A Perspective for Economic and Social Unfoldings of AI

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Abstract

This paper aims to introduce an overview of several aspects of the so-called Artificial Intelligence, their potential impacts on economic and social dimensions, and suggestions for possible approaches of investiment based upon effective and mature techniques. In this fashion, it is important to address from educational and academic issues to industrial densities and profiles, relatively to a given region, country or continent. Even etymological adequacy and psychological consequences of the denomination "Artificial Intelligence" need some reflection, and suggestions for a lucid replacement are presented. In addition, suggestions about how can specific firms choose the right type of technique in order to improve profit and organizational efficiency.

After all, what are the main transformations needed to amplify gains and structural improvements from the use of higher level technological mechanisms? Which connections can be established between the pillars of evolutionary economics and this field of knowledge? Which institutional contexts are able to benefit from AI tools, inducing constructive externalities to firms in terms of education, technical and scientific skills upgrading, so as to reach higher levels of employment in the long term and limit unemployment in the short one? Which branches of the so-called Artificial Intelligence are best suited to which types of activities? This work aims to contribute in the search for answers to these questions.
This article may be considered a POSITION PAPER, containing opinions and suggestions for improvements - the purpose is not
to offer new quantitative results, just to highlight certain practices with high autophagic potential, in economic and (mainly) social dimensions.

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1. Introduction

As the expression "Artificial Intelligence" is associated to the idea that the future of human kind is strongly related to its applications, playing a key role as a substitute for human intelligence, it is not difficult to infer that the techniques composing AI probably will have a very significant economic and social importance.

However, nowadays, products based on the field itself, its sub-areas and some related and misleading ideas, have been spread by certain huge firms for obvious reasons - it seems like a massive mystification process going on.
Among the misleading and vague expressions, reheated terms and buzzwords, are "machine learning", "data science", "deep learning", "big data", "data engineering", to cite a few.

This state of affairs is definitely not positive for a sustainable economic development based on AI, and beyond the scientific and technological dimensions, the social impact of the belief that human beings could be easily replaced with machines without substantial losses in the quality of services is certainly very deleterious, mainly in underdeveloped regions. In certain countries, big (and usually uninformed) firms are firing thousands of people that are fated to stay without a formal job for a long time (perhaps forever) - this happens without provision for helping employees to adapt to a new scenario or a solid study assessing all facets and consequences of the decision, causing frequently a large decrease in the quality of services offered to customers. This is so because even companies sometimes get "convinced" that machines are really able to THINK and perform better than human beings in ALL situations and contexts, a completely false inference. Frequently, however, the strongest argument relates to operating costs - decision makers, naturally, always search for maximum profit, and such a directive seems, at first sight, sensible - but in truth they are trying to minimize some possibly unknown cost function. The big potential difficulty is that constructing such a cost function related to AI benefits is a rough task and demands an expressive modelling effort, coupled to a reasonable level of theoretical knowledge and practical experience, and this is not easy to achieve. Therefore, certain decisions might not be very well founded - it is not a question of financial power, but technical knowledge. After all, big companies may commit big strategic mistakes as well [1].

In harmony with the previous statements, this article will suggest some directives that may help investors and/or governments whenever designing and implementing AI-related tasks or organizations.

It is not difficult to see that AI-related initiatives are strongly coupled to the knowledge economy, a system based on intellectual "assets". More specifically, it is related to the possibility of profiting with basis in scientific and technological discoveries. At present, this branch represents a substantial part of overall economic activity in many developed countries.

This setting is totally compatible with the fundamental directives of evolutionary economics[2], considering the potential of AI techniques in provoking "waves" of innovation. In [2] it is also cited that technological advance may be viewed as an evolutionary process as well.

This segment is characterized by the utilization of highly skilled workers whose tasks demand special knowledge, featuring services and industries with positions requiring analytical thinking. In this fashion, the most valuable assets that an organization owns are intangible ones – people skills, patents, copyrights, accumulated knowledge. It is somewhat different from the past, comparing to the agrarian or industrial economies, associated to physical production assets.

2. Fundamental conditions for a happy ending

Once a problem is detected in real life, the first piece of information to determine is its domain: is it a biological, mathematical or engineering problem? Which subarea does it belong to? Only then it is possible to construct models and try to obtain a satisfactory solution through available methods in that well-defined and consistently named area of knowledge.

