Universidad del Rosario


# Influence of Artificial Intelligence in the firm outcomes by the innovation and R&D perspective

Ana María Arciniegas Jiménez

Administración de Negocios Internacionales

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GRADUATING PROJECT

Rennes School of Business

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MSc in Global Business Management

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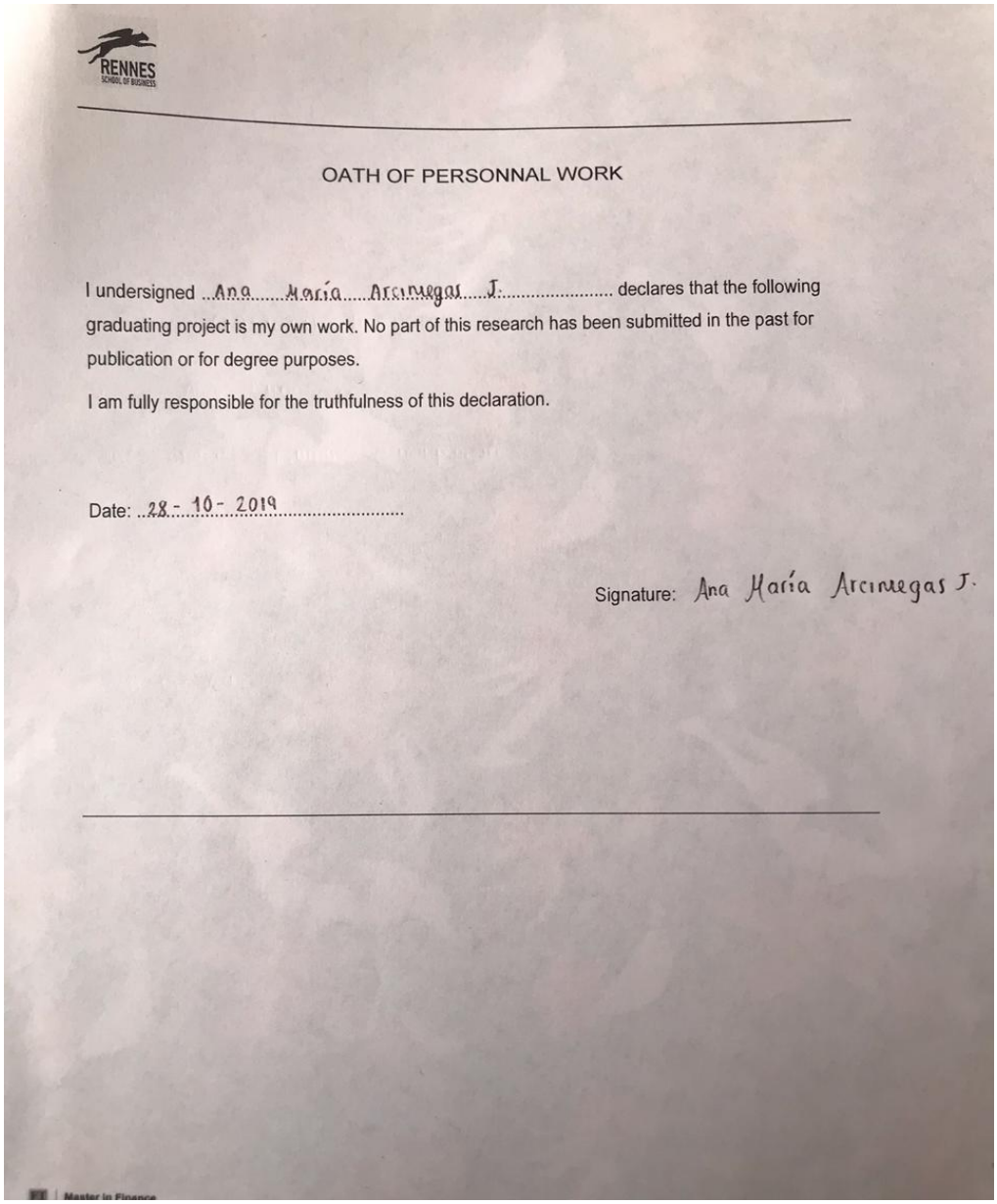
## *Oath of Personal Work*



RENNES SCHOOL OF BUSINESS

OATH OF PERSONNAL WORK

I undersigned Ana María Arcinegas J. declares that the following graduating project is my own work. No part of this research has been submitted in the past for publication or for degree purposes.

I am fully responsible for the truthfulness of this declaration.

Date: 28 - 10 - 2019

Signature: Ana María Arcinegas J.

Master in Finance

***Acknowledgments***

Throughout the development of my research project, I had the help of my Graduating Project Supervisor, Hamid Mazloomi, I would like to thank him because he has been my guide during all this process, and beyond that, he has been such an inspiration for my life. Thank you, for lending me the time to determine my project direction and guide me with your knowledge. In the same way, thank you to help me to understand concepts and methodologies that have make me a better professional.

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***Glossary***

| Word | Explanation |
|---|---|
| Patterns | Is a regular situation or way that used to happen. |
| Networks | It is a computer system connected with other computer systems, in order to transmit information and resources |
| Algorithms | It is a procedure, which is used to solve problems by following a sequence of actions. |
| Fuzzy systems | It is a mathematic diffuse control system of control based on the diffuse logic, which analyze inputs values translating this to logical variables. |
| Hybrid Intelligent Systems | It is a software, which used different systems such as fuzzy systems. |
| Deep Learning | It is a subfield of machine learning, which solve complex problems with not just structural and organize information, but also unstructured data. |
| Fuzzy Logic | It classified the information in the degree of truth that it has |

***Abstract***

The main purpose of this thesis is to analyze and evaluate the company culture complexity which due to the new business environments and the new internal work dynamics has changed in several ways. This thesis examines the role of Artificial Intelligence in the organizations and the way it influences innovation and R&D. Moreover, this project evaluates and analyze the challenges, which the companies are facing to optimize their resources, increment innovation, incorporate R&D depending on the size, corporate culture and available budget that due to the new business environments and the new internal dynamics to work has changed considerably. Furthermore, it analyzes the tendency of the new uses of artificial neural networks to analyze data and as a new tool to develop in-depth the AI in the companies. In this research, I am going to select a specific industry to be analyzed, the Pharmaceutical Industry. This paper will reach all the processes from the R&D and innovation area of the companies that AI affect. In addition, this vision will identify the proportional relation of AI instruments and the increasing outcomes. On the other hand, this study wants to purpose a new way of how AI can change organizations in a corporate context, through the usage of innovation and the application of it in the whole process of R&D.

Knowing this, the proposed approach wants to understand the most important components of company decision making using new technologies, such as AI.

***KeyWords:*** Artificial intelligence, machine learning, neural networks, pharmaceutical industry, R&D, innovation, future trends, drug discovery, intelligent systems, firm outcomes.

