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# Machine Learning and Deep Learning Patentable Developments and Applications for Cost Reduction in Business and Industrial Organizations

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**Abstract: The objective of this research is to determine the feasibility of cost reduction through the use of technologies based on two of the most relevant recent branches of Artificial Intelligence (AI), such as Machine Learning (ML) and Deep Learning (DL), with such cost reduction it is expected that companies or industries can obtain a competitive and comparative advantage. Likewise, emphasis will be placed on locating Mexican private or public organizations that have developed and registered patents that have helped them to reduce costs or be more competitive at a business or industry level.**
**The materials and methods carried out will be 1) A literature review. 2) A documentary review in databases of the Mexican Institute of the Intellectual Property (IMPI), with it will be announced the quantity of investigations, developments and most recent applications for the reduction of costs, and finally to know the position and competences of Mexico at the moment of patenting technologies based on ML and DL.**
**It is concluded that in several business and industrial areas more and more patents, ML & DL developments applications are being used and registered for cost reduction, however in Mexico there is a lack of R&D contribution in this type of technological developments, since there is only one patent registered by a university.**

**Keywords: Business, Cost reduction, Deep learning, Industries, Machine learning, Patents.**

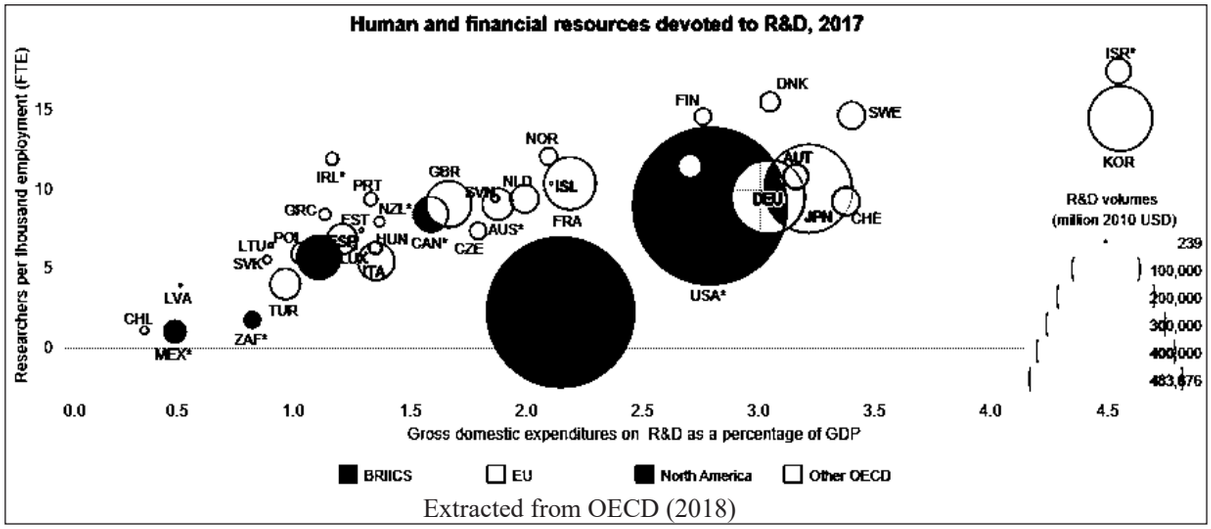
## I. Introduction

Artificial Intelligence (AI) plays a key role in knowledge economies because it can be used to develop systems that think like humans, act like humans, think rationally and act rationally (Russell & Norvig, 2010).

It is important that all systems, developments and patents worldwide promote the reliability and predictability of artificial intelligence (AI) inventions as it has enormous innovative potential. AI has been called part of the fourth industrial revolution and is considered central to economic growth. Research and investment in AI is growing rapidly, and there is a race between large technology corporations and new companies to obtain patents on AI.

In today's so-called knowledge society, it is advancing at an important pace, it is expected that artificial intelligence will have an exponential development in the next 25 years, some authors estimate that by the year 2029 machines can pass the Turing test (by Alan Turing, the father of Artificial Intelligence), which means that machines can have an intelligent behavior as capable as a human being. Cabanelas (2019) calls AI the expertise and ability of a computer, computer network, or Robot's network controlled by other computers to perform other tasks. He also comments that by the middle of the 21st century, this AI is expected to become a super AI, whose intelligence would be able to overcome the networking of the best brains, including scientific creativity, collective learning network and social skills.