AI problems should not be an exception, but in certain aspects they still are. For example, even the denomination of AI lacks precision in that there is not a definitive and satisfactory definition for the concept of Intelligence, let alone ARTIFICIAL Intelligence. Perhaps Artificial **Inference** be a more realistic and precise label, because it is reasonably well-defined and portrays better the actual intention - given certain inputs or facts, it is desirable to obtain outputs containing conclusions, predictions or decisions, that is, **INFERENCES** based upon given information. In [3], for instance, the definition of INFERENCE is clear: "a conclusion or opinion that is formed because of known facts or evidence" and in [4] the denomination "Artificial Inference" is suggested.

Another overloaded and almost mythical expression is "machine learning", giving again the false impression that machines, programs or electronic/photonic circuits are able to learn as humans do. In truth, existing "learning" processes consist predominantly of parameter fitting by means of numerical optimization procedures - it is not difficult to detect this in the literature [5]. So, feedforward neural nets, self-organizing maps. neuro-fuzzy systems and parametric fuzzy inference systems, to cite a few, "learn" by adapting their characteristic parameters, being guided by some kind of cost function, explicit or implicit. Moreover, most well-known training algorithms are based on gradients, and consequently vulnerable to getting caught in sub-optimal regions (poor attraction basins), sometimes not producing the best possible design for that particular device [6].

In [7] it is possible to find a very interesting and detailed discussion of some topics cited above. In particular, some very lucid considerations relative to the buzz expression "deep learning" are included, even in the Abstract.
Some questions could be formulated about this concept (and so many others):

- Is there something that could be called "shallow learning" ?
- In the affirmative, what is the difference between the 2 concepts?
- Is it really (scientifically) necessary to invent new names for old things from time to time or is it a waste of time and energy?
- Would it be only a marketing quibble?

After a few queries over the Internet it is possible to find some pages stating, for example, that shallow learning may refer to everything that is not deep learning (for example, traditional machine learning models, such as those used in SVMs), but it usually refers to learning in neural networks with only a small number (0-2) of hidden layers, that is, non-deep neural networks. On the other hand, it is not so easy to find a definition for "deep learning" in the literature. In [8], for instance, among many statements about DL (Deep Learning), no precise definition was identified. However, many characteristics and aspects are enumerated in many parts of that excellent book [8].

- "Deep learning, also called deep neural networks, is originated from modelling biological vision and brain information processing."
- "Deep learning is one part of the contents of machine learning or machine intelligence. "
- “Deep learning is closely related to mathematics, especially optimization, graphical theory, numerical analysis, functional analysis, probability theory, mathematical statistics, information theory. These subjects could provide the analysis for a neural network model.”
- “In deep learning, we use gradient descent to update the parameters of our deep learning models. Gradient descent is a first-order iterative optimization algorithm for finding the local minimum of a function.”

In a different direction, in [9] it is stated that if the information source is a probability distribution, then the estimation process is called statistical learning, and the system is said to be a statistical model or a learning machine. In addition, it is said that in statistical learning or statistical inference, the main study concerns a method to produce a probability density function. Hence, it is clear that the author faces "learning" and "statistical inference" as synonyms.

In summary, the fundamental conditions for a happy (economic) ending when it comes to AI-based enterprises and respective markets are, at least:

- To establish precise concepts and definitions, without room for myths or low quality and misleading marketing procedures.
- To work with experienced and well-formed people, mainly in terms of mathematical modelling. This is advisable because all methods of AI have mathematical foundations and to develop truly new paradigms it is essential to have strong familiarity with some fields. In the case of undeveloped regions, with lack of adequate workforce, on the job training certainly is an absolutely reasonable alternative.
- Investiments should be done with basis on very well tested paradigms, presenting a high level of technical maturity.

This perspective is compliant with [2], Chapter 2, stating that a characterization of the technology level should recognize at least some aspects, namely, present technological artifacts and processes, and how they are used; the scientific and experimental evidences supporting the set of techniques and key factors determining how it works; evaluations of strengths and weaknesses of predominant best practices, coupled to perceptions of promising and unpromising approaches to further improvement.

3. Other premises for a successful path

3.1. Educational and social dimensions

As said above, the implementation of good quality AI products requires well prepared developers - this is valid in hardware or software construction and industrial or commercial applications. On the other hand, considering the fast expansion of the AI marketplace, productive and creative developers became a scarce resource, demanding from firms an extra effort to start or just maintain development groups capable of facing present day technical challenges. In this fashion, if a given company is experiencing difficulties in finding good professionals, it may be a good alternative to "open channels" with universities in order to recruit just graduated people and complement their training inside the workplace. This could be easily done (and it is) by offering student or research grants. Furthermore, it is generally necessary the availability of specialists in data preparation and model validation and testing, not to mention other types of related activities.