***Resumen***

El objetivo principal de esta tesis es analizar y evaluar la complejidad de la cultura de la empresa que debido a los nuevos entornos empresariales y las nuevas dinámicas internas de trabajo ha cambiado de diversas formas. Esta tesis examina el papel de la inteligencia artificial en las organizaciones y la forma en que influye en la innovación y la I + D. Además, este proyecto evalúa y analiza los retos a los que se enfrentan las empresas para optimizar sus recursos, incrementar la innovación, incorporar la I + D en función del tamaño, la cultura corporativa y el presupuesto disponible que debido a los nuevos entornos de negocio y las nuevas dinámicas internas de trabajo ha tenido que cambiar considerablemente. Además, analiza la tendencia de los nuevos usos de las redes neuronales artificiales para analizar datos y como nueva herramienta para desarrollar en profundidad la IA en las empresas. En esta investigación, voy a seleccionar la Industria Farmacéutica, para analizarla. Además, esta visión identificará la relación proporcional de los instrumentos de IA y los crecientes resultados. Por otro lado, este estudio quiere proponer una nueva forma de cómo la IA puede cambiar las organizaciones en un contexto corporativo, mediante el uso de la innovación y su aplicación en todo el proceso de I + D.

Sabiendo esto, el enfoque propuesto quiere comprender los componentes más importantes de la toma de decisiones de la empresa utilizando nuevas tecnologías, como la IA.

***Palabras Clave:*** Inteligencia artificial, aprendizaje automatizado, redes neuronales, industria farmacéutica, investigación y desarrollo, innovación, tendencias del futuro y sistemas inteligentes.

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# 1. Introduction

Within the framework of the fourth industrial revolution, where new technologies are fusing the world, Artificial Intelligence is leading an enormous change in the traditional ways of production, consumption and work that until now we knew. Different countries have developed their ways of introducing this technology into their industries, for example, Germany is one of the country's leading the innovation processes by offering unique services and enabling manufacture (Heiner, Fettke, Feld, & Hoffmann, 2014). This shows that countries are specialized in certain areas of the AI, boosting the concept of AI technologies. Furthermore, one of the major challenges for industries since along times have been the process of handling information and using the useful one for developing their functions and objectives, due to the large amount of information that they get from different sources. This leads companies to face a complexity in the decision-making procedures due to the huge quantity of information, which makes that organizations find out a big problem and ,in that sense, they need to reach new methods and taking AI as a new opportunity for find advancements inside the company and understand the power in taking certain decisions, especially in a competitive environment where the technology is always present (Fast, Schroeder, 2019). Because of this new technological era, companies have been transforming their internal processes, for example, many of them started creating new departments specialized in AI, where the main objective was to find the perfect match between the company's necessities and the implementation of new technologies. On the other hand, the incorporation of the AI in some companies generates pressure to the rival companies forcing them to acquire AI to compete in the same conditions, since certain organizations that have strong AI departments have influenced to unbalance the market, demonstrating how important is the access and analysis of information.

Developing the concept of AI it is important to see that Machine Learning (ML) is the most significant subfield of it, and it has revolutionized big data by learning and taking into account the databases which already exist (Gilvary, Madhukar, Elkhader, 2019). Mechanisms and software's that use ML can learn from data without rule-based programming. Hence, thanks to this methodology, the software can adapt easily and quickly to the new market conditions, identifying

specifically the clients' needs, being less time consuming and being an excellent way to discover certain elements which influence the market by having the larger capacity in analyzing elements of different methodologies. Moreover, through research, AI was introduce as a method to develop research in new fields, trying to contribute or solve problems within the organizations. Its implementation has gone from technological, economic, political social and even medical research.

Furthermore, one of the most involved industries in the implementation of Artificial Intelligence is the Pharmaceutical industry, where it is possible to find several discoveries, and new ways of proceeding in medical cases, due to the use of AI tools. Nowadays many companies such as Apple, Google, Amazon and Facebook are disrupting the market with new technologies and business that it did not exist before, and even they are disrupting the health care (Alexander, McGill, Tarasova, et al., 2019). Artificial Intelligence, is revolutionizing the drug development process, but at the same time, it generates challenges to the pharmaceutical industry because of the high costs in the drug development and the necessity of developing R&D and maintain a balance with the efficiency inside the companies (Mak, Pichika, 2019). Likewise, medical decision making has been a big challenge for the entire world, due to the complexity that it represents, this is why AI has been used to help to diagnose medical cases, collect and analyze the information with past medical cases and try to figure it out the proper solutions. Pharmaceutical and medical industry are undergoing rapidly as innovation changes, and every year new mechanisms and medical devices are elaborated, as a result, meaningful information from this type of sources have contributed to this field and one of the principal objectives is to provide the “customer/patient” with a more personalized and dynamic service. In the same way, companies have started realizing the importance of introducing R&D into their companies in order to be sustainable and innovate. In that sense, to be profitable and reduce hour human labor and resources wasting, especially by taking advantage that AI software perform its operations based on human decision-making, this technique has been applied in different stages of the R&D processes and in the pharmaceutical and medical health sector, with the main focus on improving the service and the treatment of patients (Tsang, Perkins, Dickinson, et al, 2017). Therefore, this research project focuses on understanding the impact of the implementation of Artificial Intelligence and innovation on the pharmaceutical companies, understanding the challenges, risks and benefits that it brings. First, the thesis will start seek to provide a clear context to make it easier to interpret the application of certain tools in the

pharmaceutical industry. After, there is a brief explanation of the advancements of the usage of AI in this industry, as well as the continuous challenges. Further, there is some recommendations and the conclusion of the research work.

## 2. Research Question

Research Question**:** How AI will influence R&D and innovation as the firm outcomes?

In the last years, companies have faced numerous challenges due to the new technologies existing and their adequate implementation within the company. Furthermore, it also exists a debate between the utility of the implementation of certain technologies and if the investments are going to worth, translate it this to benefits for the companies. With this research project, I would like to demonstrate the effect of the implementation of new technologies in an organizational environment and the role of innovation during this process. Therefore, this project is of my interest because I am passionate for innovation and I am a loyal believer that innovation makes companies sustainable through time. Thus, with this document, I intend to provide an overview of how AI technologies affect and challenges companies nowadays, especially in the pharmaceutical and medical industry.

## 3. Literature Review

Today, due to the various challenges that the companies have to face every day, it is necessary to focus on the main aspects that are revolutionizing the different economic industries. The following literature review aims to offer a clear and simple understanding of the main concepts that have defined and identified the processes in which the companies involved new technologies to increase their outcomes.

*3.1 Artificial Intelligence (Context) & Machine Learning*

To start talking about the challenges that nowadays the companies are facing, it is important to define a concept such as, Artificial Intelligence (AI) for it, is necessary to know the exact meaning or at least the approximate one. According to the Oxford Dictionary, AI is the "theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages". To have a better approach of this concept, we can take the definition that Merrian-Webster gives about this term, so AI for her is "A branch of computer science dealing with the simulation of intelligent behaviour…".(Forbes, 2018), demonstrating that this technology aims to understand and implement characteristics of human reasoning, more specifically understanding human capabilities. In that sense, AI operations work inspired by human beings, because their main solutions are focused to satisfy them. Its body, senses, reason and actions, all are considered by AI technology (Simon, 2019). This means that the main goal of AI is to become human functions into a set of systematic tools that facilitates or fix daily problems. However, how it works? AI systems need sensors to capture the data from the environment, analyze this data and then recommend some decisions to follow through. Thus, AI acts as a method of inventions and not just as an optimization tool in business fields (Cockburn et al., 2018).

