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INDUSTRY 4.0 IN ROMANIA - A PRACTICAL ANALYSIS OF THE COUNTRY POTENTIAL FROM ECONOMIC AND HUMAN RESOURCES PERSPECTIVE TO SUPPORT A SUSTAINABLE DEVELOPMENT OF CEMENT SMART FACTORIES

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Abstract: *The actual focus on sustainable development based on a circular economy, moved in a new economic era, Industrial Revolution 4.0. Although in the last decade, some of the EU27 countries have taken important steps towards this new industrial transformation, there are still many aspects to be clarified with regards to how Romania is prepared for these changes. Thus, this paper has analyzed the situation of our country from the point of view of economic and human resources, in perspectives for Industry 4.0 and how this can support the sustainable development of local smart cement factories. For this purpose, 41 Key Performance Indicators (KPIs), grouped by five areas of interest, have been used to analyze the information available in the EUROSTAT databases. Results showed that Romania needs to further adapt its transition strategy to Industry 4.0 to remain competitive on the European industrial market, including the cement industry, given the need for more efficient use of existing resources, solving social-economic problems, and protecting the environment.*
Keywords: *Industry 4.0, operator 4.0, sustainable development, research and development, Romania industry, cement smart factory*

1. INTRODUCTION

Within the 27 member states of the European Union (EU27), it can be found some of the most competitive companies operating in the industrial field worldwide, but this is also forcing them to keep up with technological changes or even be their promoter.

The need to maintain competitiveness in a globalized and extremely competitive market determines companies in the industry to move on to another level of development periodically, these types of transitions being referred to as industrial revolutions [1]

Let us first see what the most important industrial revolutions of this type are. It is generally accepted that true scale industrialization began in the late 18th century, with the use of mechanized equipment driven by the power of steam to produce goods in large manufacturing series [2] The second industrial revolution then followed, which took place at the beginning of the 20th century, and which brought about, as main elements of novelty, the use of electricity to power work equipment, the development of mass production and the division of labor [1] Subsequently, in the early 1970s, a third industrial revolution occurred, entailing the use of information technology to produce goods with the help of automated systems, which has led to a reduction in the effort made by the human factor in conjunction with a massive increase in productivity [3]

The fourth industrial revolution is Industry 4.0, was started to become a reality over the last decade. This brings about high process transparency across the entire manufacturing flow, provides relevant and complete process information, ensures increased productivity, streamlines the consumption of resources, all of this being possible with respect to the relevant stakeholders' requirements [1]

At the European level, the most intensely discussed is the German initiative Industry 4.0, but it is not unique, as there are other similar projects worldwide, such as Smart

Manufacturing in the US or Smart Factory in South Korea, all having as shared aims technological and workforce transformation [4]

2. INFLUENCE FACTORS OF INDUSTRY 4.0

The first attempts of industrial organizations to transition to the fourth industrial revolution are characterized by the introduction of the Internet of Things and Services and Artificial Intelligence in manufacturing processes, a transformation that will allow them to join the links between equipment and people in a cyber-physical system capable of acting independently and autonomously. For this to happen an interconnection of existing networks, a horizontal integration of data and an exchange of information need to come about so that they can act as the pillars of smart factories [5]

Industry 4.0 and the growing development of cyber-physical systems are causing changes in the way the work is organized, thus creating new challenges and opportunities for the current workforce [6] One benefit of implementing Industry 4.0 is that workers will no longer have to spend most of their working time with tasks considered routine. In Industry 4.0, these are taken over by fully automated systems within smart factories, thus reducing the likelihood of human error and reducing risks.

In terms of workforce, more and more developed countries are facing a negative demographic growth, and an aging population, which poses major challenges for industrial organizations in finding the necessary skilled labor force, although with the increase of immigration it was attempted to reduce these negative effects [4,7]

In a study published in 2017 by E. Ras et al., the authors analyze various ways to develop skills and learning areas for employees, in order to reduce the gap between the current education of the human factor and the skills needed for Industry 4.0, with the conclusion being that fast action needs to be taken for the appropriate training and education of young people and leaders of future generations in order to see an improvement in performance [8]

Along with Industry 4.0, the concept of Operator 4.0 also emerged, representing the future employee, and referring to a different type of worker, more adapted to new technologies, better prepared and more qualified, with extensive skills, and performing cooperative work with robots, assisted by intelligent equipment through cyber-human systems [4]. Industry 4.0 provides a dynamic connection between people, objects, and systems, which can impact all company processes, but is likely to generate new emerging risks [9]

In order to make sure processes become safer and more efficient, the planning of industrial activities 4.0 should be approached taking into account the intervention of human factors [10]

Industrial organizations have a major impact on the sustainable and durable development of society, significantly influencing environmental and social factors, therefore they become the parties that are most interested in new technologies allowing for digitization, automation, and the ability to customize production [11] This also applies to cement factories that are an intensive consumer of energy, natural resources, and fuels, being a major source of industrial pollution, so an ideal candidate for improvement by advanced means of Industry 4.0. [12,13]

Sustainable development in the context of Industry 4.0 also conduct to creating a circular economy by increasing social benefits, ensuring economic competitiveness, and protecting the environment [14]

One can notice that industrial entities generate an increasing impact on the environment through the consumption of non-renewable resources and energy, but also through noxious emissions, negatively and sometimes irreversibly affecting the environment and society as a whole [15,16] Sustainability issues have led more and more industrial organizations to abandon traditional production methods, and resort to new market requirements, such as the use of innovative technologies to increase productivity under the conditions of a durable and sustainable development [17] The turning point in the relationship between technological evolution and environmental impact in the cement industry is plotted in Figure 1.

