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Automation and Environmental Sustainability: A critical Analysis

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Abstract

Automation, in a broad sense, i.e., encompassing robotics and information technology, has been mainly responsible for the strong increase in productivity felt in recent decades, thus contributing to economic sustainability, i.e., making companies more profitable and competitive, lowering production costs, making products more accessible to the end customer, and thereby increasing economic growth. However, automation can and should also play a leading role in the development of processes, drastically reducing their environmental impact. Moreover, increasing the productivity without increasing the employment, automation can play an important role in the spiral cycle induced by the economic growth, which usually translates on increased consumption of the populations. This work aims to develop some critical ideas about the way in which the economy, automation and the environment are correlated, seeking to contribute to strengthening the use of automation as a way to increase environmental sustainability.

Keywords: Automation; Environmental sustainability; Green automation; Energy saving; Processes improvement

Introduction

The world population continues to grow significantly and, as a result, the need to produce consumer goods also continues to grow. In political terms, the idea is rooted that the Gross Domestic Product (GDP) is the best indicator to show the well-being of populations, which normally translates into a higher consumption rate [1]. Increasing consumption generates an increased need for natural resources, which the planet is beginning to have serious difficulties in regenerating [2]. The need for more natural resources is encouraged and accompanied by the secondary (industry) and primary (agriculture and livestock) sectors, which need the means to satisfy growing demand. Given the labor cost constraints and the difficulty in finding workers to perform certain tasks, especially in more developed countries with better living conditions, automation has emerged as the solution to all these problems [3]. Indeed, in economic terms, automation is an essential pillar in meeting the production needs of products required by the market.

In fact, automation has seen exponential growth in terms of miniaturization, integration between systems and software development that allows interconnection and interaction, leading to what is currently known as Industry 4 or Smart Manufacturing [4]. In this way, automation has also contributed to the reduction of low-skilled labor, requiring much more qualified labor to meet the complexity of the systems necessary to fulfill more complex and advanced production functions, as well as the needs programming and maintenance of these systems [5]. Thanks to these production systems, and despite high initial investment costs, companies have become more competitive, promoting a decrease in prices in the long term. This benefited the end consumer, who now has access to a wider range of goods at an affordable price. However, the production of these goods involves the consumption of material resources, the production of waste, and also the emission of gases and fluids that usually are harmful to the environment.

For decades, the environment was relegated to the background, with the focus essentially being on the economic plane, one of the three pillars of Sustainability [6,7]. In this aspect, automation presented itself as an essential factor for economic growth, but few anticipated that this would be reflected in the way it is impacting the environment. In fact, intoxicated by economic growth and the ease of automating tasks that were previously painful for human beings, the industry saw automation as an escape to overcome the population's need to increase consumption and the difficulties in

finding labor available to carry out repetitive tasks, or avoiding the exposition of workers to environments that are clearly harmful to humans, either due to exposure to toxic products or the risk that certain tasks involve [8].