Contextualizing AI, it is important to know that this term was use for the first time by John McCarthy in 1956 giving a conference at the Institute of Technology in Massachusetts. Hence, the term Artificial Intelligence is not new, this preoccupation began a century ago, even when mankind had not started applying technologies that we used nowadays (Antonescu, 2018). Other important actors into the development of AI, are the recognized Warren MC Culloch and Walter Pitts who created an artificial neural networks model which tried to imitate the human brain. In the 1940s, Donald Hebb promoted the creation of the research of Artificial Neural Networks by the development of a theory of learning known as Hebbian Learning, which uses the human brain by replicating the process of the neurons' connections (Haenlein, Kaplan, 2019). Nevertheless, the first program considered as an Artificial Intelligence was the Logical Theorist Program, applied for computers in 1956 and created by A. Newell and H. Simon. During the 1990s, more tradable systems of Artificial Intelligence started to appear and be commercialized.

The most important technology is AI, more especially ML, that as was mentioned before it consists in the performance of a machine, which learns by the experimental data, without the necessity of human intervention to complete a task (Antonescu, 2018). In the last years, AI systems have gained more power due to the successful strategies by using "Machine Learning (ML)", a subfield of AI, which consists in a trial and error developed by some algorithms that learn patterns from training data. Most of these predictions consider the costs and benefits of different scenarios to develop deeper analysis and produce the needed data for the company. Hence, it can improve productivity by making the production process more through automatic decision-making. On the other hand, the existence of Big Data generates a considerable growth and progress in the machine learning methodology. For example, many health care organizations are developing many techniques by applying machine-learning, and the result of this research of new tools, artificial neural networks (ANN) was created, among the most relevant results in the timely delivery of care, which depends on the selection of information from different databases by the Big Data. (Shahid, Rappon, Berta, 2019). This mention technique contributes not only for the reduction of cost, but also to reduce errors and split the information according to the goal of the investigation, that is why it is important for the development of various projects.

Furthermore, there is another subfield of AI and ML called Deep Learning (DL), that also used the databases in order to learn from it, to do this, this system used artificial neural networks (Mak, Pichika, 2019). This helps considerable in any kind of investigation, such as the biological changes in the discovery of any disease, because of the ability of this system to process and analyze the information. Additionally, is important to mention that DL mainly rely on the artificial neural networks which permits the analysis and learning form of a large amount of experimental data, to then identified important elements that may be hidden in a large volume of information (Mak, Pichika, 2019).This term appears in 2015, as a representation of a specific type of Artificial Neural Networks, when Google developed a program called AlphaGo, which "was able to beat the world champion in the board game Go". (Haenlein, Kaplan, 2019). This game was very complex, even more than chess, and nowadays is the basis of many applications such as Facebook, for the algorithms used for the image and speech recognition.

Moreover, artificial intelligence can be classified into three branches: Natural Language, Expert Systems, and Computerized Perception. It is shown in the graph below

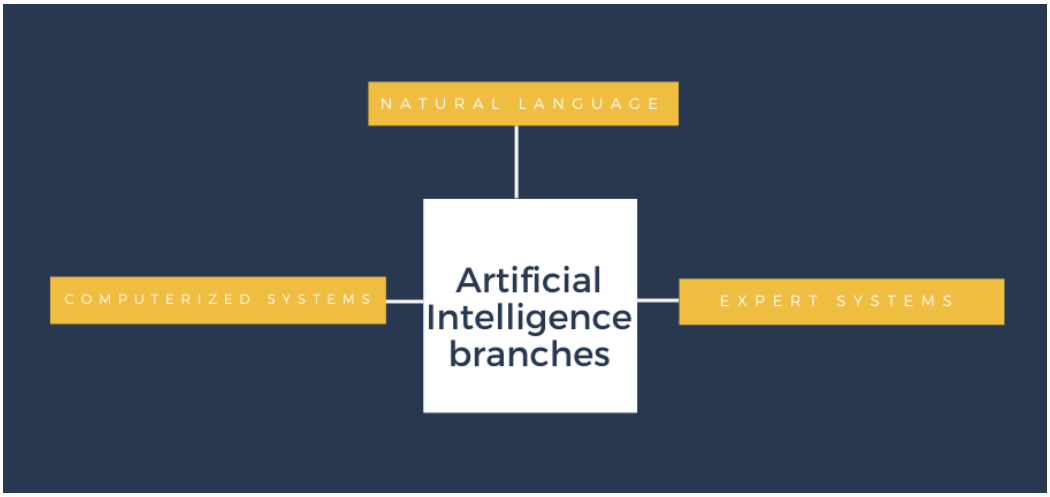


*Figure 1. Artificial Intelligence branches, Raunch (1989)*

Nevertheless, according to Kazuyuki Motohashi (2018) for applying AI technologies, we should categorized AI systems by image, text data recognition, and human interfaces, producing better results. Besides, one of the possible classifications for AI is "the analytical, human-inspired, and humanized AI depending on the types of intelligence it exhibits (cognitive, emotional, and social intelligence) or into Artificial Narrow, General, and Super Intelligence by its evolutionary stage" (Haenlein, Kaplan, 2019). Besides, according to Wendy B. Rauch (1990), AI can be applied in different areas such as configuration, design, vision and automatic programming, database managers, analysis, planning, natural language, and interpretation.

Consequently, artificial intelligence represents a new source of innovation; by taking into account, the actual context characterized for the great number of methods becoming a rapid decision-maker, in order to achieve the company's goals. Another open door for the innovation is the opportunities that born in the process of taking decisions with the recollected and analyzed data by the AI systems. For example, Amazon creates a virtual home assistant called "Alexa" which involved many neural networks and artificial intelligence to help the customer to satisfy

their needs in a shorter period of time. Furthermore, a solution to optimize services and products needs are the usage of algorithms such as ML, which represent an optimal solution for analyzing, predict and manage information (Far, Zanjani, Saif, et al, 2017). Customers nowadays are asking for more, they are demanding better, faster and more personalized services with their branches, and as the customer is changing their mind and necessities constantly, companies need to do the same, and it is only viable through AI. It is evident, that AI has contributed almost all the industries and has created new business models due to the impact that it has generated, challenging companies to get out of their "comfort zone" and trying to dive into new ways of managing their current activities. Unquestionable, Artificial Intelligence is and will be necessary to work with big data and manage the constantly changing environment which is complex and uncertain, it also is a tool for managing the deployment of the Internet of Things (Simon, 2019)

From the different implementations mentioned above, it can be inferred that AI is a system who will be further developed in the future, therefore, any conclusion that may be drawn from it, cannot totally be accepted. Recollecting data is only the first step to transforming information into something valuable for any company. Moreover, for finding meaningful information, it is necessary to appeal to this kind of analytic algorithms, which can turn data into initiatives of transformation for the organizations. Additionally, it is expected that more fields of this system will continue to be developing in a greater way, as one of the most important tasks that AI has is the ability to generate new and valuable information for companies. Moreover, AI has an eminent task, prediction, which is the generation of new information, and usually is abundant and inexpensive (Agrawal, Gans, Goldfarb, 2017). This means that machines need to get the information, analyze it, predict what is next and then determine the following steps. Thus, companies can make a forecast to determine the future of the organization and prepare them for the uncertainty, by preparing a series of activities to implement it in the future, identifying the crucial periods and trends. Hence, AI has changed the way the world works and it goes beyond the technological sector, it had impact our personal life, our society and the way as firms take decisions, performances and interact with their external stakeholders.