Related to this last topic, certain internal social actions may be very important and highly beneficial to employees and firms. Suppose that a certain number of workers are about to lose their jobs due to changes induced by the insertion or production of AI-based items in the dynamics of a given firm, and this happens because their functional activities are going to disappear or they lack the necessary knowledge to cope with tasks related to the new technological apparatus. Although the "standard" action (in certain regions) might be just to fire the group, a more civilized corporate attitude may be simply to reinsert them in new positions, by means of adequate training and adaptation. By following this procedure both parts may win, taking into account that employees preserve their incomes and gain new and possibly more interesting occupations, and firms, with lower corporate organizational instability and residual firing costs, not to mention the potential preservation of accumulated knowledge and good organizational climate and culture. To be a winner in technological matters, it is advisable to have very well prepared people and an excellent organizational atmosphere. Both conditions take time and a certain volume of resources, but to improve the chances of success, it is worth to employ the necessary effort.

Furthermore, in the intersection of social and educational spheres, governments should clarify matters related to AI so that respective populations be aware of the actual possibilities of devices and services provided by it. These initiatives should neutralize deleterious effects caused by bad marketing campaigns, in all social layers, mainly end users. Obviously, private companies could help in this direction as well.

Therefore, viewing technological advance as an evolutionary process, a positive selective pressure factor is the educational and technological level of people designing, working and using AI-based products and services. Although seemingly obvious, following such a directive, especially in poor countries, requires a formidable effort, including government and population.

3.2. Commercial and strategic dimensions

Establishing an appropriate AI infrastructure may be time-consuming and costly for most firms, but there are ways to minimize the overall amount of resources to be invested in order to get things working well. For obvious reasons, some vendors in the relatively young AI market argue that there are services and products available and ready to make new developments accessible and affordable to all firms, for example. According to their discourse, it might not be necessary to build the infrastructure and recruit or train people from scratch. They insist that it is better for your company to use those facilities to help in AI initiatives. It is the old game of "Make or buy", that traditionally tries to maximize ONLY the long-term financial outcome. It occurs that things are not so simple and the strategic perspective should be emphatically taken into account whenever making decisions about outsourcing. Considering that we are talking about a knowledge-based activity, a huge amount of technical information is usually generated, constituting the most important asset to be protected and being coupled to the survival of the enterprise. Although several services and products can be obtained from third parties, the operational and intellectual independence degree should be kept as high as possible.

This is compatible with [2] when stating that scientific understanding of how a technique works greatly amplifies the ability to learn how to improve it by analytical methods, and experimenting with simplified models. Developers have always tried to learn which objects might work by simulating and calculating the characteristics of the designs, and by experimenting with prototypes of the systems under study, but the importance of offline research and development in technological evolution clearly has increased a great deal along the decades. In this fashion, considering that a given organization has its operation and, consequently, income based on knowledge, it seems sensible not to depend on external agents relatively to significant operational issues.

3.3. Scientific and technological directives

In this type of activity, fundamental knowledge may be synonymous of market power and income, but abstract ideas must be implemented with efficiency, reducing waste of resources to a minimum, including computer processing time and associated energy, needed to keep devices working well. However, a curious phenomenon is happening right now: certain interpreted languages became very popular and are being used to build and release (mainly) software products to the market, including AI-related stuff. Even amateur programmers use those tools because they include several libraries, programming aids and so on. In terms of prototyping, this approach might be acceptable but, in runtime, interpreters are certainly inferior, when compared to code generated by mature compilers, simply because the latter generate directly executable machine code. Therefore, considering that numerical oriented applications are CPU intensive, nothing more natural than constructing code based on very efficient models, algorithms, and programming tools - by following these simple directives, time, money and natural resources will be preserved and ecological premises respected. Even more interestingly, there are thousands of good quality, free and open source mathematical software libraries available for free download and use. Typically they are written in C/C++, considered good for the construction of applications demanding high processing performance.

Accordingly, to follow a path compatible with the evolutionary viewpoint, it seems reasonable to use the most efficient implementation tools along with the best theoretical models. This is so simply because, in many applications, poor performance may result in failure of a given product or service - real time fuzzy control systems are a good example.

