in Table 1 were chosen to be searched only in conjunction with some other keyword, in order to return only patents relative to the study area. An example, related to the area of Cloud Technology, is "grid computing", which was chosen to be searched only in conjunction with the term "cloud", so it is placed in the Table 1 list as "grid computing AND cloud". For searches on the patent platform, the terms presented in Table 1 were entered with their truncation characters, in order to search for every possible variation of each keyword.

The patents related to each area were searched through the ORBIT platform, which was chosen because it covers a large number of patent offices worldwide and presents good tools for analysis. The searches were done using the keywords indicated in Table 1. Each search was conducted in order to search for patents that contain any of the keywords

Table 1. List of keywords by technology area.

Technology Area	Keywords
3D Printing	3D Printing; Bioprinting; Additive Manufacturing; Selective laser melting; Fused deposition modeling; Stereolithography; Selective laser sintering.
Advanced Materials	Advanced Materials; Nanotechnology; Nanomaterials; Nanostructures; Smart material; Self-healing material; Self-cleaning material; Memory metal; Nanocomposites; Piezoelectric materials; Advanced composites; Nano-based material; Nanotubes; selfassembly material; shape memory alloy; shape memory material.
Autonomous Vehicles	Autonomous Vehicle; Autonomous Car; Autonomous transport; Automated vehicle; Automated car; Automated transport; Autonomous truck; Automated truck; Self-guided car; Self-guided vehicle; Self-guided truck; Driverless vehicle; Driverless car; Self-driving; autonomous driving.
Cloud Technology	Cloud technology; Cloud computing; Cloud resources; Cloud-delivered service; Cloud delivered software; Cloud delivery; Cloud-enabled service; Cloud-enabled software; Cloud facility; Cloud service; Cloud models; Cloud capability; Cloud system; Private cloud; grid computing AND cloud; task scheduling AND cloud; cloud security; software as a service; resource provisioning AND cloud; infrastructure as a service; data security AND cloud; distributed computing AND cloud; service level agreement AND cloud; mobile computing AND cloud; Virtualization AND cloud; Data center AND cloud; Quality of service AND cloud; Distributed systems AND cloud; Privacy preserving AND cloud; Fog computing.
Digital Currency	Digital currency; Cryptocurrency; Bitcoin; Digital money; Virtual currency; Digital base money; Network money; Blockchain AND (currency OR money); smart contract AND (currency OR money); ethereum AND (currency OR money); proof-of-work AND (currency OR money).
Energy Storage	Energy storage; Lithium-ion battery; Li-ion battery; Molten salt battery; Flow cell battery; Fly wheel battery; (supercapacitor AND battery); liquid metal battery; lithium-air battery; lithium-sulfur battery; sodium-ion battery; na-ion battery; nanostructure AND (battery OR storage); reduced graphene oxide AND (battery OR storage); electrospinning AND (battery OR storage); porous carbon AND (battery OR storage); manganese dioxide AND (battery OR storage).
Mobile Internet	Mobile internet; Mobile services AND (internet OR connect); Mobile computing devices AND (internet OR connect); Mobile cloud access; Smartphone AND (internet OR connect); Mobile devices; Mobile application AND (internet OR connect); Mobile app AND (internet OR connect).
Renewable Energy	Solar power; Wind power; Solar energy; Wind energy; Solar photovoltaic; Solar panel; Solar cell; Wind turbine; Wind tower; Wind farm; Solar farm; doubly fed induction generator.

related to the technology studied in its title or abstract. The searches were conducted in order to return patents with publication between 01-01-1998 and 12-31-2017, to cover the last twenty years. The search was not extended until 2018 because this was the current period at the time of the searches and therefore its addition could bring confusing results to the trend. All searches were conducted in the period between April 30, 2018 and May 7, 2018.

Based on the results of the searches, we fulfil the other objectives of the study through a basic analysis of the data gathered.

4. Results

This section presents the main results obtained for each technology area. We gather data to build a set of three graphs by technology. This set comprises data on the number of patents in the last twenty years; the location of R&D, comprising the number of patents in each country, when these were marked as “1st priority country” in the patent sheet; and the distribution of patents related to the 30 largest players in the University-Industry-Government distribution.