### *3.2 AI, R&D and Innovation*

In the early modern years, (1500-1800). Innovation had a negative connotation because it was considered as unnatural and revolutionary for not following the order of things. Since 1930 until this century, innovation has a positive and disruptive connotation. Besides, the innovation had great impact within the 20th-21st century and as a piece of evidence it was possible the creation of very important terms associated with this area, such as: technological innovation, commercial innovation, or industrial innovation. Fundamental terms to give way to what is known as innovation in modern times (Schramm, 2017). It is precisely in the modern age, that due to new conditions in the environment, the new technologies particularly gave way to the creation of a new type of innovation as it is, innovation 2.0. It is defined as a parallel development which integrates horizontally the industry, the government, the types of research inside organizations and universities, with the goal of creating and drive economic growth. The implementation of these new forms of innovation in the actual atmosphere brought many barriers or challenges to have a successful innovation process, such as the technological barrier, financial, manufacturing, and even legal. Therefore, to have a correct innovation process, companies must identify first these barriers in order to know how to manage them and decide in short, medium and long-term which strategies are they going to follow through. Similarly, companies must increase flexible structures to cope with these new challenges and even have auxiliary plans.

During the last years, the study of the effects of the innovation on the market structure has been an important focus point. In fact, it has been considered a key factor in economic growth and development (De Silva, Howells, & Meye, 2018). Thus, technological change has been one of the major forces, which influenced the industry's market structure. Karl Marx, emphasize that traditional models are not complete enough to demonstrate the relationship between innovation and market structure (Griliches, 1984). This is due to the lack of planning inside the industries to adjust their necessities with the technology existent nowadays. Moreover, some studies have found a lack of links between innovation and the performance of a firm, by relating it to other elements that do not fit in, with those present in the current environment and impeding the understanding of the scope of this factor on organizations (Rosenbusch et al., 2011). However, while innovation is not considered a major development factor, there are some approaches within this concept that focus on organizations. This is supported by Damapour (1996) by establishing that there are many types of innovation, including the following types, the Administrative Innovation & The technical innovation, clearly focused on the corporate area. This differentiation let easier to understand the

differences between the social and the technical parts of an organization, which means that each innovation starts and end in different moments and follow through separate process. Consequently, it is easier to analyze and understand the actions that companies must take to cause impact and do not fail in the process, while they understand that not all the areas can innovate in the same way. Thus, they have to think and organize themselves strategically, implement radical innovations through the overcoming of organizational barriers, boost the adaptability, and promote the search of new ideas and even new markets. In spite of, the search to carry out these new processes and implement new solutions, it has generated that the organizations create areas focused on these topics such as R&D. Showing that if a firm wants to introduce R&D and innovation within its processes, they need to incur in fixed costs (Chen, Pan, Zhang, 2018). Therefore, it is a necessary investment but it has to be managed correctly, to performance what the company wants to achieve.

Furthermore, Alan L. Frohman (2001), determine that the innovation process is composed of the information gathering, analyzing and idea-generating, champion and demonstrating, and implementation. However, in practice, these steps are not linear, they can occur simultaneously.

Below is shown a brief of these steps.

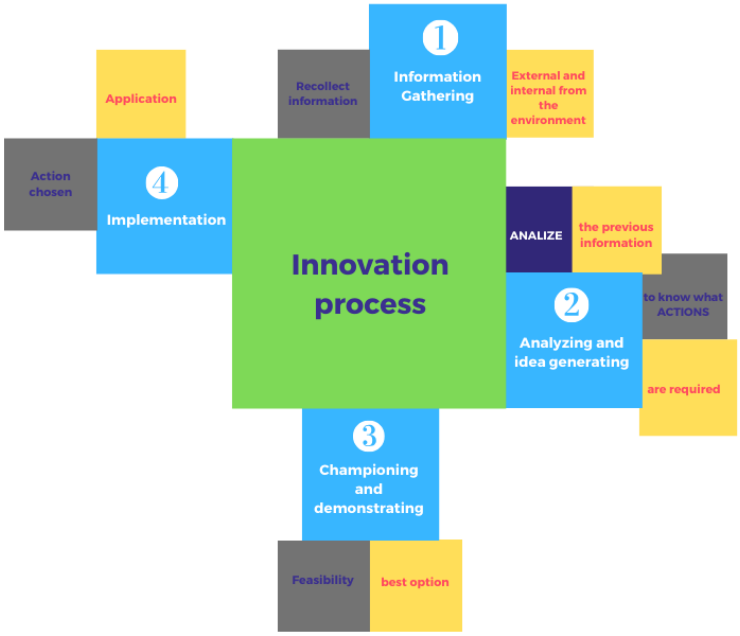


*Figure 2. Innovation process, Frohman, A. (1999)*

According to the graph, it is possible to have a brief path of the steps that companies should follow, in order, to involve innovation inside their processes. Moreover, after the implementation, it is necessary to evaluate and control the actions taken.

On the other hand, R&D has had an important growth over time and likewise has changed considerably. It has moved from the firm´s boundary contractors to explore the trend of "open innovation". Nowadays, there is a wide group of firm´s offering this kind of services such as public research institutes, universities, and innovative manufacturing firms. These firms are playing an important role and their activities are knowledge in the value chain, Moreover, it is important to mention that these agents must be constantly actualizing their processes because thanks to new technologies, it makes it more complex to have an updated R&D department. (Tether and Tajar,

2006). As a result, organizations have more efficient systems, better relations with their clients, better or new products/services, and therefore, higher-quality results. That is why R&D firms used analytical knowledge to produce own innovation (Pina, Tether, 2016). In that sense, companies are more likely to not waste their resources unmeasured and distribute their processes to hedge the investment risk and work following the company's goal. Although, innovation inside companies has been a challenge over the years for them. Most of the enterprises believe that R&D is not linked to innovation, but according to Frohman (1978), it is necessary to use R&D as the principles of a strategy for innovating. In this way, it is necessary to understand the importance of innovation after a process of research to identify the necessities of the company and follow the objectives that will make them accomplish their mission and vision. Furthermore, according to Love and Mansury (2017), internal R&D should be considered as the most important determinant of innovation and firms must create and develop their technological capabilities, to improve their performance and increase innovation into their products and processes. Is at this crucial moment when R&D provides the necessary conditions for the innovation arises. Additionally, Chesbrough, insist on the importance of the creation of R&D departments due to the facilities that it could bring to the companies in the generation of ideas. Thus, it is necessary that firms enhance the internal innovation level and take into account the importance of the creation of R&D departments, in order to improve the performance and to direct the company to implement different innovation projects (Hameed, 2018). Hence, R&D is needed to not launch products or services with not high quality and that the market does not need. To point out this idea, one of the trends, discuss for many scholars is the model to outsource the R&D to external suppliers (Howells, J. 1999.). In that way, it is easier for companies to focus only on their main activities, but introducing in their activities the help of AI.