On the other hand, it is important to point out that seemingly the Mexican companies or organizations generate very few developments, uses and patents that provide them with greater competitiveness in a global framework, this is partly due to the proportion of government investment in R&D with respect to the Gross Domestic Product (GDP), which can be seen in OECD (2018), see Fig. 1. Today, international business requires innovations based on these technologies in order to meet the demands of increasingly demanding and intelligent customers when purchasing goods and services.



Extracted from OECD (2018)

Fig. 1: Investment in R&D, Countries by 2017

In the image above, we can see how Mexico is one of the countries with the least investment as a percentage of GDP (0.05%) and with the least number of researchers per thousand employees (0.8 researchers per thousand employees). Mentioned the above, it will be determined and evaluated within this investigation if such lag exists in Mexico in the patenting of ML and DL technologies.

On the other hand, today's industries project a prominent future as they are being renewed quite a bit, now this quality step is known as industry 4.0, this label is more than anything an additional revolution of the already known industrial revolution, where products and services will be made more intelligently by economic providers making use of disruptive technologies such as information technologies and artificial intelligence.

## II. Technologies Principles

### *A. What is Machine Learning?*

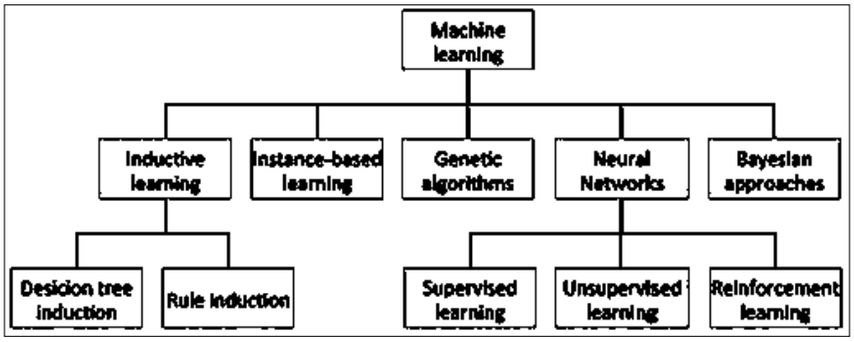
The ML is a branch of AI that through iterative processes can do work activities at a higher efficiency, accuracy, reliability and in less time/cost than humans, the "bots" can analyze complex algorithms and combine it with very large databases in iterations. This subclass of AI includes induction, deduction, applications involving learning (i.e., data mining and knowledge discovery) and statistical learning techniques. It is also important to mention that patents for their originality and inventiveness must generate economic benefits either in a company or in an industry in order to compete within the framework of globalization.

The applications of ML can be very diverse, for example Wuest *et al.* (2016) comment that during industrial manufacturing it can give rise to patterns derived from existing data sets, which can provide a basis for the development of mathematical approximations of future system behavior. This new information (knowledge) can help process owners in their decision making or can be used automatically to improve the processing system directly. In the end, the objective of certain ML techniques is to detect certain patterns or regularities that describe relationships (Alpaydin, 2010).

*Machine Learning* powers many aspects of modern society - from web searches to social media content filtering and recommendations on e-commerce websites - and is increasingly present in consumer products such as cameras and smart phones. These systems are used to identify objects through images, transcribe speeches into text, relate news items, publications or products to users interests and select relevant search results. Conventional machine learning techniques had a limited capacity to process natural data in its original form.

LeCun *et al.* (2015) emphasized that building a pattern recognition or machine learning system required careful engineering and considerable domain experience to design a feature extractor that would transform the raw data (such as the pixel values of an image) into a suitable internal representation or feature vector from which the learning subsystem, often a classifier, could detect or classify patterns at the input.

There is a structure to the classification of the ML and its subdivisions that is widely accepted, however, Wuest *et al.* (2016) mention that there are still differences with regard to what falls within them or what these three classes fall into. In their publication there is a mapping of the LFA classification, mainly this technique is divided into: supervised, unsupervised processes as part of Neural Networks. The structure is shown below:

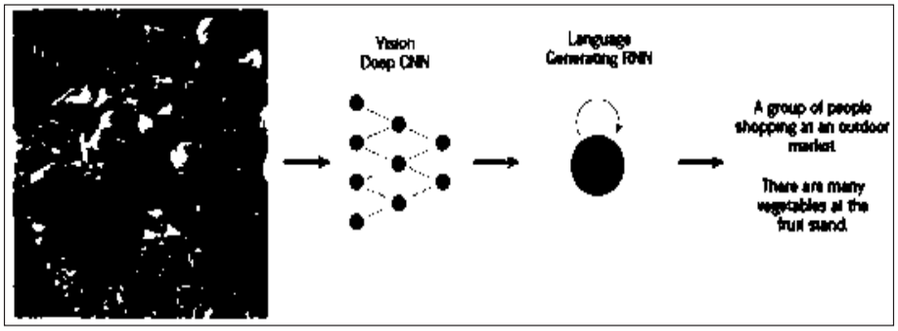



From Wuest *et al.* (2016)

Fig. 2: Machine Learning Classification

### *B. What is Deep Learning?*

*Deep Learning* allows computer models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. LeCun *et al.* (2015) describe that these methods have dramatically improved the state of the art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics. *Deep Learning* uncovers a complex structure in large data sets by using the retro-propagation algorithm to indicate how a machine should change its internal parameters that are used to calculate the representation in each layer from the representation in the previous layer. Deep "convolutional" networks have made advances in image, video, voice and audio processing, while recurrent networks have illuminated sequential data such as text and voice.




From LeCun *et al.* (2015)

Fig. 3: An Example of the Process for Image Recognition by *Deep Learning*

The previous image shows a photograph captured by some digital device, this passes through a neural network called CNN deep vision, then the language is coded and generated (RNN), and finally the *Deep Learning* gives an interpretation of that image, which says "A group of people buying in a street market" also replied "There are many fruit and vegetable stands".

This is why companies such as Microsoft, IBM, Yahoo!, Twitter and Adobe, as well as an increasing number of new companies are starting research and development projects and implementing image understanding products and services based on ConvNet, (LeCun *et al.,* 2015). For example, Facebook can now automatically detect, hide, and remove via its DL one or a set of images posted by users that violate its policies and terms of use.

## III. Patentability

### *A. Machine Learning*

Jones (2018) comments that in recognition of the growing importance of AI and *Machine Learning for* applicants in all fields, the EPO (European Patent Office) has taken the time in its 2018 update of the examination guidelines to focus specifically on the patentability of inventions that have an AI or machine learning aspect to them.

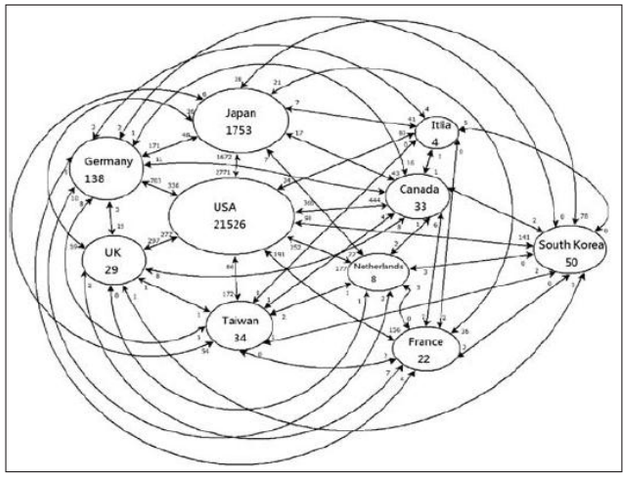
The new guidelines make it clear that EPO intends to treat AI and *Machine Learning* as a form of mathematical method. Mathematical methods appear in the list of non-inventions defined by Article 52, paragraph 2 of the European Patent Convention, explained in the EPO regulations (2020) and are therefore inherently unpatentable "as such". However, a mathematical method that is linked to the control of a technical system or process can acquire technical character, taking it out of the exclusion "as such" and into the domain of a patentable invention.

This has always been the position of the EPO in handling exclusions from patentability, so it is not surprising that the artificial intelligence and *machine learning* section of the new guidelines is largely commercial as usual. Jones (2018) describes that inventions involving AI and ML will be patentable whenever they are described and claimed in

the context of operation in a technical system or control of a technical process. Careful drafting will be sufficient to ensure that this requirement is met: describe and claim the AI or the machine learning component in the context of the technical system in which it operates, not as an abstract entity, in order to obtain a European patent.