Currently, developed countries have highly automated factories, where most or all of the routine tasks are carried out by extremely flexible production systems, equipped with numerous sensors and actuators, which, thanks to careful production programming, allow the production of goods with a reduced incorporation of highly qualified labor [9], sending less qualified labor to other sectors, namely the tertiary sector (commerce) [10]. Despite the high level of development recorded by automation, the last few decades have been dominated by the evolution felt in information systems, particularly in software [11]. To achieve this, it became absolutely necessary to make the signals emitted by some devices and received by others compatible, so that communication was compatible and coherent, speeding up interconnection [12]. This type of production, also commonly known as Industry 4.0 or Smart Manufacturing, has opened new doors for industries that are in great need of increasing their production flexibility, meeting market requirements, which increasingly demand products with high levels of customization [13]. The automotive industry is one of these sectors, but by far not the only one, in which this production flexibility has resulted in less need for labor and greater productivity, as downtime due to setups has become extremely reduced and carried out almost entirely automatically [14]. With the use of robots and Automated Guided Vehicles, as well as massive doses of investment in automation, it is now possible to witness the manufacture of automobiles with a high degree of automation and sophistication, where different models are manufactured in a same production line in a completely random way, but faithfully following an initially drawn up production plan [15]. These principles were transmitted by Original Equipment Manufacturers (OEMs) to their suppliers, who have intensively implemented the same production principles, with a view to supplying OEMs with components at competitive costs. However, this level of sophistication in production requires large investments, which are only in developed countries. Thus, the world has developed at various speeds, in which at the extremes there is an intensive use of automation, high flexibility of production systems, competitive prices, little labor used, but with a high level of knowledge, while at the other extreme, we can observe very manual production systems, very low labor costs, a relatively low level of professional specialization, and working conditions that are not always worthy of human beings [16]. Between these extremes, there are a number of countries that, for economic or political reasons, are slow to make the transition between the two states mentioned above. These countries base their competitiveness on the low cost of their labor, but this makes economic growth and the well-being of their populations unfeasible. In these circumstances, the social pillar of sustainability is often ignored or neglected [17]. The tasks do not take into account the fatigue related to performing some cyclical movements that are repeated many times a day, day after day, nor the working position [18]. Ergonomics should always be present in the creation of workstations and task design, but it is common for many tasks to have no concern for the problems that may be caused to operators by occupational illnesses. These problems are often reflected in absenteeism from work, which makes it difficult to adequately manage human resources and meet initially agreed delivery deadlines [19]. Automation also has its faults, but it is much less subject to fatigue and carries out repetitive tasks with rigor, eliminating the errors characteristic of human work.

Having addressed the economic and social pillars of sustainability, it now becomes necessary to dissect how automation is related to the environment. In fact, the initial relationship between automation and the environment could be considered mixed, given that it promotes greater energy consumption, which, without considering the production of renewable energy, which fortunately has developed very positively in the last three decades, would cause a negative environmental impact. However, automation also makes it possible to avoid characteristically human error, avoiding the generation of defective products that could end their life cycle even before they are sold [20]. Perhaps this analysis cannot stop here, since the competitiveness and cost reduction induced by high levels of automation directly leads to an environmentally harmful effect on consumption, i.e., it boosts consumption by making certain products more accessible. The consumption of goods is directly linked to a greater need for materials and energy, which has definitely negative impacts on the environment [21]. In fact, the increase in consumption, much desired by the general population, and also strongly pursued by governments, which are able to charge higher tax values, is largely responsible for the environmental deterioration we are experiencing. Probably, reducing the environmental impact can only be achieved with a significant reduction in consumption, especially of goods that most negatively affect the environment throughout their life cycle [22]. However, can automation reverse this negative influence on the environment? This is exactly what will be analyzed below.

Automation and Environment

At home

The daily life of human beings, both personally and professionally, is surrounded by consumption, which usually results in environmental aggressions. Reducing the environmental footprint in general must start at the base: our personal life. However, unfortunately, it is something that is only within the reach of some people, because humans like to live comfortably, which requires a home with the appropriate installation, temperature, lighting and space conditions for the time they need to stay in their home, and the tasks that need to carry out

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there. Depending on the location of the home, the use of heating or cooling is a need that is almost universal to the entire world population, but only a moderate percentage of the population gets this level of comfort [23]. In fact, this kind of comfort consumes energy resources, which, if properly considered at the time of home design, can be greatly reduced with the help of automation [24]. Effectively, the use of photovoltaic panels, more efficient energy management, the orientation of the house, and the materials used in its construction, can significantly reduce energy consumption that could be necessary in the future [25]. In this case, as in so many others, the product, in this case housing, must be designed and built focused on its life cycle, and the energy that will be consumed both in its construction and over the estimated useful life [26]. A building is a particular case within the range of products normally considered for analysis, as it can be the target of interventions throughout its life cycle with a view to reducing its ecological footprint and thus contributing less negatively to environmental degradation [27].