Analyzing this overview with the pharmaceutical industry, it is evident that pharmaceutical companies face considerable challenges in improving the efficiency of R&D. One of the main reasons is the cost that it produces for the companies, to start researching and developing new drugs, and furthermore, the process of receiving the approval from the FDA and then introduce this drug to the clinics. Additionally, companies have to be prepared for the trial of error and try, to get that new drug, and most of the times, this process takes a lot of time. However, AI has versatile tools which can make this cycle efficient, for example, "identification and validation of drug targets, designing of new drugs, drug repurposing, improving the R&D efficiency,

aggregating and analyzing biomedicine information and refining the decision-making process to recruit patients for clinical trials" (Mak, Pichika, 2019). AI has demonstrated its success in this industry even if in the past decades R&D was considered an unnecessary expense. Nowadays, we can say that this vision is debating their real importance and impact inside the economic industries. On the one hand, in the last 60 years, there's been many advancements to increase the efficiency of commercial drug R&D, through scientific, technological and managerial advances (Scanell, Blanckley, Boldon, Warrington, 2012). As we see, the impacts or R&D and innovation every day are huge. Even though, some experts say that this investment is not fair enough to do for some companies, due to the "lack of efficiency" in developing these methods.

Finally, nowadays companies collect big data as a result of the increase of digitalization (Lichtenthaler, 2018). Nevertheless, one of the major difficulties is an effective and efficient way to collect and analyze the data. Besides, many firms experience issues in the moment of designing the proper digital models, which they are going to use to offer their services, but the problem here is that most of the companies start new digitalized projects, without having a strategic plan, flexible and able to adapt to all the technological transformations. Thus, innovation calls to generate strategic ideas to optimize AI and go beyond the technological changes, to use these tools intelligently. At an organizational level, innovation affects the success or failure of firms (Crossan and Apaydin, 2010). Because sometimes companies believe that they have to sacrifice competitiveness instead of innovation, and the reality is that innovation is a competitive factor and currently companies need innovation to have intelligence into their processes. Moreover, they need to renew themselves with AI and HI to leverage the benefits of both types of intelligence, currently, a good company is recognized when they have the ability to transform themselves and use R&D in order to try to reduce the uncertainty. Even countries are reinvented themselves and introducing AI into their operations, becoming users of new technologies. In 2016, the report of Atomico/Slush showed an optimistic overview of the technology capacity and innovation in Europe, making this area very attractive for large investments or projects (Simon, 2019). On the other hand, open innovation has been beneficial for many organizations because it has facilitated the creation of synergic relations between the sources of knowledge in innovation, demonstrating the importance of cooperation in innovative processes. Companies such as Apple and SAP, have transformed their Human Intelligence (HI), by focusing on design-thinking logic processes, instead of using the existent and traditional ones (Lichtenthaler, 2018). In that way, companies seek to transform and

build ideas, to improve the future of the company, and going to disruptive innovation techniques. Additionally, organizations have begun to involve people and their clients in innovation processes, being a very attractive source of information and creativity, as they are the people who know best the products or services of the firms, knowing what needs they want to be attended (Randhawa, 2017).

### *3.3 AI, R&D and Innovation*

Medical decision-making is a complex process, which has challenge AI and Science in general. AI is used to get and analyze complex medical data to finally find relations between the data and the possible alternatives to solve the medical diagnosis. “Since the middle of the last century, researchers have explored the potential applications of intelligent techniques in every field of medicine.” (Ramesh, Kambhampati, Monson, Drew, 2004). Besides, the last two decades the interest of application of AI into the surgeries has grown and the principal challenge is to apply the data recollected to analyze it and then apply it into the clinical problems. Thus, developing more this industry systems such as Medical Decision-Support System was developed to help in the clinical decision making to the professionals of health (Shortliffe, 1987). It also monitored the conditions to then know how to manage and interpret the information. Moreover, it helps to improve the process of decision-making, speed up the diagnosis and medical procedures, reducing medical errors. Specifically in this industry, the decision making is crucial and with the more information collected, will be possible to have better diagnoses and improve the way of treating patients. To diagnose and predict, it is necessary to follow four steps, the first one is to get the information, that basically, is the patient’s databases with general information of them. After that, the prediction module through neural networks techniques start analyzing the history of the patients with some illness conditions and mix this with the actual patient and its symptoms. In the diagnosis module, it is used logic techniques to find the illness according to the patient symptoms, and finally create the user interface, where patients and doctors can interact in the system chosen. The most used AI techniques in this sector are artificial neural networks, fuzzy expert systems, evolutionary computation, and hybrid intelligent systems, being one of the fields where a great

number of techniques are developed, due to the great amount of elements that must be analyzed (Tull, Miller, 2018). For example, Modified Robust Fuzzy C-means was developed by Song et al. (2019), which consists of an algorithm that shows MR images of the brain segmented, after taking the images, these results are compared with another algorithm based on fuzzy clustering, allowing to create a new image detecting the real state of the client and allowing to arrive at better conclusions for the doctor and his patient. Moreover, currently, AI has been part of the study in the interpretation of electrocardiography (ECG), which is a critical diagnosis and it is a huge step for AI. (Chan, Shan, Dahoun, Vogel, Yuan, 2019). In addition, cardiovascular cases are also being a focal point in all the technology advances, for example, D'Aloia et al. developed (2019) a mechanism to detect and locate the noisy electrocardiogram signals, where can be a peak. "The wavelet transform for R point detection and localization. Results obtained are presented, discussed, and compared with some other R wave detection algorithms" (Impedovo, Pirlo, 2019).

On the other hand, one of the methodologies used in this field is the CBR, Case-Based Reasoning, started twenty years ago. CBR utilizes knowledge of cases, which are previous situations or experiences, with the purpose of solving a paradigm (Montani, 2007). They used past information taken from resources as HIS, Hospital Information Systems, which contain a huge quantity of data, to reutilize successful solutions. Thus, create standardized processes to help to solve and diagnose medical cases, mostly the difficult and the not well-understood diseases. It is a very suitable methodology and overall is used to change the inside processes of medical organizations. Another system used often is the Data Mining, which is a technique of AI that analyze huge databases, in order to collect the hidden data with the purpose of help in the medical science, this concept brings together different techniques with not a supervised learning, using the neural network for understanding the fuzzy pattern of HIV and AIDS (SitiNurul Huda and Miswan, 1999). Fuzzy logic is applicable in medicine, because of its agility to recollect information and then applying it into traditional programs. Moreover, Fuzzy logic is a useful tool to diagnose lung cancer, acute leukaemia, breast cancer, and pancreatic cancer, also it has been used in diagnose aphasia, arthritis and hypothyroidism (Tull, Miller, 2018)

As a matter of fact, several methodologies of AI cooperate to provide medical decision support and it also works as a support for the daily health-care workers' duties, here is where ANNS, Artificial Neural Networks, are applying it, it is the most popular technique used in medicine. This computational analytical tool is inspired by the human nervous system (Ramesh, Kambhampati, Monson, Drew, 2004). For Medicine, it is a very attractive analytical tool used in almost all their branches, for being a practical model and because it tries to perform the function of the human brain (Hussain, Ishak, Siraj, 2004), the ANNs learns through experience about the environment where are being utilized and they have a wide range of applications. “The behaviour of a neural network is determined by the transfer functions of its neurons, by the learning rule, and by the architecture itself”. (Kustrin, Beresford, 2000). For example, a researcher call Baxt developed a model using neural networks to diagnosed acute myocardial infarction. Also, in 1995 Lippman used ANN to deal with a coronary artery, in the same year, this model helped doctors to treat pneumonia, and in 1999 brain disorders. With ANN, it is possible to make a huge variety of diagnosis because it is used in procedures since radiology to surgery.