However, there are adversities and collateral disadvantages to entering the patent offices of the ML. Rai (2018) explains that for patent examination, a window is provided on how such use, even by agencies that do not address issues of rights, bias and privacy, can face constitutional and non-constitutional challenges to administrative law. For these agencies, the most important challenge is likely to be in analyzing the relationship between poor explanation and transparency.

Continuing with patentability, Tseng and Ting (2013) comment that by 2010 the patent count in the field of *Machine Learning* was more than 10 times the patent count of *Network Structures* (another branch of AI). The annual growth rates of patents in both the *Machine Learning* and *Knowledge Processing Systems* fields are higher than those of the other two sub-technology fields of AI. The authors present this image where they show the number of patents among 10 countries in the period of 1976-2010 regarding the flow of *Machine Learning*:




From Tseng and Ting (2013)

Fig. 4: Amount of Patents by Country

The United States is in the lead in terms of patents, followed by Japan and Germany, and is one of the countries with the most stable, mature, but above all, innovative industries.

### *B. Deep Learning*

A method patent application does not necessarily cover something physical, but covers the steps in a process. A method patent application covers the act of performing some step or action, which can be applied to a physical object. As a result, a method patent application represents an effort to patent something beyond the physical aspect of the invention and covers an act that is intangible.

Ebrahim (no year) concludes that the acts involved in method patent applications are of a fleeting nature, since they lack an associated physical aspect and, as a result, represent something intangible about an intangible property right. Therefore, since there is an inherent gap between the intangible nature of the process in a method patent application and its physical instantiation. While in the industrial era, where the focus was on tangible means, with information technologies where the DL comes in, the process steps have the inherent ability to capture instances beyond the invention.

A lack or inefficiency in the explanation and interpretation of a DL invention represents the dynamic manifestation of entering new data in an automatic learning model. Ebrahim (no year) describes that in particular, patent law can view these examples of DL as existing outside the patent document. In other words, the invention, through the eyes of dynamism, lacks physical manifestation of the invention. Dynamism in the sense of deep learning means that an invention does not physically exist until and unless it is fed with new data. Method patent applications present challenges as to how the patent system should demonstrate possession of algorithms, data and models, the facets of deep learning inventions.

## IV. Cost Reduction in Business and Industries

These techniques of the artificial intelligence can help in diverse solutions that are required in the industrial private organizations like in the automation of processes, to identify patterns or statistical behaviors or images with high precision, to project data to a speed and scale not before seen, which makes more efficient the decision making; this could help in all the economic sectors including the public sector, it is important that before deciding to implement a patent of ML and DL, we ask ourselves what utility or added value will generate to some sector? And mainly, will it be profitable? To define the issue of profitability by means of cost reduction we must start from a traditional cost-benefit analysis and the decision analysis generally involves multiple steps such as the following Cox (2019), which serve to identify options and viable alternatives, decision rules or courses of action.

- Identify viable alternative options, decision rules or courses of action.
- Identify preferences and assess trade-offs for possible outcomes.
- If the results for each option are uncertain, calculate the probabilities of different outcomes for each option (e.g., your risk profile); and
- Optimize options subject to feasibility constraints (e.g. time, budget or limited resources).

Part of this work focus is to identify the business and industrial importance and relevance of these techniques, as well as their optimization in decisions in various economic sectors. Cox (2019) represents it algebraically in this way:

$$\max a \in A \; \mathbf{R(a)}$$

Where:

- a is a decision variable or policy (for example, a vector or time series of decision variables, or a feedback control decision rule that assigns observations to actions).
- A is the set of feasible alternative decisions (the "set of options").
- R (a) is the reward (expected profit or net benefit) of choosing a. In many traditional economic, political and operations research analyses, it is assumed that the reward function to be maximized is known. In the statistical design of *Machine Learning* and *Deep Learning* experiments it may be necessary to discover this.

## V. Research Question

- How can patents, developments and/or technological applications based on the ML and DL be used in businesses and industries to reduce costs?
- What is the situation of private or non-private Mexican organizations at the time of generating patents for ML and DL based systems, processes or technologies?

## VI. Research Assumptions

- There are many industrial-business developments and applications that are already beginning to be implemented in various sectors and which will be discussed in section VII "literature review", this because AI is taking on more of a momentum.
- Not only for cost reduction, but in general there is a lack of registered and implemented patents in Mexico for ML and DL-based systems, processes or technologies, due to what has already been mentioned, i.e. low production and investment in R&D, as well as the low degree of innovation of Mexican companies.