The idea of building housing that meets the population's comfort needs and respects the environment as much as possible led Irulegi et al. [28] to develop a prototype house that mixed passive and active environmental impact reduction strategies, trying to make the most of incident solar energy to create a house that was completely self-sustainable in terms of energy, but which, at the same time, ensured comfort and the required sensation well-being for its occupants. The concept integrated both architectural and technological solutions, taking advantage of natural lighting, and essentially using natural materials conveniently aligned with the initially established self-sustainability purposes. In parallel, an intelligent passive strategy was also developed, placing photovoltaic panels as a way of isolating the facade of the house from solar radiation, which promotes the generation of electrical energy and reduces overheating of the house, avoiding the need for forced cooling. The exterior panels of the remaining facades were also selected taking into account their thermal behavior depending on the solar exposure to which the house was subject, which strongly depends on the way it was oriented. In addition, passive strategies to adequate insulation considering the building's location were used, also take into account the building's orientation, such as the materials used in each area of the building, as well as the water heating using solar energy and the generation of electrical energy through photovoltaic panels. In any case, to make feasible the energy balance between consumption and generation, preserving the comfort of the inhabitants, some active techniques can also be used, depending on the direct action of the inhabitants, which can essentially contribute to reducing power consumption [29]. In this case, automation, computer systems and smartphone applications have assumed particular relevance, both in terms of information to the user and in terms of suggestions for improving the energy efficiency of systems and energy management strategies [30]. These systems are increasingly user-friendly, allowing the number of beneficiaries to increase. In fact, the friendlier to the user and the more informative the systems available are, the more comprehensive their use will be, taking advantage of the intended scale effect to slow down the harmful effects that we are inflicting on the environment on a daily basis [31]. However, these systems have non-negligible costs, are not always adequately supported by governments, and require something that is vital and transversal to this entire problem: environmental awareness and basic education. These are probably the most difficult factors to overcome, given that the population with lower levels of education tends to reproduce more quickly than the more educated population with more favorable economic means. This being a fact, it is still worrying to predict that winning this challenge will become much more difficult to achieve. It is worrying to realize that people deprived of a certain level of comfort during the initial part of their lives, when they begin to have better financial conditions, tend to consume less consciously than those who have never felt these deprivations [32]. This factor, combined with gaps in basic education, makes it difficult to predict whether this group of the population will be able to plan their lives and have selection criteria for the house they want to live in. This makes all the on-going research efforts to reduce the environmental impact corresponding to our day-to-day lives fruitless. This is corroborated by a study by Del Rio et al. [33], in which an integrated analysis is carried out of how the culture of inhabitants, energy savings and environmental sustainability are correlated in four different countries, verifying their appetite for adopting smarter technologies in managing their daily lives and your comfort at home. In fact, any change in habits usually entails a set of drivers and barriers that need to be dissected, trying to mitigate some difficulties in their implementation. The countries considered in this study were the United States of America, Japan, the United Kingdom and the United Arab Emirates, focusing on different aspects, such as social, technical, political, economic and environmental. Although all the countries considered in the study have high average salaries and there are no perfectly defined economic barriers to the acquisition/adoption of new technologies due to economic limitations, these countries have very different socio-political and socio-cultural patterns, which conditions the adoption of these technologies in their homes [2,34]. However, when underdeveloped countries are considered, such as in certain areas of Africa, Asia, South America, and even some European countries, the predisposition and technical knowledge for the adoption and implementation of these systems is drastically reduced, as, unfortunately, many of these people struggle to survive, and not to have ideal comfort conditions. Although these populations do not contribute significantly to the degradation of the environment, the phase in which some of these people or families transition from more unfavorable conditions to better living conditions cannot be neglected. The rapid development of some Asian countries, such as China, has led to alarming levels of pollution, which corroborates everything previously stated [35]. If this fact represents a concern with a

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population that is also progressing very consistently in terms of knowledge and basic education, it will be necessary to have even greater concerns in terms of basic education and environmental awareness with many people who have not yet integrated a system of economic evolution like China has seen in recent decades.

Returning to research into technologies that minimize the environmental impact of our daily lives, the reuse of water, the automatic opening and closing of blinds, automated air conditioning, the use of certain times to carry out certain domestic tasks that require higher levels of energy, are some of the strategies that have been explored through automation and computer applications, and which have produced very satisfactory results [35]. However, many other strategies based on automation can still be adopted, such as motion sensing and lighting timing in the different rooms of each house, warning and/or triggering to carry out certain household tasks at times of lower global energy consumption, conditioning the use of water through dosing the amount of water consumed in each operation, the reuse of water for less demanding purposes, among many others, would allow to reduce or even eliminate some harm that we cause to the environment in banal acts of the day -a-day [36].