3.4. Funding and incentives

A substantial level of investments in AI and its applications is essential for countries wishing to maintain or attain a good industrial rhythm of growth and leadership in this area - this is valid in research and development as a whole, in all knowledge domains. Along the twentieth century, governments of some countries played a critical role in fostering technological innovation by funding basic research. Government funding has been essential to developing devices and components that transformed the world economy. Nowadays, government support again may be very important both in fostering new AI advances and ensuring access to the resulting assets (discoveries). In some countries, not only money but computing resources are granted to researchers.

Outside AI scope, overall research and development expenditures change, and countries move in the global ranking of scientific, technological and industrial progress. In developed nations the private sector, universities and the government frequently cooperate to accelerate technological innovation. Academic researchers, frequently supported by federal grants, conduct much of the basic research that has enabled private sector to improve applied research and commercialize new products. In practical terms, venture capital funds have worked well over the years and certainly may be a good and objective financial tool for advancing AI, mainly because their dynamics is well-known in the market.

In [10] it is highlighted the critical role venture capitalists have traditionally played with regard to R & D associated with deep science based industries and activities. Also, deep science and software investments are said to intersect in their use of computer science, and this one is classified as a deep science because science itself is presently done using computers - therefore, computer science would be essential for the advances in deep science R & D.

Considered as a subset of computer science, AI has both theoretical and applied sides. The theoretical side includes results of applied math, algorithms and data structures - all of them requiring knowledge of deep science. The applied side includes multiple fields in engineering, medicine, law, business, and so on, which may also require knowledge of deep science. So, by following the reasoning above it is possible to infer that previous experience with this type of funding indicates its adequacy for AI projects.

In [2], Chapter 4, it is cited that since the end of World War II the establishment of venture capital has been used in many countries, representing a significant source of funding for emerging firms in several industrial branches. On the other hand, some studies have shown that venture capitalists sometimes may be reluctant to support new ideas, at least before solid evidences that promising commercial products may result from them. So, many countries have created government programs to provide financial support for the development of new industries, but typically resources are aomewhat limited. Although it is true that investing in highly uncertain initiatives, and this is what ventures are in a "newborn" industry, remains a highly risky business in most markets, once final products present good commercial performance, things tend to change radically, with financial agents and the stock market opening to new public offerings and so on. Finally, if the industry succeeds, it is usual that financial institutions start developing expertise in evaluating projects and requests for funding.

4. Some feasible lines of action for specific fields

This section discusses two very significant and mature areas of knowledge, namely, fuzzy logic and global optimization. They were chosen due to their huge application spectrum and large number of devices and systems already using their methods. The information provided includes some considerations that indicate their enormous economic potential when adequately used.

4.1. Fuzzy Logic

Fuzzy logic is a revolutionary field of applied mathematics which makes it possible to mimic inferential human abilities by means of computer programs. Besides, many human perceptions and sensations may be modelled in a very precise way. It is based on the concept of fuzzy set, introduced by Lotfi Zadeh in 1965 [11]. A fuzzy set is defined as a class featuring multiple membership degrees. That is, a fuzzy set A is associated to a universe of discourse X, characterized by a membership function A which associates to each element $x \in X$ a real number A(x) (usually restricted to [0, 1]), having the interpretation that A(x) is the membership degree of x in the fuzzy set A [12]. Accordingly, an ordinary set is a fuzzy set as well, with membership degrees 0 or 1. For instance, a glass of water may be empty with degree 0.5 and full with the same degree, at the same time. It is not hard to show that fuzzy sets are able to model linguistic and, more generally, semantic, uncertainty.

By using fuzzy sets and operations between their elements it is possible to design fuzzy inference systems (FISs), devices capable of approximating the behavior of multiple input/multiple output systems in the sense that the mapping characteristic of the actual system is modelled using a parametric device, implemented in hardware or software. All this provides a model from which decisions can be made or actions taken. There are multiple types of FISs, but the most common are Mamdani and Takagi-Sugeno systems, both of them universal approximators under very general theoretical conditions. It is possible to design FISs manually or using empirical information - for low dimensonal systems it is feasible for human experts to design and implement several types of mechanisms without the use of samples or input/output data. On the other hand, more complex modelling tasks typically require parametric training - being universal function approximators, training usually occurs by globally minimizing very complex objective functions. Although their application spectrum is very ample, most well-known and successful applications are in pattern recognition, instrumentation, signal processing, control engineering and decision making, among others. Therefore, initiatives in using or producing items based on fuzzy logic may give back good results, considering that it features a mature set of techniques and good conditions of interpretability for the structure of rule bases.