Consequently, AI helps medical science to manage the uncertainty and works every day in new environments, taking the information through different models to then propose solutions. In 1998 Hoong, explain in summary the benefits of AI in the different techniques of Medicine, he said that AI provides support to medical decision-making through new research tools; providing a categorization of medical knowledge; and integrating technology with science. It is precisely the union of technology with medicine, which has generated interesting advances such as the relationship between the doctor and the patient which is more interactive, through the use of artificial intelligence, and allows finding relevant information as well as provides a complete knowledge to the doctor about his patient. (Hussain, Ishak, Siraj, 2008) letting either patients and doctors a wide range of ways to find the best solution, practical and less risky form of proceeding in a medical case. The creation of applications using neural networks trained to learn from researches, books and patient’s experiences have been a dynamic and effective tool in speed up the medical decision- making. It exists Chabot’s and apps such as Melody and Doctor App. Additionally, Universities and Researchers are developing new facets of these type of systems to reach better and faster results.  A good case is the Radiology has benefited from R&D as in this sector it has developed to a great extent with the image processes that are part of this area. (Alexander, McGill, Tarasova, Ferreira, Zurkiya, 2018).

***-AI in the Medical Device Industry***

The Medical Device Industry is growing and changing fast, due to the acceleration of the innovation in medical decision-making. An exponential indicator that the industry is having thanks to the intervention of the Innovation, is the number of patents related to medical devices. One of the main results is that the number of patents related to medical devices has tripled in the last 10 years and technology cycle times have reduced to 5 years, demonstrating that the updating of technologies is happening very quickly. (Alexander, McGill, Tarasova, Ferreira, Zurkiya, 2018). In the same way, there are many innovative resources management platforms (RMP), which involved clinical and homecare decision support systems known as DSS, that thanks to the innovation in this type of management, with its structure, is possible to identify real-time alerting conditions and improving the preventative actions that have great results by analyzing and finding relations of historical data, making easier the process to forecast some situations and plan some actions (Impedovo, Pirlo, 2019). Another interesting program that reinforces the relationship between technology and user is the HOLMS (Health Online Medical Suggestions) which according to Amato et al. (2017) using algorithms of machine learning provide advice through a web page and chat-bot to offer a dynamic interaction between the patients and the software. In the same way, a impactful devices that have generated a great impact in the industry are the hybrid medical devices comprise of multiple materials, which is looking to use different materials, mixing the synthetic and biological components that give way to some tools that are currently changing the traditional processes, such us the nanotubes, polymers, stem cells and others. (Ho, Wong, Chua, Chui, 2018) Considering this as a complex and wasteful process. For example, companies in Taiwan have started introducing and developing new medical devices through new technology, because they have focused on putting attention to their patients and their needs, including technologies like IT, bio-tech, optics and electronics. (Hsu, Tseng, Chuang, 2012). The trend of medical device development is focused on long-term monitoring, mobile assistant and homecare, as Chien-Lung Hsu et al. (2012), affirm in their study call "*A secure IRB system for assisting the development of intelligent medical device*s", that these areas are the main ones because of the long-distance and the costs that means all the health-care problems.

The medical industry is developing dramatically to be more efficient. At the same time, artificial intelligence revolutionize the pharmaceutical industry by R&D programs, especially as a machine learning form, where it works in the early stages of the product development, targeting the drugs with the possible candidates (Tsang, Kracov, Mulryne. et al., 2017). On the other hand, R&D inside this industry is relevant and crucial. According to the study of Donato Impedovo and Giusseppe Pirlo (2019) computers, mobile technologies, machine learning, pattern recognition, and especially AI, are changing the pharmaceutical industry and the way of making research. Besides, all of this is possible thanks to the massive databases of medical cases and further the patient's experiences. The role of technological devices, such as robots are playing a crucial role into the eHealth domain, Robots have increased their appearance in fields such as medical assistant devices (Hengstler, Enkel, Duelli, 2015). However, one of the major problems of the development of medical devices is the low of incentives in the majority of countries and mostly because it depends directly on the government policies. Nevertheless, it is necessary to know how to handle the market trends and reinvent itself to grant a better service to the customers (patients, doctors, etc).

*-How is the process of developing a new medical device?*

Firstly, it is necessary to obtain the approval from the Department of Health (DOH), secondly, it is necessary to get the permission of the Institutional Review Board, and at the end, if the device is going to be for users it has to pass by a clinical trial. "The governmental department introduces the Joint Institutional Review Board (JIRB). In this system, each hospital can establish personal IRB to certificate equipment and medical devices in the hospital or clinical trials" (Dziak et al., 2005). Therefore, it is understood that governments are constantly determining new control activities for the use and experimentation with medical equipment, as it is the future of the patients' lives. Likewise, it is observed how each time new people are needed for the equipment that enters into operation, generating new roles in the industry. Hence, the first step is to recollect the information from the databases, analyze the data, process and planning, medical device evaluation, then the clinical trial management system, functional improvement, therefore some reviews to finally manufacture the product to continue with the legal and medical processes.

### *3.4 AI in the pharmaceutical industry*

Pharmaceutical Industry is crowded with Artificial Intelligence research and it has been supported by the Artificial Intelligence developments. For example, through the use of data, it is possible to contribute to the process of drug discoveries by determining the possible behaviour that its molecules may have and determining what reactions they may generate in the future, managing to determine the scope of each of them (Ekins, 2016). There are many methods involved in these processes, such as deep learning, which has many applications in this industry. This method is training by adjusting the weights of a dataset, which shows the activity or inactivity of certain inputs (Ekins, 2016). Furthermore, AI systems recognize images even if they have many features and in order to have a successful system, AI needs to be trained to be efficacy use into the classification and diagnosis. For example, according to Chan, Shan, Dahoun, et al, in *the study of Advancing Drug Discovery via Artificial Intelligence, in the pharmaceutical Industry* (2019 ). ML is used to sort and classify cells by image, predictions of physical properties, predictions of Bioactivity, predictions of toxicity, drug design, planning chemical synthesis, automation of chemical synthesis.

Even though, one challenge that this industry face is the high costs and the reduction of efficiency into the drug development processes ( Chan, Shan, Dahoun, Vogel, Yuan, 2019). However, the idea of reduced the gaps of time researching is an advantage for industries even if the process of drug discovery is long and complex, it can be broadly divided into four major stages:Target, Compound, Preclinical studies, and Clinical trials, as it is shown on the illustration 3.