Agriculture

The global growth of the world's population puts the agriculture and livestock sector under immense pressure. This sector covers a basic need for the population but, at the same time, is exposed to several imponderable factors, such as weather conditions, land productivity, and the appearance of pests. In order to increase productivity, fertilizers commonly supplied by the chemical industry are used, which is also responsible for supplying products with a view to preserving crops from pests [37]. In this way, the agricultural sector is responsible for a strong ecological footprint in several ways: (a) it consumes immense natural resources; (b) produces a very significant amount of gaseous, liquid and solid effluents; (c) consumes a lot of water; (d) has very specific productivity needs and the need for protection against pests, which are normally met by the chemical industry, but using products with a strong ecological footprint [38].

There has been a strong component of research added to agricultural production and the products it consumes, trying to find alternative ways of increasing productivity, either by increasing production itself or by removing threats to harvests. Therefore, new fertilizers based on natural products have been developed which, despite consuming resources, have a much smaller impact on the environment and prevent water from being heavily contaminated [39]. Furthermore, the soil is not as overloaded with chemicals, meaning degradation in terms of production rate is also lower. The same goes for pesticides, which were initially based on chemical formulas with a strong environmental impact. Very significant efforts have also been made in this regard, through the less intensive use of these products and their replacement with others of more natural origin and with less environmental impact, maintaining effectiveness in terms of protection. In this aspect, automation has had a less significant role, being used essentially in the production processes of these new fertilizers and pesticides. However, new systems for assessing the needs of the land used in these crops have emerged, which make it possible to monitor needs and minimize the use of products that, even so, produce negative effects on the environment, thereby reducing environmental impact [40].

The reuse of effluents, through new composting technologies, has also been widely explored, as it allows converting effluents that had a strong environmental impact into fertilizers, thus minimizing the global environmental impact, and thus contributing to a circular economy system, which brings both economic and environmental benefits [41].

Another area where agriculture and livestock have a strong impact is on water consumption. Massive irrigation of arable land is still a common practice in many countries and types of crops, but efforts have been made, albeit slow, to implement intelligent irrigation systems [42]. These systems are based on algorithms that take into account the state of the land in terms of humidity and productivity, the weather conditions and the particular irrigation needs of each species to be irrigated, dosing the water supply by the minimum quantity necessary to obtain the results intended in that culture. Drop-by-drop and perfectly targeted irrigation has also been heavily explored, but its implementation has been restricted to more contained spaces and to certain species, as others do not adapt so easily to this controlled type of irrigation. Automation has enabled a strong development of these technologies, both through sensing and monitoring, and through the control of water supply systems to crop fields [43].

Industry

There is a very deep-rooted idea that industry is the sector that most significantly contributes to environmental degradation. However, it was also the industry that developed solutions to mitigate the effects of the environmental degradation it caused, solutions that have involved the massive use of automation and the development of complex research/engineering projects. One of the factors normally associated with the industry is the strong emission of gases and liquid effluents, as well as the production of waste. The chemical and electricity production industries are normally considered to emit enormous amounts of GHG (Green-House Gases). Furthermore, the chemical industry needs to process dangerous raw materials, the leakage or reaction of which could have catastrophic effects on safety. After some notable accidents, the chemical industry significantly improved its procedures, and has adopted a much more selective policy regarding the raw materials it works with, in order to achieve the same effects in terms of the final product, but with the introduction of raw materials that are less harmful to the environment and that pose less danger to the safety of operators and installations [44]. In fact, the number of major accidents has decreased significantly,

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but this industry is still far from adequately reducing its ecological footprint.

However, all efforts that have been made to mitigate the environmental effects that this industry has caused in the past are welcomed. In the case of the chemical industry, which is normally considered a process industry, automation is extremely important, coupled with powerful IT systems, which allow the process to be evaluated in real time, issuing the necessary alerts in case of any change that represents a danger to safety, the environment, or the quality of the final product [45]. All processes are equipped with sensorization, which allows the corresponding information to be sent to the central system that manages the entire process, having established acceptable limits for each variable and producing the necessary alerts whenever a variable crosses the lines that delimit its variability.