## VII. Literature Review of ML and DL Cases for Cost Reduction

Below are some of the more recent developments and business/ industrial applications, some of which have been patented. The authors of each study highlight the functionality of these ML and DL-based technologies in various economic sectors, and describe the impact they have on firm finances by reducing costs.

Table I: Developments, uses and Applications of the ML and DL in Companies and Industries to Reduce Costs

| Type of Business or Industry | ML - DL Activity | How can Costs be Reduced? | Authors |
|---|---|---|---|
| M.L<br>Industrial processes | * Process monitoring in an automatic and intelligent way.<br>* Quality estimates based on production data feeding.<br>* Predicting performance indicators based on a range of internal and external data. | *Automated process monitoring reduces payroll, less supervisors.<br>* Quality estimates are relevant to avoid customer rejection. It serves to guarantee the requirements of clients and consumers.<br>* The production of operational indicators reduces time, energy and resources It anticipates any contingency to avoid delays in the processes. | Ge, Z. *et al.* (2017) |
| D.L<br>Commercial and service companies | * Through the neural networks that emulate the human brain, people with their facial features can be identified and recognized.<br>* Company information can be accessed through facial recognition, retina (cyber security log in). | * When a crime occurs, the images from the cameras make a comparison with a series of databases that collect images, if there is a match then the police can quickly identify the offender of the crime.<br>*This prevents corporate losses from crime and prevents losses from cyber fraud. | Hurwitz and Kirsch (2018) |
| M.L<br>All companies in industry, commerce and services | * Forecast market changes based on statistical patterns.<br>* Creation of model for the types of promotions, new launches and offers for the types of customers. | *Cost reduction by external consultants.<br>*Cost reduction of skilled labor like data scientists.<br>*In addition to reducing costs, it helps increase sales and cover operating costs. | Hurwitz and Kirsch (2018) |
| M.L<br>Industrial processes | Many industries rely on sophisticated Preventive Maintenance approaches to ensure that processes and systems are safe and perform as expected. Industries such as manufacturing, oil and gas, and utilities succeed or fail based on their ability to prevent accidents. | *A regression algorithm can be used as the basis for a model that can predict the time a machine will fail. Such a prediction saves a lot of money on:<br>Costs to repair or replace machinery.<br>*Stopped production lines increases the impact of fixed costs, which reduces the profit margin (wages are paid - rewinding and no production). | Hurwitz and Kirsch (2018) |

| Type of Business or Industry | ML - DL Activity | How can Costs be Reduced? | Authors |
|---|---|---|---|
| M.L<br>Industrial processes | Ability to adapt to the changing environment with reasonable effort and cost. | * The HFK can learn and adapt to changes, "the system designer does not need to foresee and provide solutions for all possible situations". Learning from changing environments and adapting helps to reduce costs from human error in factory processes. | Wuest *et al.* (2016) |
| D.L<br>Music industry production | A large scale of music can be analyzed for its distribution of notes (on staves, piano rolls, digital matrices and MIDI numbers), dynamics and serial time. Deep Learning also suggests how the music should be played and therefore creates a piece of music with excellent quality. | * The DL has a significant impact on music production technology by improving the quality of music production. However, music is a unique expression of human creativity that can reflect life, thoughts and emotions. The results of this research remind technology developers that the direction of DL development is not to replace the unique artistic creativity of humans, but that it can reduce the barriers for music producers to enter the production field (e.g., eMastered provides online mastering services through AI).<br>* The reduction of entry barriers positively impacts the finances of start-up producers. | Weng and Chen (2020) |
| D.L<br>Sustainable energy industry | By designing a new custom energy demand forecasting algorithm based on the LSTM Deep-Learning method with respect to recent energy demand patterns. This through tests in residential buildings, public offices, hospitals and industrial factories. It intends to confirm the sudden change of energy patterns in the real energy demand monitoring system. | * Using demand responses can bring economic benefits to facilities, allowing countries to achieve additional benefits such as cost savings and environmental conservation.<br>* Unnecessary costs of demand management can be reduced by the designed accurate forecasting method. | Choi and Keun (2020) |
| D.L<br>Companies from all sectors, with an emphasis on pharmaceuticals | In this study, the authors propose a validated mathematical model that is predictive, using the neural network-based DL that assesses a company in terms of financial performance (revenue, operating profit, and net profit). | * Costs are reduced for external consultants and for hiring financial analysts to carry out qualitative analyses.<br>* Qualitative judgments are highly subjective and limited in the sense that the conclusions have a significant cost in terms of time and money. | Lee and Park (2017) |
| D.L<br>Food production (Agriculture) | The authors propose an effective model based on a deep neural network (DNN) that was used to incorporate historical data and predict future evapotranspiration in crops. Evapotranspiration is one of the most basic components of the hydrological cycle that is effective in the design and management of irrigation systems, water resources planning and programming, and water balance. | The DNN (deep neural network) method has been used in agricultural and hydrological fields due to the difficulty of software data availability, high costs and complexity, it also works to boost crop production. | Elbeltagi *et al.* (2020) |
| D.L<br>Energy industry | The circulating fluidized bed boiler is an advanced clean energy technology that has received much attention in the energy industry because of its fuel flexibility. In this study, a deep neural network with a modified early detection algorithm and a least-squares support vector machine was developed to predict SOx and NOx emissions associated with coal conversion in energy production. | The models and results developed by the authors of this empirical study can be applied not only to the online operation and optimization of a coal-fired CFB boiler with high accuracy, but also to the expansion of energy production at low computational cost. | Adams (2020) |