In the light of evolutionary economics and according to[2], Chapter 2, fuzzy logic is a perfect example of "technological opportunity", taking into account its immense potential of generating innovative AI products, coupled to its strength of relevant scientific knowledge. This is so because its theoretical foundations are solid and practical results abound in all areas of knowledge since decades ago. Also in [2] it is suggested the general belief is that science is oriented towards the search of abstract foundations of knowledge and not to developing practical know-how, but they argue that engineering and other related areas direct efforts to the advancement of practice. Another very sensible statement is that knowledge of what is likely to work, and of how to do things, may determine the success of a given product or service, even when there is no deep understanding of why and how things work as they do - this happens in certain fields of AI arena. Fuzzy logic, on the contrary, is endowed with practical methods associated to deep theoretical results - this state of affairs enlarges the robustness of fuzzy logic based devices and systems.

4.2. Evolutionary global optimization and global (machine) learning

Although in the last decades the theory of machine learning has advanced, many questions are not resolved yet. However, it is now clear that a machine learning method is a complex combination of different components, such as the available data sets, the (predominantly parametric) model to be adjusted and a given optimization algorithm, as cited above.

Having strong intersection with computer science, linear algebra, probability theory, differential calculus and global optimization, it was originally faced as a subset of artificial intelligence, and even the expressions “machine learning” and “artificial intelligence” have been subject to several influences and interpretations over the years. Although during the decades of 1980 and 1990, the denomination “artificial intelligence” was not very popular and normally replaced with “machine learning”, a recent surge in popularity happened and AI is often fused with ML - mainly when discussed in business settings or by non-specialists. ML can be faced as one particular flavor of AI, which produces computer algorithms able to generalize from configurations found in training data, in order to make predictions using previously unknown inputs, as suggested in [13].

Therefore, the interest in machine learning lies mainly in its capability to process very large data sets, producing a final model capable of making inferences about several types of problems.

It has much in common with traditional statistical inference and, depending on the approach, it may be difficult to explain why the final trained model converged to that specific configuration. That is common in the case of feedforward neural networks.

So, except for fuzzy logic based systems, it may be infeasible to automatically design a model with an intelligible description. Machine learning, for example, typically uses parametric mathematical models, with empirical data composing a particular cost function, but the final "machine" usually is not easy to understand.

But what happens if raw data input contains incorrect or incomplete information, or have been distorted on purpose to "poison" online data acquisition servers, for example? Naturally the final inference system will not represent the reality under analysis simply because the furnished information is wrong - this will occur even though theoretical model and optimizer are the best possible.

In any event, when examining the final model, we do not necessarily have information about the creation of the input data, but face it (the trained model) as an opaque machine that was adapted for the sake of producing adequate inferences. As expected, one of the most common criticisms against machine learning is that its models are typically not easily explainable or interpretable, furnishing outputs (final models) difficult to verify.

Another very important (and negative) issue is when certain vendors state that their AI products are perfect, with 100% of certainty and no false positives or negatives in inferences, leading to frustration and possibly financial losses to final customers. For example, in certain not correctly regulated contexts, banks may force customer authentication in ATMs exclusively by means of biometric recognition and state that the process is error free - but until the present day no known AI method can do that. For instance. considering that a given bank has 30 millions of customers and a given algorithm features an average error rate of 3%, it is not difficult to infer that around 900,000 of people may experience problems with their accounts, not considering possible calibration problems in data acquisition devices due to bad maintenance and other factors. This type of event demonstrates bad usage of serious pattern recognition techniques, taking into account that only deterministic methods should be used (traditional magnetic cards, for example) in this kind of application, given the nonzero error rate cited above.

Returning to the topic concerning the false belief that machines can really think (artificial intelligence), let us take as an example the results obtained in [6][4] by means of evolutionary global optimization techniques applied to a specific function, described in [14], whose global minima correspond to Nash equilibria of strategic games, according to a theorem of R. McKelvey. In the cited references, machine learning occurs by means of global optimization, but a crucial part of the "intelligence" resides in the theoretical findings of McKelvey, which, complemented by the optimization process, gives the desired result. So, the NATURAL and HUMAN intelligence contained in previous theoretical knowledge conveyed by McKelvey's theorem, coupled to GLOBAL machine learning (global optimization), gave back the result of an artificial INFERENCE, corresponding to a set of Nash equilibria. Accordingly, this process is not qualitatively different from so many others, like finding solutions of nonlinear equations by means of optimization techniques, which are not examples of artificial intelligence at all.