Our first result is about the amount of patents in each area on last twenty years. These data are presented in Figure 1.

As can be seen the areas where more money are invested in patents in these technologies are “renewable energy”, “energy storage” and “advanced materials”. These can indicate three different ways for explaining. The first is about the amount of research in each area, suggesting these three fields are more prominent. The second is about the timeframe related to these fields, because energy and materials started to be highly investigated from the middle to the end of 20Th century, while the others are more contemporaneous themes. And, the thirty possible explanation is related to the possibility of short-term results which is not feasible for the majority of technologies in energy or material sciences, but is a realistic chance in the others fields.

That is, it can maybe more interesting to the companies researching “3D printing”, “autonomous vehicles”, “cloud computing”, “digital currency” or “mobile internet” to go fast to the market, and trust on industrial secrets, than go to patent deposits and protect them around the world, while other competitors launch new products. This propositions

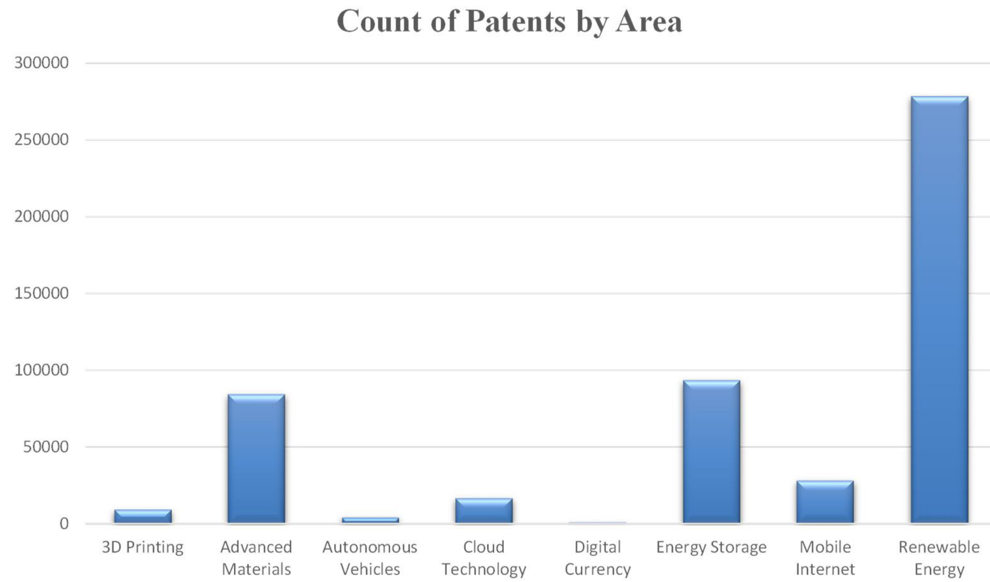

Figure 1. Count of patent publications by area during the period of 1998-2017.

need to be tested with another kind of data in future researches.

Graphs on Figure 2 show the evolution of patents in each disruptive technology studied. Firstly, these graphs helps to confirm the disruptive profile of these fields with a consistent profile of annual increments in patent deposits along twenty years.

One more time the number related to "renewable energy", "energy storage" and "advanced materials" highlights, with annual deposits of most than 30000, 15000 and 10000 respectively. New fields like "digital currency" for instance, presents deposits numbering 300 a year in 2017, but the same profile of evolution is noticed.

Figures 3, 4, 5 and 6 show the most active countries in each disruptive technology here analysed. Except for "renewable energy", China and United States occupies the first two positions, Chinese organizations lead patent deposits in six from eight technologies, and United States lead only two fields – "autonomous vehicles" and "digital currency".

Analysing the "Top Players", which is related to the group of the 30 largest patent holders related to the each area, we classify them in University, Industry and Government as a way to study triple helix relations in this set of technologies.

From Figure 7 we also see "renewable energy", "energy storage" and "advanced materials" as fields where there is considerable participation of university, industry and government organizations in patent deposits. Industry dominates the other technologies. "Digital currency" has an important effort from government, and "3D printing" counts with good presence of universities.