| Type of Business or Industry | ML - DL Activity | How can Costs be Reduced? | Authors |
|---|---|---|---|
| M.L and D.L<br>Construction industry | Carbonation of concrete, which can accelerate corrosion, is one of the main mechanisms of deterioration in reinforced concrete structures. The authors propose an application of an artificial neural network algorithm, which simulates the human nervous system, to evaluate concrete carbonation. In this study, the possibility of applying L.M. to predict the concrete behaviour of carbonation is evaluated. A D.L. model was also applied. This model is structured in such a way that hidden layers of hierarchical artificial neural networks are formed in several layers. | Cost reduction due to structural failure and reconstruction. | Lee and Suraneni (2020) |
| D.L<br>Health sector | A major challenge in magnetic resonance imaging (MRI) is speeding up the scanning time. Beyond improving the patient experience and reducing operating costs, faster scans are essential for time-sensitive imaging. The authors introduced a practical software framework, based on the L.D., to accelerate MRI acquisition while maintaining an anatomically meaningful image. This is achieved through MRI sub-sampling followed by estimation of missing k-space samples through generative adverse neural networks. | * The discriminating interaction of the generator allows the introduction of a contradictory cost.<br>* Reputation cost reduction associated with losses in fidelity and image quality used to optimize the reconstruction. | Shaul *et al.* (2020) |
| M.L<br>Food and Beverage Industry | Cleaning is an essential operation in the food and beverage manufacturing sector, although it entails significant economic and environmental costs.<br>The authors in their research combine ultrasonic measurements and ML methods to determine when fouling was removed from a pipe test section for a range of different food materials. This allows for optimal cleaning times and does not lead to over-cleaning or over-cleaning as is often the case in industry. | * Reduction for water and chemical materials due to over-cleaning of factory surfaces.<br>* No time is wasted on unnecessary cleaning, productivity is increased which translates into a reduction in costs per manufactured part. | Escrig-Escrig *et al.* (2020) |

Own elaboration with author's information.

## VIII. Patents Registered at IMPI (Mexican Institute of Industrial Property)

In order to strengthen research and to make known the situation of Mexico when patenting ML and DL based systems, processes or technologies, which appears to be a very poor production, the IMPI's databases were searched to evaluate the amount of patents registered either by private or public organizations.

Also, a couple of searches were made in the database of the official offices in Mexico for the registration of patents, the SIGA system of the IMPI was used by keyword, in total there were two searches, the first one with the words *"Machine Learning"* and the second one with the word *"Deep Learning"*. The purpose of the search was to identify if Mexican companies are generating these patents that would allow them to be more competitive in terms of cost reduction.