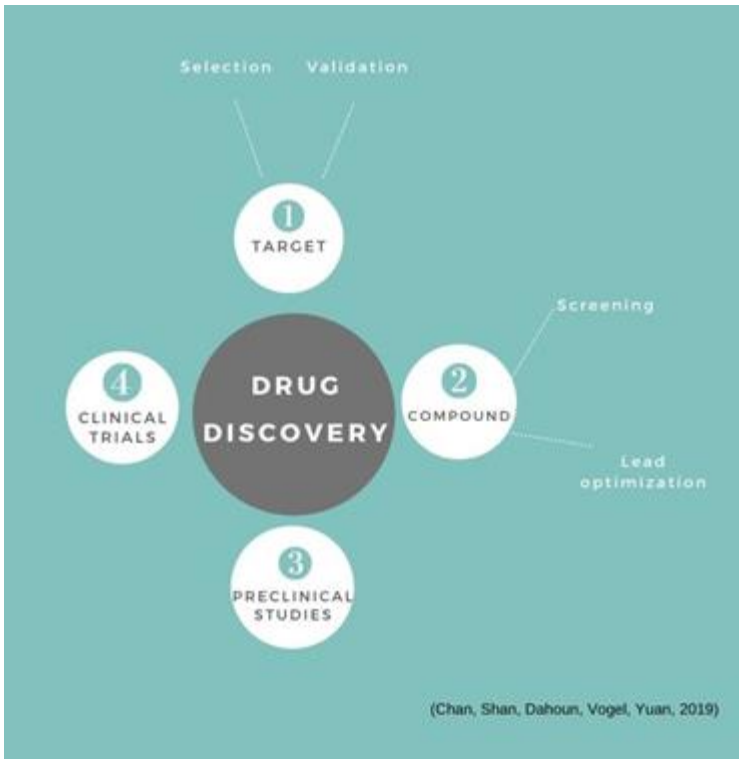


*Figure 3. Drug discovery, Chan, S., et al. (2019)*

As it is evident in the illustration 3, drug discovery has to follow some stages, in order to develop a new drug or enhance an existent one. Additionally, the pharmaceutical industry, need a deep research, it also needs fast results to the customers, and explore the combinations to find out the correct ones with less human intervention and with less waste of time. This is why, the success of AI is based on how much this system used or not the human intervention, being a low human intervention better to precise the veracity of the results of the analysis. In fact, AI systems can also go beyond human capabilities, and in that way facilitate the process of decision-making. Even data-savvy scientists like Daniel Cohen (2019), are using AI to figure out the optimum ways of combined the existing drugs into promising new therapies. According to Cohen, his team and he are introducing big data and automation to the study of genomics, demonstrating that it was possible to use super-fast computing to speed up the processing of DNA samples.

Moreover, the first applications of the AI were developed in big technological industries, such as petroleum and informatics industries because are the ones with enough resources to invest in this and have the leadership to be the pioneers in this field. But also, the pharmaceutical industry was

one of the pioneers too. In fact, through the data mining, it is possible to discover potential new drugs, or redesign the existing ones into more potent drugs, improving the quality and efficiency of the medications. Nevertheless, this process has to pass some phases, to identify the efficacy and the safety of the drugs, after being confirmed, some agencies approved and start commercializing the drug. During these phases, Artificial Intelligence has an important position, with the purpose of reducing costs and improve not just the quality of the medicaments but also the speed up of the production of them, increasing R&D in the discovery and development of this industry. Between the years 2016 and 2017, pharmaceutical companies made investments in AI healthcare and as a strategic decision they have made joint ventures with companies expert in AI, with the objective of developing more and better healthcare tools (Mak, Pichika, 2019). This partnership generates multiple advantages for both companies, because there is a mix of resources and knowledge, in that way, it is possible to increase productivity and generate higher profits.

To further improve the drug discovery efficiency, there are many aspects that companies must fix about the implementation of AI into their researches. They need to explore more, and measure adequately the methods and the conditions where they have the main challenge. For most of the companies, it would be impossible to process the data manually and then analyzed this information to understand what it means, for that reason, they need the help of AI. As an example, Atomwise decided to invest in AI through an R&D department, in that way, it was possible for them to carry out precise investigations looking to reduce Ebola. Thanks to the effort and the different resources invested in these investigations it was possible by the use of AI technology to find two drugs to fight against this virus, taking only one day in the process instead of years. Likewise, another example, is the "BERG's AI "Interrogative Biology" which is based on the implementation of AI technology characterized by its incredible speed in analyzing a large amount of data in a short period of time compared if it was done manually. This feature allows to analyze about 14 trillion data points in a single tissue sample. Mainly, it analyzes the data of about 1000 patients, which present different conditions, including cancer. By analyzing this data that are so varied and which are robust with such efficiency it is possible to define certain drug treatments (Tsang, Kracov, Mulryne, et. Al, 2017). Besides, companies such as Johnson & Johnson started a partnership with IBM in 2015, where they agreed to use AI to personalize diabetes management solutions and let the patient monitored their blood sugar levels, by a digital platform. The patients have the possibility to interact in real-time with doctors that answers them quickly. Without the utilization

of AI, companies should spend not just more resources, but also more time and work, that is the main reason why pharmaceutical companies realized the importance of investing in AI R&D since 2017.

### *3.5 AI and the continuous challenges, innovation and Future Trends*

Are the companies that introduced AI into their processes more innovative? First, is necessary to understand the relevance of the function of innovation in this study. For that reason, it is necessary to define innovation as the process that involved multiple activities, new ideas or methods to reinvent the past ideas into new ones through a creative process to adopt it by the corporate life. The most important characteristics of innovation are interaction and interdependence. Hence, "Actors involved in innovation processes cooperate" (Smith, 2000) and in that way, they are going to work following one same goal, developing strategically networks which help companies to increase the capabilities of the company to innovate and reduce the uncertainty. According to Rodríguez, López, N (2016), the success of a company depends mostly on the time and resources dedicated to working on innovation. Additionally, innovate inside the companies gives a competitive advantage, for example, Porter (1990) said that a competitive advantage can be achieved by putting new and better ways of competing on the market and this advantage will rarely be sustainable if it is based on imitation. Therefore, innovation is a fundamental variable in the development and growth of an organization showing that every day the gap between innovation, science and business is closer. The distance has decreased and the relationship between the science and innovation occur simultaneously through their interactions with each other (Ikeuchi et al., 2016). Some applications of Artificial Intelligence as Deep learning, have been characterized by increasing the profitability of different industries, making them develop in new competitive conditions. Likewise, it has generated a revolution in innovative processes, rethinking the most basic processes of this one (Cockburn, Henderson, Stern, 2017).

There are many debates about the challenges of AI and their future trends, the principal ones are going to be summarized in this study: First, "Artificial intelligence promises both to improve existing goods and services, and, by enabling the automation of many tasks, to greatly increase the

efficiency with which they are produced." (Cockburn, Henderson, Stern, 2017). Although, there are many advantages of the implementations of AI inside the companies, also has some weaknesses in requiring large investments, large processes and changes that affect company structures, high-risk decisions and among others (Agrafioti, 2018). As has been seen, many researchers believe that AI is too expensive for be assumed by companies. On the other hand, another criticism respect the implementation of AI in companies is that many people believe that AI eliminates human jobs some economists think that through the different devices implemented with AI technology, many jobs will be eliminated, generating an unemployment problem, since this technology can perform both intellectual and physical jobs, leaving many traditional jobs to cease to exist, as well as possible new roles (Kustrin, Beresford, 2000). For example, in the medicine field there is not any consideration that AI can replace completely the doctors' role, but in the next 20 years, AI is going to have an important role, especially in radiology, because it is going to be more efficient by extracting more complex information from the images. Nevertheless, according to Wendy Rauch-Hindin (1985) in its book call "Aplicaciones de la Inteligencia Artificial en la Actividad Empresarial la Ciencia y la Industria" she said that AI systems do not replace people, rather it increases the potential of them. Also, it is necessary for human expertise and knowledge to monitor and update the system (Ishak, Malaysia, 2008). That is the main reason why companies must train their personal so that they understand what is happening in the company, what is going to change and what is their role in all this process, because most of the time, humans are very resistant to new ideas and innovation. In the medicine field, where we can see the constant usage of AI, one of the fears is that someday they would be replaced for these kinds of systems, but the truth is that they would no replace them, therefore, AI is going to set the new standards of health-care.