5. Discussion and analysis

The trend graphs presented in section 4 indicate that most of the technology segments studied in this article show a significant increase in investments in the last six years, more precisely from 2012. This behaviour can be clearly observed in the trend graphs of the segments of 3D Printing, Autonomous Vehicles, Cloud Technology, Digital Currency and Mobile Internet (Figure 2), especially 3D Printing and Cloud Technology, which prior to this period practically did not present patent results. The segments of Advanced Materials, Energy Storage and Renewable Energy show a less abrupt behaviour, especially in the Advanced Materials segment, which has shown almost constant evolution in patent results for the last twenty years.

Such behaviours can be justified by the characteristics of the areas themselves. The Advanced Materials, Energy Storage and Renewable Energy segments are not a great novelty and have been developed for many years. The other segments, such as 3D Printing, Cloud Technology and Autonomous Vehicles, present themselves as a novelty in recent years and it is only natural that their investment trends are presented with the abrupt evolutions confirmed in the graphs. It should also be noted the patent quantities found for each segment, which corroborates the analysis of older or new areas. While the segments defined as the newest show patent results in a range of up to 30000 publications over the period studied, the old ones presented results in the range of 80,000 to 280,000 publications (Figure 1).

The analysis of the data of R&D location indicates a clear dominion of the United States and China in the development of the disruptive technologies studied in this

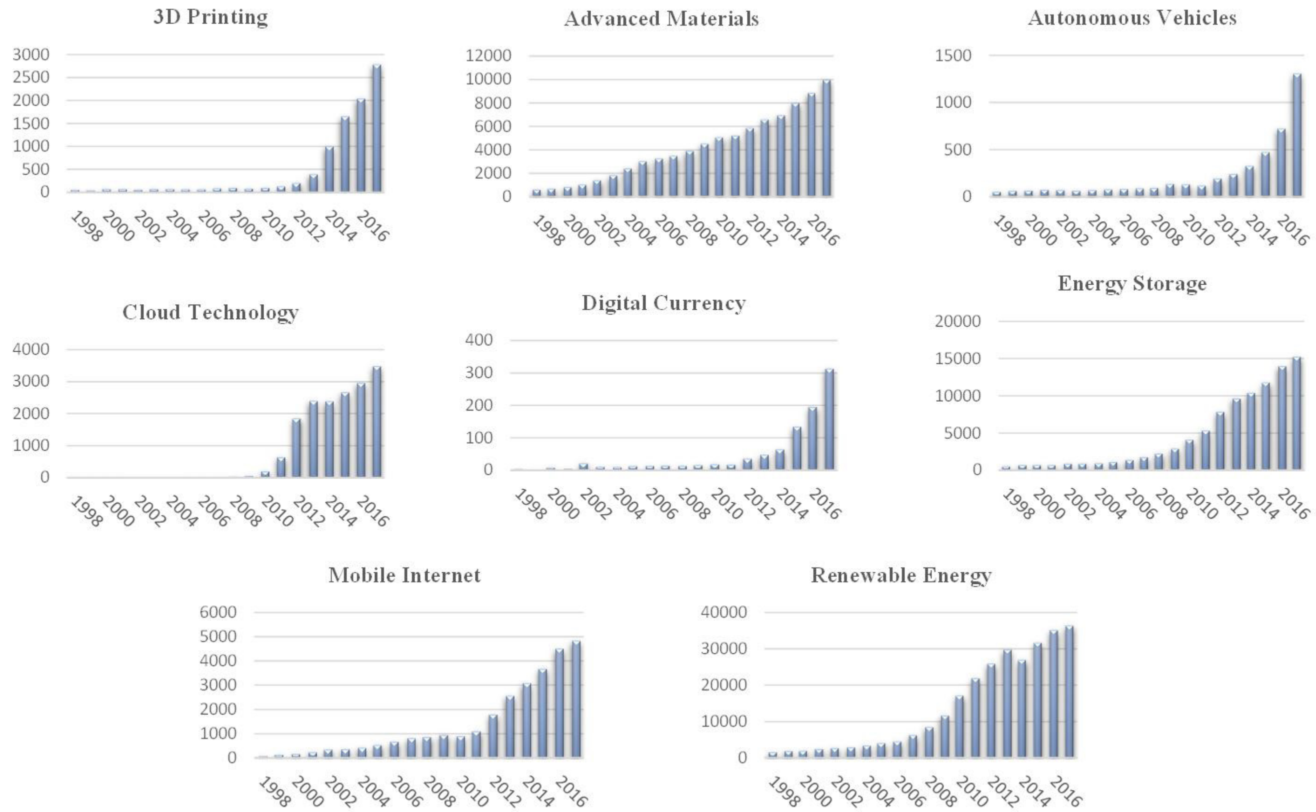

Figure 2. Evolution of number of patents for the disruptive technologies during the period of 1998-2017.