A table with the results obtained is shown below for practical explanatory purposes:

Table II: ML and DL Patents Registered at IMPI Website

| Type of Technology | Country of the Company-Research Center | Application Number | Title | Abstract |
|---|---|---|---|---|
| ML | Brazil | MX/a/2018/008872 | Predictive, Integrated and Intelligent System for Time Control in Traffic Lights | The present patent of invention refers to the predictive, integrated and intelligent system for the control of opening and closing times of traffic lights for vehicle flow control that uses the set of data and information provided by the various available geo-processing systems (GPS) and traffic control systems to generate computational intelligence and adjust the times of each traffic light according to the flow of people and vehicles foreseen for each intercession. The system employs crowdsourcing systems monitoring/big data information, intelligent and capacitive algorithms in decision making based on Machine Learning and loT. A central supported in artificial intelligence and "big data" interacts with traffic lights, "PMVs", Smartphones, personal systems, WEB systems, among others. This allows lives to be saved, since those vehicles will have their roads free from normal traffic. |
| ML | Mexico | MX/a/2016/016261 | Real-Time Electric Motor Monitoring System | The present invention provides a real-time engine monitoring system that serves to identify failures in early stages. The system consists of a data acquisition board, temperature sensors, vibration sensors, and a communication interface via WiFi essential for recording and managing the information from the sensors on a computer. Also, the system incorporates an automatic learning subsystem; developed to perform the recognition of electric motor failures using Machine Learning. |

Own elaboration with data obtained from the IMPI.

## IX. Analysis and Discussion

Based on the literature review, it is more than evident what practical effects and applicability the ML and DL is having on businesses and industries by making these developments and patenting them, the companies may gain competitive advantages. It is remarkable that in the older economic sectors that do not usually innovate such as the food industry including agriculture are adopting better technological practices based on ML and DL to be more productive, sustainable, competitive but above all more profitable by minimizing costs. This shows the importance that AI is taking in all global markets, in such a way that the *first assumption of the research is confirmed.*

*The results prove the second assumption of the investigation;* there is almost no patent activity by Mexican organizations in matters related to technologies based on the ML and DL, the results suggest that in the first result, the patent MX/a/2018/008872 belongs to a Brazilian company called "CINQ TECHNOLOGIES LTDA" who patents in order to commercialize the technology of the intelligent traffic lights in Mexico, The second one if patented by a Mexican university called "BENEMÉRITA UNIVERSIDAD AUTÓNOMA DE PUEBLA" with registration MX/a/2016/016261, this patent helps to make a failure recognition in early stages of engines, where costs can be reduced at the moment of avoiding an irreparable failure of the engine, or, it is made by reducing reworks due to an imprecise diagnosis. These findings make sense since there are 0.8 scientists per thousand registered employees in the country according to OECD data (2018).

## X. Conclusions

With the argumentation and the literature review of recent scientific articles mentioned in the present research (Table I), it is observed that both the ML and the DL have many developments, uses and applications for the reduction of costs, in fact they are more and more, likewise it is demonstrated how relevant is starting to be the AI in all its branches, it is expected that in the decade of 2020 many more patents and intelligent systems start to be developed in this area of knowledge that although it is not new, if it is having an outstanding boom and revolutionizing the world. Without a doubt, ML and DL

are highly efficient techniques, if they are applied in various industrial and business sectors it can generate a competitive advantage in multiple areas, in the present work only emphasis was made on cost reduction but in reality such advantages *are multidimensional,* they can have economic and financial benefits from a micro level, to benefits to increase investment, consumption, productivity of economic sectors, as well as generate a greater specialized labor force of engineers, data scientists and programmers, if Mexico manages to further develop this labor force in several years it could stop being a maquiladora and become a technology developer.

However, to achieve this there is still much to do by virtue of the results shown in the search of the SIGA IMPI (2020), the second assumption of the research (Table II) is fulfilled which means that in general (not only to reduce costs) there is a shortage of patents registered by Mexican organizations, the only one was made by the renowned University of Puebla, the other patent is from a Brazilian company. If a comparison is made with image 4 of the document, where the United States had 21,526 for the year 2010, it is concluded that it is a catastrophic and abysmal difference, an alarm for Mexican science and technology. It would be interesting to see and analyze the policies to follow in the CONACYT (National Science and Technology Council), because in addition to the lack of investment in R&D as a proportion of GDP and for the 0.8 researchers per thousand employees, there seems to be a lack of linkage between universities, research centers and productive sectors. On the other hand, Mexican companies are not innovating in these areas.

Finally, it should be mentioned that education systems are triggers for innovations, if university curricula begin to teach and implement the development of these AI tools, and this in conjunction with a linkage of industry is likely to begin to have a developed economy in the long term.

## References


[1] D. Adams, D.-H. Oh, D.-W. Kim, C.-H. Lee, and M. Oh, "Prediction of SOx–NOx emission from a coal-fired CFB power plant with machine learning: Plant data learned by deep neural network and least square support vector machine," *Journal of Cleaner Production*, vol. 270, 122310, 2020.