However, it is not just the chemical industry that contributes to environmental degradation. Other industries, namely metallurgy and metalworking, also contribute significantly to the industry's high ecological footprint. The steel industry consumes massive energy and water, and emits an abundance of GHG, in addition to other solid effluents that are impossible to recycle. Currently, the most advanced companies, or those that are operating in countries with more demanding regulations, already treat the water used by returning it to the watercourses from which it was initially removed, and already have emission treatment systems, with a view to recover energy and minimize harmful effects on the environment [46]. Regarding energy consumption, despite the increase in furnace efficiency, the evolution has been more modest, as the scope for evolution in this matter seems much more limited. However, the steel industry is just one characteristic example within a panoply of industries that are characteristically very polluting. The cement industry is also a very polluting industry, which consumes large amounts of natural resources, massive amounts of energy, and which also releases GHG emissions. Also in this industry, numerous efforts have been made to modify energy generation sources, burning waste from other industries [47]. The emission of GHG has also been the subject of strong research, with the aim of reusing energy and converting the resulting gases into gases with less effect on the environment.

The metalworking industry, in general, has been where the use of automation has been most noticeable, in the first phase essentially with a view to gaining competitiveness, i.e., acting on the economical sustainability component. However, increasingly demanding regulations in environmental terms have led to a significant increase in the intensity placed on research into new processes, lower energy consumption, and even replacement of raw materials and alloys which, presenting greater mechanical strength, allow savings in terms of resource consumption in initial manufacturing [48], but also reduction in energy consumption in the normal life cycle of the product, particularly when it comes to products related to mobility [49]. The industry has made a notable set of small efforts aimed at reducing the consumption of natural resources, energy and water, and reducing gaseous and liquid effluents, as well as by-products that are impossible to recycle. The automotive industry, due to its permanent need for competitiveness, and the fact that it is subject to strong regulation, has been a pioneer in the development of many solutions that have reduced the ecological footprint of the metalworking industry in general. Thre are a lot of examples of small efforts that, together, have contributed to a decrease in the ecological footprint for which this sector is responsible [50-52].

Public spaces and buildings

The concerns in terms of energy consumption and environmental degradation previously mentioned in the daily lives of populations also have parallels in the business world and public services. It will certainly be part of the memory of many who have visited large cities such as New York, Toronto, Tokyo and others, the interior lighting of office buildings that remains turned on at night, when the buildings are not in use. If the lighting of some of these buildings even constitutes a reference in some of these cities and makes these areas more attractive and even a landmark for certain locations, and despite lighting not being one of the most energy-consuming aspects, it cannot but be worrying. The lack of balancing between the benefits of certain areas having a greater charm at night, and the harm caused to the environment by the consumption of resources and emissions that are generated to produce the energy necessary for this purpose needs to be considered and reviewed. Furthermore, automation can play a key role in lighting timing, allowing considerable energy savings, without the need for a radical attitude of completely turning off lighting in buildings immediately after the end of each working day [53].

Water consumption is something that is also increasingly worrying, since, despite the evolution of desalination technologies, the scarcity of drinking water is beginning to deserve particular attention in areas where global warming is felt more acutely. Given the problem of water scarcity that has been noted in certain hotter regions of the planet, some strategies are now becoming mandatory to adopt, otherwise there will be no water available for basic day-to-day functions. Public spaces, and even some private ones, are intensive consumers of water, such as public and private gardens, golf courses, municipal swimming pools, among others. Given the scarcity of drinking water, it is necessary to carry out more intelligent irrigation, with a view to producing the same effects, but consuming less water. This can be perfectly achieved with some irrigation strategies suited to each purpose, as well as conditioning water use depending on the weather. Once again, automation and computer applications can play a key role in this sense, receiving information from humidity and temperature sensors and, through an algorithm suited to each case, triggering irrigation depending on the specific needs of the area intended to be irrigated, the type of plantation in question, and the atmospheric conditions of each period considered [54]. Water from swimming pools, both private and municipal, can also be conveniently

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treated and reused for irrigating gardens, flushing water in public bathrooms, washing municipal waste containers, etc. Automation can also play a fundamental role in these cases, by monitoring the condition of the water, issuing alerts for its replacement in the pools, and forwarding it for treatment/filtering and reuse for the purposes that are considered appropriate for directing the water.