article. China dominates most areas, with special emphasis on Advanced Materials, Cloud Technology, Energy Storage and Renewable Energy. The United States leads the segments of Autonomous Vehicles and Digital Currency, but without a large domain.

Regarding the distribution of patents from Industry, Universities or Government, it is clear that most of the segments hold patents coming from the industry as their major source. This dominance is more evident in 3D Printing, Autonomous Vehicles, Cloud Technology, Digital Currency, Mobile Internet and Renewable Energy, all with at least 70% of industry share in the segment.

The 3D printing segment is virtually all dominated by industry, which holds 82% of patents related to the area. Universities account for 16% share in the segment, while government agencies hold only 2% of patents. The Autonomous Vehicles segment has a distribution of 97% of the patents coming from the industry and only 3% of the government. For this segment, there are no records, among the main players, of patents coming from universities. The Cloud Technology segment has a distribution of 86% of patents coming from industry, 10% from government agencies and only 4% from universities. Digital currencies have a distribution of 75% for industry and 25% for government, so there are no patent publications coming from universities for this segment. The Mobile Internet sector has a distribution of 91% of patents coming from industry and 9% from government agencies, also without university participation. And the Renewable Energy segment has a distribution of 72% of patents coming from industry, 15% from universities and 13% from government.

The other two studied segments present distributions with lower dominance of any of the three actors. The Advanced Materials sector accounts for 55% of patents coming from universities, 36% from industry and 9% from government agencies. The Energy Storage segment has a distribution of 57% of patents coming from industry, 29% from universities and 14% from government agencies.

Some discussions can be made based on the results. The cases of 3D Printing and Autonomous Vehicles have a very small participation of government agencies. First, the automotive area is a consumer goods industry, typically private, which conducts to a biggest participation of industry in patent publication. Another hypothesis that can be imagined for governments' lack of interest in these sectors is the extremely innovative nature of these segments, coupled with a still distant relationship with the services commonly offered by the governments of the most varied countries