[2] J. Cabanelas, "Artificial intelligence. Dr. Jekyllor Mr. Hyde?," *Mercados y Negocios magazine* (ISSN 1665-7039 printed; 2594-0163 electronic), vol. 1, no. 40, Jul.-Dec. 2019.

[3] E. Choi, S. Cho, and D. K. Kim, "Power demand forecasting using long short-term memory (LSTM) deep-learning model for monitoring energy sustainability," *Sustainability*, vol. 12, no. 3, p. 1109, 2020.

[4] T. Cox, "Muddling-through and deep learning for managing large-scale uncertain risks," *Journal of Benefit-Cost Analysis*, vol. 10, no. 2, pp. 226-250, 2019.

[5] OECD, "Research and development statistics (RDS), 2018 edition," 2018. [Online]. Available: http://www.oecd.org/innovation/inno/researchanddevelopmentstatisticsrds.htm

[6] T. Ebrahim, "Patenting deep learning," n.d. [Online]. Available: https://ostromworkshop.indiana.edu/pdf/seriespapers/2019fall-colloq/ebrahim-paper.pdf

[7] A. Elbeltagi, J. Deng, K. Wang, A. Malik, and S. Maroufpoor, "Modeling long-term dynamics of crop evapotranspiration using deep learning in a semi-arid environment," *Agricultural Water Management*, vol. 241, 106334, 2020.

[8] EPO Regulation, "The European patent convention," May 2020. [Online]. Available: https://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ar52.html

[9] J. E. Escrig, A. Simeone, E. Woolley, S. Rangappa, A. Rady, and N. J. Watson, "Ultrasonic measurements and machine learning for monitoring the removal of surface fouling during clean-in-place processes," *Food and Bioproducts Processing*, vol. 123, pp. 1-13, 2020, doi: https://doi.org/10.1016/j.fbp.2020.05.003.

[10] Z. Ge, Z. Song, S. X. Ding, and B. Huang, "Data mining and analytics in the process industry: The role of machine learning," *IEEE Access*, vol. 5, pp. 20590-20616, 2017.

[11] J. Hurwitz, and D. Kirsch, "Machine learning for dummies," IBM Limited Edition 75, 2018.

[12] S. Jones, "Patentability of AI and machine learning at the EPO," December 2018. [Online]. Available: http://patentblog.kluweriplaw.com/2018/12/21/patentability-of-ai-and-machine-learning-at-the-epo/

[13] Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," *Nature*, vol. 521, no. 7553, pp. 436-444, 2015.

[14] J. Lee, D. Jang, and S. Park, "Deep learning-based corporate performance prediction model considering technical capability," *Sustainability*, vol. 9, no. 6, p. 899, 2017.

[15] H. Lee, H.-S. Lee, and P. Suraneni, "Evaluation of carbonation progress using AIJ model, FEM analysis, and machine learning algorithms," *Construction and Building Materials*, vol. 259, 119703, 2020.

[16] A. K. Rai, "Machine learning at the patent office: Lessons for patents and administrative law," *Iowa L. Rev.*, vol. 104, p. 2617, 2018.

[17] S. Russell, and P. Norvig, *Artificial Intelligence – A Modern Approach*, Upper Saddle River, NJ: Prentice Hall, 2010.

[18] IMPI, "Results obtained in search by keywords at SIGA (IMPI) website," May 2020. [Online]. Available: https://siga.impi.gob.mx/newSIGA/content/common/principal.jsf

[19] R. Shaul, I. David, O. Shitrit, and T. R. Raviv, "Subsampled brain MRI reconstruction by generative adversarial neural networks," *Medical Image Analysis*, vol. 65, 101747, 2020, doi: https://doi.org/10.1016/j.media.2020.101747.

[20] C. Y. Tseng, and P. H. Ting, "Patent analysis for technology development of artificial intelligence: A country-level comparative study," *Innovation*, vol. 15, no. 4, pp. 463-475, 2013.

[21] S. S. Weng, and H. C. Chen, "Exploring the role of deep learning technology in the sustainable development of the music production industry," *Sustainability*, vol. 12, no. 2, p. 625, 2020.

[22] T. Wuest, D. Weimer, C. Irgens, and K. D. Thoben, "Machine learning in manufacturing: advantages, challenges, and applications," *Production & Manufacturing Research*, vol. 4, no. 1, pp. 23-45, 2016.