Hotel swimming pools and gardens are another significant source of water consumption. However, if automation and adequate management of pool water are applied, it, after proper treatment, can be used to irrigate gardens, avoiding wastage of water. Furthermore, treating swimming pool water can lead to a longer period of water maintenance between renovations, avoiding excessive water consumption. The use of automatic localized irrigation systems and in the necessary proportion, appropriate to atmospheric conditions, can also lead to significant savings in the consumption of drinking water, thus minimizing waste of this natural resource. Using automation or even small devices, it is also possible to save a lot of packaging plastic, which becomes waste when the individual packaging of shampoo and shower gel is replaced by a dispenser for these products. The amount of packaging saved is very significant, also leading to less product waste, as significant parts of chemicals that end up not being used in each packaging are not wasted [55].

These are just a few examples of the countless situations in which, through the use of automation and computer systems, and applying solutions that inevitably pass through the common sense of system managers, extremely favorable environmental sustainability strategies can be adopted, thus contributing to an environment and a better future for humanity.

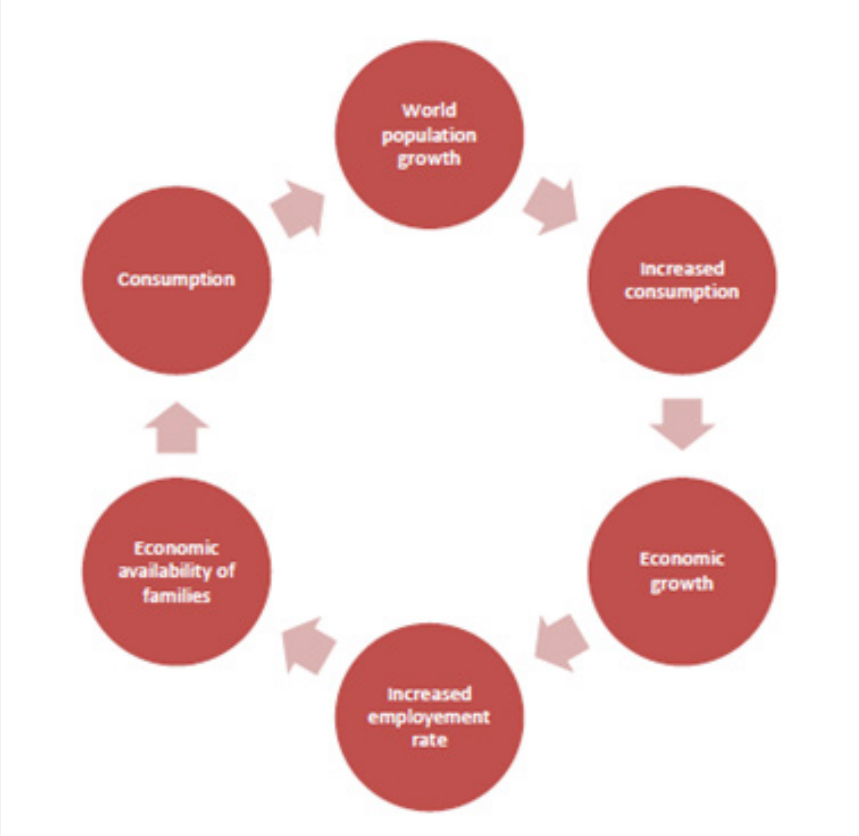

Figure 1: Consumption cycle fed by the population growth and/or economic growth.