Moreover, many tasks as ethical judgments, symbolic reasoning, and social situations, cannot be developed by intelligent technologies, because they are not able to execute it (Brynjolfsson and McAfee, 2014). Besides, another challenge is that AI generates complexity in the organizations, because of the uncertainty which comes with it. Moreover, the duality in the impacts is unexpected, because it promises better decisions and at the same time it creates accidents in unexpected environments (Garcia, 2018). The real issue exists when we do not know how to manage AI and we are not expecting uncertain results, Machine Learning is not a develop system, and there are many areas and task on development to improve. Furthermore, thanks to the new elements in the environment, it is necessary for companies to adapt to them, with flexibility as one of their main

priorities, that is why “The main objectives in this context are the development of the dynamic and flexible business and engineering processes, where the smart factories will have the capabilities of self-awareness, self-prediction, self-comparison, self-reconfiguration, and self-maintenance” (Lee et al., 2014). Another weakness or challenge is the low or lack of explanation in the conclusions of the diagnostics (Schuerman, 2019). Sometimes, AI systems just show a result base on the data, which they count on, but not the process about how they conclude the diagnosis. Moreover, one of the topics more debated is the ethical issue of confidentiality, despite in many countries the regulation is very strict, it continues as a not total regulated system, because of the size of it.

On the other hand, there are many trends in AI, for example, it is looking forward to improve human interaction. In fact, the new advancements in AI are boosting human and AI interactions (Fast, Schroeder, 2019). An important factor here is that trust is the base between the relationship among human and automation (Ghazizadeh et al., 2012). However, how this link can be done? By teaching people, by being dynamic and letting a real-time interaction with these systems and devices, in that way, the benefits are going to be tangible. There is a remarked importance in giving the patient the possibility of being part of the process. Specifically through, “chatbots, which leverage a specialized area of AI called natural language processing (NLP), which have been introduced to help with general medical literacy and diagnostics, among other things.”(Gilvary, Madhukar, Elkhader, 2019). Furthermore, another trend or challenge for AI is drug development, due to the enormous help that AI systems can do in order to reduce the failure, and the low efficiency of the traditional techniques.

Finally, it is remarkable that the use of internet and technology platforms can be a “double-edged weapon” due to the access of information that the patients can obtain because the information available is very sensible and sometimes it cannot be 100% true. But, there is where the challenge of AI and the medical industry are, they need to work together, the patients now are looking for fast information, fast solutions, there is no point in trying to hide the information anymore. Now, it is necessary to know how to give the information fast, easy and truthful, so the medical chatbots, need to have a close partnership between doctors and patients. There is a huge quantity of people around the world that would be benefited with a similar tool that is the Telemedicine, this tool has had good results in helping patients better understand diagnoses and become better informed about different medical concepts, allowing patients and physicians to make informed decisions, making

the information clearer. Given this, it has been implemented by more clinics (Alexander, McGill, Tarasova, et al. 2018). These tendencies are the approximately future for this industry to offer an efficient and more personalized service, reducing costs and advancing in the implementation of AI. Moreover, there are many tools and updates that sometimes companies do not know which one is the best option and which one fits better according to the companies activity.

## 4. Conclusions and Recommendations

Artificial Intelligence is a powerful tool, which is changing the paradigms and approaches already known of determined ways of doing things. AI has being applied into numerous investigations, numerous process into the companies but moreover it has change the way of image, record, develop and treat medical cases. This is why it is so important to integrate the diverse types of data within any "AI framework to limit bias, increase accuracy, and model the interdisciplinary nature of medicine. We believe that widespread adoption of these practices will help accelerate the continued integration of AI into our current healthcare framework." (Gilvary, Madhukar, Elkhader, 2019). Thus, to ensure that AI reach its full potential it is necessary to continue doing experimental models and prioritize the principles necessities and shortcomings of the existing methods, to improve the quality of them and interpret correctly the algorithms, by focusing on the main point. Besides, to reduce the randomness, errors and the lack of efficiency through the drug development, it is necessary to includes automation as a vital part of the process. Furthermore, business leaders also need to improve their skills to understand better the challenges that their companies are facing, and what is the path that business are taking into the forward years, thank you to the new technology systems. For that, it is necessary that they understand the importance of how to train algorithms and the importance of doing the right partnerships that allowed them to continue with the focus point of their organizations but at the forefront of the changes that the technology is bringing.

Even if nowadays there is not any drug discover and develop 100% by AI, in the forward years it is going to be the objective. Thus, understand that innovation is a progressive process and the industries need to be prepared to manage new and better digitization initiatives, it is very important, because managing the interdependencies between the HI and AI will be a key factor in the future

transformation. Consequently, companies need to develop meta-intelligence in order to accomplish the optimal management of those intelligence, a merely focus is not enough to have a competitive advantage, it is absolutely necessary to know in deep the way in which the company is going to use intelligence and what are the goals to know exactly the strategies to use for. If companies continue advancing in the application of technology, the opportunities are going to increase, taking into account the preparation that these companies need to receive the leverage of technology. Consequently, it is important that firms hire qualified personal in topics of AI, if they want to start implementing these systems, and work together with the current personal by training them and making them to understand the impacts that this brings to the companies. On the other hand, in the pharmaceutical industry, it is possible to conclude one of the trends that it will seems to happen in the near and long future, they are looking for faster, more efficient and effective ways for develop drugs and give prior attention to their patients. Now companies through AI can know what the client thinks about their company, what they need and want. Moreover, they can know what are their failures and base on that take more intelligent and adequate decisions, to satisfy the client's needs.

To conclude, these tools should be seen as an ally and not as an enemy. It is a fact, that the technology is here to stay and we must learn to live with it and seek the greatest utility for all. It makes companies more attractive and competitive, as well as it catches the attention of new employees and even partnerships. Artificial Intelligence and innovation have benefits, but in the same way it presents risks. Additionally, it is evident that it has created at least a chance for companies to increase their outcomes and ensuring them a better quality and efficiency in the development of their products, through the demonstration of the incremental innovation related to the companies.

It is important to emphasize that through this research project, it was possible to identify limitations that can be reflected through the project. In a certain way this can divert the results of the research, when analyzing the texts, it is possible to find misunderstanding between the terms or specifically words. Moreover, the sample of scientifically documents taken is directly affected by the AI impact, but still exist the convergence between the positive and negative results. Additionally, it is important to remark that even the majority of the studies showed a positive

overview of the utilization of AI into all the companies' processes, it does not mean that the future would be as positive as expected.

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