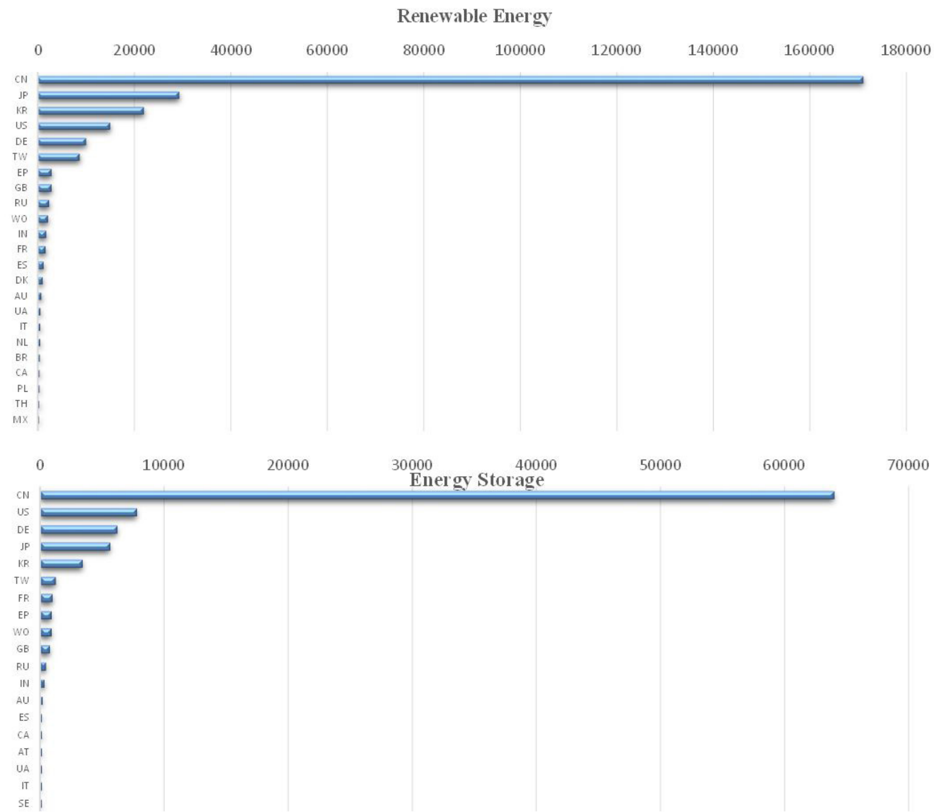

Figure 3. More representative countries in “renewable energy” and “energy storage”.

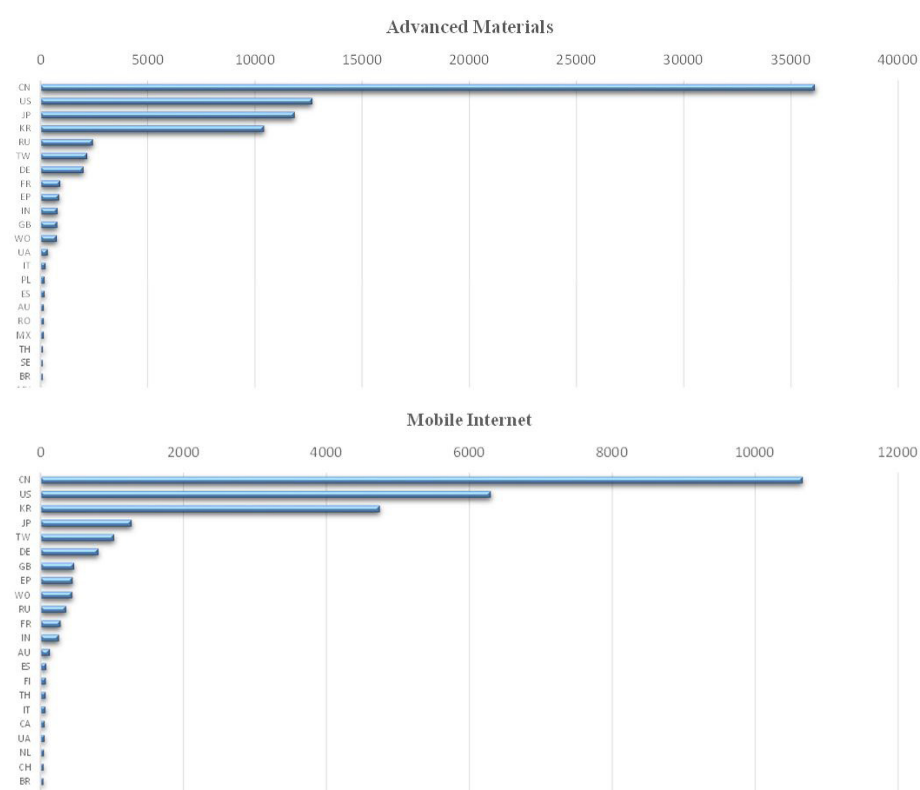

Figure 4. More representative countries in “advanced materials” and “mobile internet”.