Discussion

The growth of the world population is an unavoidable fact, which in itself generates higher consumption rates, both of natural and processed products. This fact places significant pressure on all sectors of the economy, but with particular emphasis on the primary and secondary sectors. It is often seen that the planet is experiencing serious difficulties in regenerating the resources that are consumed and that the amount of time that corresponds to humanity's consumption that can be regenerated by nature is increasingly shorter. Both the primary and secondary sectors are mainly responsible for environmental degradation, although the tertiary sector is also beginning to assume some relevance in this aspect. Consumption is at the root of the problem. Both

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population growth and economic growth are harmful factors for consumption, which tends to grow, and, with this, the volume of necessary resources is also increased, as well as the damage to the environment, through more waste that is generated, more emissions that are produced, more liquid effluents that are generated, more water that is consumed, and more energy that is needed. It is up to humanity to be able to generate the resources it needs without causing waste and causing harm to the environment. In fact, this is a cyclical problem that can begin with population growth or economic growth, which leads to an increase in consumerism, which triggers a new increase in economic growth, with repercussions on employment growth, which leads to an increase in budgetary availability of families, which, in turn, tends to transform into an increase in consumerism. This cycle can only be broken in two ways: (a) encouraging savings, which prevents families' greater financial availability from turning into increased consumption; (b) increased productivity through the mass use of automation and robotics, a factor that generates an increased quantity of products, but does not induce a substantial increase in employment, stopping the cycle shown in Figure 1. In this case, automation can play a fundamental role, as it would curb the excessive creation of jobs, which would lead to an increase in family income, which in turn would translate into an increase in consumption.

There is another way to stop the excessive consumption of goods and services, but its action takes much longer and depends drastically on the societies where it is intended to be implemented. In fact, a more intense and effective level of education and awareness among the population could result in greater sensitivity among populations to the harmful effects of consumption and remove the negative impact that it tends to have on the environment. However, the re-education of populations is something that can take several generations to achieve, meaning its effect would only be felt in the long term. However, this factor works in certain countries in Northern Europe, so it is not unreasonable to consider it. However, this re-education would cost governments a lot of money and would have a harmful effect on consumption, which could result in very moderate economic growth, or even recession. In political terms, this does not seem to be the friendliest way to get votes, which is why it would be unlikely to be adopted by any government that intends to renew its mandate. This path has nothing to do with automation and could only be put into practice through non-governmental associations linked to the environment, which would promote actions to re-educate populations to environmental causes, placing exaggerated consumption as the main cause of environmental degradation.

Conclusion

Automation has played and will continue to play a key role in reducing the aggressions that humanity causes to the environment, and much research is still needed to improve interfaces and implement new systems that allow the efforts already made to date to continue. However, automation requires a strong investment, and it will be necessary for governments to adopt policies that encourage awareness and education of populations about environmental causes, a situation that does not even exist in all developed countries, so there is still a long way forward in this regard. The access of disadvantaged populations to new job opportunities and higher incomes poses the risk of triggering consumption that is not properly oriented towards environmental causes, a risk that can only be overcome through the same awareness raising mentioned above. In fact, no matter how many benefits automation can bring, in addition to all the benefits it has already brought, because the attitude of change resides in each human being, and some group attitudes. This is the reason why it is necessary to invest heavily in awareness-raising actions to the environment, clearly stating how each of our day-to-day actions is reflected in the environment. In addition to the effort that each citizen needs to make for the environment, which has already been extensively dissected in this article, automation plays a key role in reducing pollution and saving resources in different sectors of the world economy. From saving water in agriculture and using agricultural waste to improve soil performance, to energy use, automation represents an excellent contribution to reducing environmental aggressions induced by the primary sector. In the secondary sector, there are numerous situations in which automation already contributes to (a) reducing the consumption of resources (less generation of defective products), (b) transforming industrial processes with a view to making them economically and environmentally friendly. more sustainable processes, (c) in the replacement of certain environmentally harmful processes with others with a smaller ecological footprint, (d) in the immense technological developments in the conversion of environmentally harmful emissions into energy, or in others that are less harmful to the environment, among many others. Also in the tertiary sector, automation has already assumed particular relevance in the activation and control of numerous more common situations, such as temperature conditioning or lighting. On the other hand, waste generation and resource consumption are matters that are beyond the scope of automation to improve. These aspects are directly related to the problem of environmental education and awareness. In this aspect, the example set by some Northern European countries should be followed, while the attitude of some Asian countries is still completely outside what would be recommended, which is reflected in very high levels of generation of solid and liquid waste, and in emissions far above what is desirable, with direct harm to their populations in the first instance, but with repercussions on the global environment.

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