Furthermore, a very significant evidence is given by the so-called optimization-based design, that is, the design of parametric systems by means of numerical (global) optimization techniques. Objects under study may be biological, economic, electronic, or even mathematical, provided they can be put into a parametrical form and an objective function may be synthesized - this function must express all design directives in the sense that the global optimum or optima correspond to the best final architecture(s). This kind of approach may be crucial whenever the theoretical apparatus in a specific field is not sufficient to achieve a certain design goal, or the complexity of conventional solution techniques is extremely high, making their application infeasible or very expensive.

Since ancient times optimization methods have been used to solve problems, although in many environments designers might not have been aware of their full potential and, probably, in many cases the resulting solutions were suboptimal ones, mainly due to the lack of adequate computational tools. It is amazing that Nature itself may be said, in a certain sense, to use global optimization methods in order to make life feasible, taking into account, for instance, that the protein folding process is supposed to search for a global minimum energy configuration state, according to a certain modelling paradigm. The biological principle of survival of the fittest, combined to species evolution theory, aims to model adaptation of the species to their environment, and is clearly related to an optimization process. Hence, it is perfectly reasonable to say that optimization-based design problems pervade the whole Universe, where (usually nonlinear) optimization processes happen all the time and at all levels - in General Relativity, for instance, the absence of acceleration means traveling along geodesics (minimum length trajectories) on smooth manifolds.

Considering that optimization problems may be global or local, techniques aimed at finding local or global optima may differ substantially - for instance, a local minimization problem requires finding a minimizer inside a neighborhood, what is a problem of a local character, not including the whole domain of the given objective function. Global optimization methods, on the other hand, face the problem of searching for optimum points over the entire domain of the function under study. Therefore, the goal of such methods is to find the best elements from a set, possibly subject to a group of constraints - these conditions are expressed as mathematical relationships.

Back to the consideration of the impact of AI techniques on economic evolution, and given the power and amplitude of global optimization methods, there is no doubt that the potential for growth is enormous, but (even in AI research) it is important not to put all eggs in only one basket. This is so because such paradigms are not a panacea, and there are alternative engineering approaches for solving the same problems - it is not hard to conclude that research must continue and be fostered in multiple fronts, in order to avoid what we could identify as "technological bottlenecks", with potential economic impact in the future. Control engineering is a good example - it is very important in robotics and other AI-related areas but it is not AI at all. Indeed, it is used in evolutionary global optimization algorithms, in order to improve their runtime performance [5].

5. Conclusion

After introducing a global view of several aspects of the so-called artificial intelligence and the possible influences on economic and social dimensions, some possible alternatives of investiment were discussed, all of them based upon solid approaches.

In order to offer a significant analysis, it was necessary to address educational, academic, industrial and economic issues, relatively to several geographic scales.

Besides, etymological and psychological implications of the label "artificial intelligence" and others were discussed, including suggestions for a sensible replacement are presented - “**artificial inference**” and “**global learning**” are among the new denominations suggested.

Furthermore, some directives for chosing the most adequate type of technique(s) for improving profit and organizational efficiency or efficacy were suggested - this is done by describing the most important features of certain fields in AI, mainly fuzzy logic and evolutionary global optimization.

Therefore, in order to improve gains or implement structural improvements in industrial or commercial firms with the use of the presented techniques, it is clear that a meticulous coupling should be made between the aim(s) of the firm and the type of technique to be adopted.

Besides, several connections exist between evolutionary economics and AI-based activities, taking into account the multitude of products and services passible of being designed by means of existing paradigms, and the almost infinite paths for evolving, in economic terms.

Finally, the presented exposition makes it easier to identify potential benefits obtained from AI in terms of positive externalities, namely, education, technical and scientific progress, higher level of employment and reduction of unemployment in the short term.

Final words

> *There are not inexact sciences - imprecise are human perception and modelling of deepest reality.*
>
> *-------- H.A.O.J.*

Declarations

- COMPLIANCE WITH ETHICAL STANDARDS and ETHICAL CONDUCT - the text is compliant with all ethical standards.
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