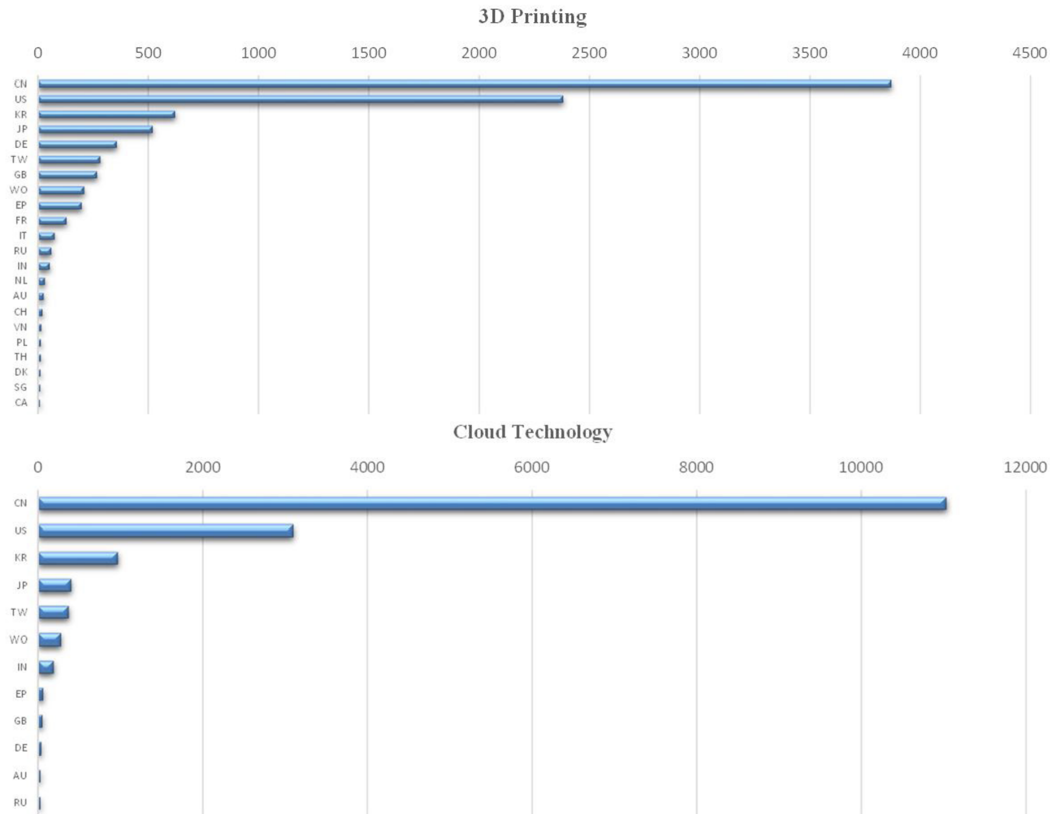

Figure 5. More representative countries in “3D printing” and “cloud technology”.

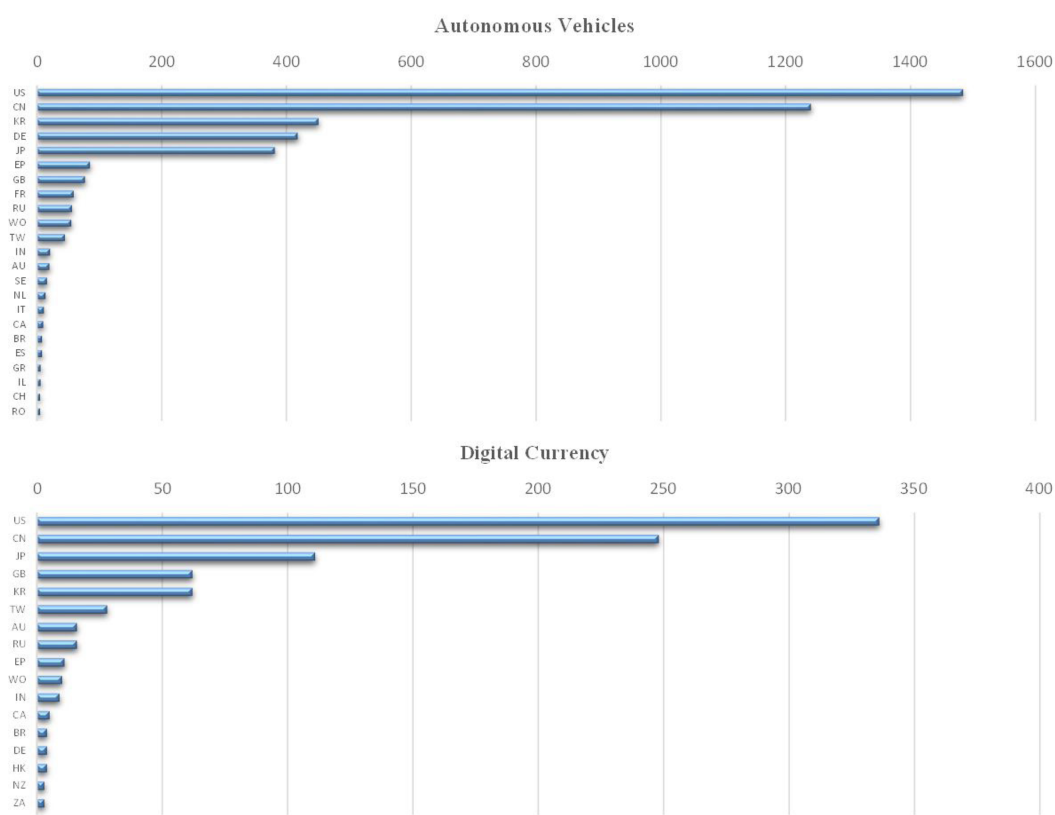

Figure 6. More representative countries in “autonomous vehicles” and “digital currency”.

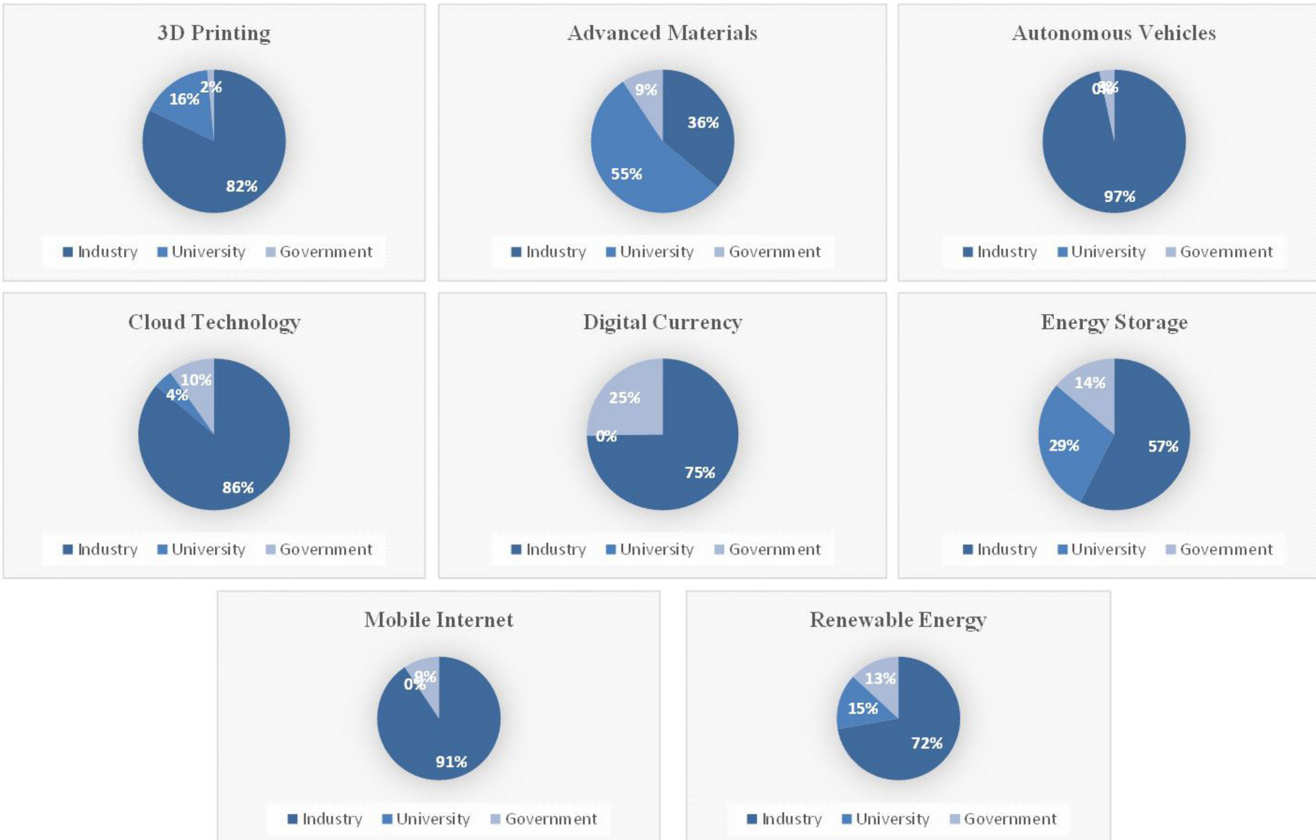

Figure 7. Industry, University and Government distribution of patent holders in disruptive technologies.

with these areas. Although Government Institutions are responsible for transportation services, they may still be reluctant to use autonomous vehicles, or are still working in this area only in regards of the necessary regulations for the development of the segment. Also, in these segments, the participation of Government is more regulatory, as an effort to create an environment for innovation and generate Competitive Advantage for their industries (PORTER, 1990). In a comparative way, it is possible to highlight the case of Digital Currency, which presents the highest percentage of government agencies among the segments analysed in this study. In this case, it is possible to imagine that the interest of the governments in the segment is due to the potential of economic changes that are made possible by the advance of the use of cryptocurrencies, besides the constant preoccupations with frauds and transactions without registration or without the payment of taxes that these technologies offer. In addition, most countries have public banks, which can explain the public sector interest in this area. In this way, given that Governments rules economies by establishing public policies, it is natural to observe a greater interest of these actors in a segment that has the potential of significantly altering the world economy in the future. In the same line of reasoning, it is possible to observe the interest of government agencies where their participation appears in a more intermediate range, as is the case of Energy Storage and Renewable Energies. For these cases, it is also possible to consider the hypothesis that the interest is greater because these areas are more directly linked to services usually provided by the state, as is the case of electricity supply.

With regard to the participation of universities in the segments, it is possible to highlight some cases. The Advanced Materials area is the only one that has the leadership of universities as the main actor. This fact can be justified due to the extremely academic nature of this area. In this context, it can be said that the Advanced Materials segment refers to a part of primary technologies that serve as a basis for the advancement of other areas. In this way, it is possible to imagine that the Advanced Materials segment finds in basic research its greater importance and performance, which would justify the great participation of universities in this area. In addition, when we compare the role of Industry and Universities during the technological innovation process, it can be assumed that the investment from industries is more likely to be held in areas that demonstrate a short-period profit prospection (MAZZUCATO, 2013). This fact can explain the majority of participation of industry in areas like Autonomous Vehicles and 3D Printing, and the importance given by Universities in areas like Advanced Materials and Energy Storage, for example.

6. Conclusion

In this article, a statistical survey was carried out on patent publications related to some technology segments considered as disruptive and with great innovation potential for the upcoming years. The objective of this research was to analyse the current context of these areas, in the scope of defining its main players, the countries that most develop such technologies and their development trends. Based on these data, an analysis was performed from the triple helix concepts, in order to understand how industry, universities and governments relate to the innovative process of the study areas, and what motivations would lead these actors to invest resources in research and development of technologies.

The results found in this work indicated that, at first, the motivation behind the investments in the innovative process of the technologies is related to the final objective of each actor. In this way, governments are more interested in areas directly related to their main services and lines of action, such as economy, energy supply, etc. Universities, on the other hand, seem to have a greater participation in areas that allow great possibilities in basic research and that support other technologies, such as Advanced Materials. And the industry has greater interest in areas with great potential of direct application, as is the case of 3D Printing and Autonomous Vehicles.

As recommendations for future work, it is important to carry out further research on each of the areas of technology studied in this article. A more detailed view of each segment can help and better understand the motivations behind its innovative processes. It is also interesting to elucidate the individual behaviour of each nation in the aspect of "triple helix" in relation to the technologies studied here. An analysis such as the one developed here, but focused on patents developed individually in each country among the largest developers, can be a good way to understand how these countries behave in the research and development of technologies in the studied segments. Another recommendation for future research is to better understand the relationship of the actors of the triple helix concept based on their participation over time. As we have presented the distribution of patents in relation to the present scenario, it would be interesting to investigate the behaviour of these technologies regarding the participation of each actor along the last two decades, in order to try to understand how the participation of each of them, in the past, may have influenced the current context of technologies.

7. References

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