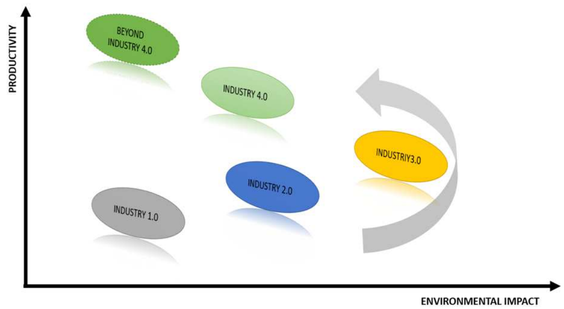


Fig. 1. The industrial revolutions and their impact on the environment and productivity

In this complex context, Industry 4.0 must focus on manufacturing products that are efficient in terms of the resources used, safe for the user, and environmentally friendly throughout their life cycle. From another perspective, with the current manufacturing method, the number of accidents at work in industrial organizations has not decreased much over the last decades, but the Industrial Revolution 4.0 promises to provide a significant advantage in the effort to reduce incidents related to work processes [18]

The European Union has decided in recent years to encourage the development and research in the field of Industry 4.0 [19] One reason is the fact that the highly industrialized countries within the EU27 are facing increasingly serious demographic problems, which adds additional pressure on future national development plans, due to the lack of skilled labor available on their markets, which should replace people of retirement age, while also having to fill the new jobs created as a result of development.

Romania is no exception to this challenge, facing significant demographic problems, primarily due to the migration of a part of the population, mainly to other EU27 countries, with the main reasons being related to economic and social aspects. These problems implicitly have repercussions on the cement companies operating in Romania, including the cement companies, especially in the context in which they will also need to make the transition to Industry 4.0.

There are studies analyzing the performance of countries with regards to the transition to Industry 4.0, such as the one published by H. Atik et al in 2019. In this study, the authors used indicators such as cloud computing services, cyber security, or big data to assess the performance of European Union countries and Turkey in terms of the transition to Industry 4.0. concluding that Denmark is the country with the highest performance in this regard [2]

According to T. Walther (2018) in the next period, the cement industry must overcome important challenges to remain competitive including capital and cost efficiency, new environmental restrictions, or energy and resources scarcity. A proper solution for cement factories to improve operational excellence and to face such demanding challenges is to embrace innovations and technological advances of Industry 4.0 [20]

However, the transition process from classical production to smart cement factories depends to a large extent on the country's economic resources allocated for technological infrastructure 4.0 and the level of specialization of the available workforce.

That's why this paper will focus on the analysis of the situation in Romania, in order to see how prepared, it is from the economic and human resources perspectives for Industry 4.0. In this context, the main objectives of the study are:

- Analyzing the current situation in Romania compared to the EU27 countries in terms of financial resources allocated for the transition to Industry 4.0, considering the current economic development of the country.
- Analyzing the current level of training of the human resource in Romania compared to the EU27 countries, in order to see whether there is a competent workforce that can work in smart factories and the research and development sector.
- Providing some recommendations for sustainable transition, especially for the cement industry.

3. RESEARCH METHODS

The research methodology used Key Performance Indicators (KPIs) to measure the following five important areas of interest regarding Industry 4.0:

I. Use of Artificial Intelligence and the Internet of Things

II. Research and Development (R&D) Expenditure and High-Tech Product Trading
III. Research and Development Personnel
IV. Education Level of Human Resources
V. Human Resources Involved in the Science and Technology Sector

The research analyzes the official data available in the EUROSTAT database [21] From the analysis of the bibliographic references presented in chapter 6, as well as the information available at EUROSTAT database, 41 Key Performance Indicators (KPIs) have been determined, which are presented in Table 1. A reference period has been selected for each of these indicators, so that information to be as relevant and actual as possible.

Considering that in the case of certain KPIs, the reference period involves the aggregation of information over several years. The preferred option was for the calculate the arithmetic mean ε using the formula (3.1):

$$\varepsilon_j = \frac{1}{n}\sum_{i=1}^{n} \gamma_i \qquad (3.1)$$

for any j=1,2,3, … 41 KPIs.
where:
ε – the arithmetic mean of the gross value of the KPI, for the reference period set.
γ – the gross value extracted from the EUROSTAT database.
n – the number of years in the reference period.
j – the sequence number of the KPI indicator.

Subsequently, to calculate the percentage market share of the KPI indicator in relation to the total EU27, it was used the formula (3.2):

$$\theta_j = \frac{\varepsilon_j}{\sigma_j} \times 100 \qquad (3.2)$$

Table 1. - The Key Performance Indicators list

No.	KPI abbreviation	KPI description	Reference period
1.	AIABS	Artificial Intelligence used for Analyzing Big data from Smart devices or sensors	2020
2.	AIABM	Artificial Intelligence used for Analyzing Big data internally by using Machine learning	2020
3.	AISR	Artificial Intelligence used for Service Robots	2020
4.	AICCSV	Artificial Intelligence used for Chat service with Chatbot or Virtual agent	2020
5.	IoTIS	Internet of Things using Interconnected devices or Systems that can be monitored or remotely controlled via the internet	2020
6.	IoTSTO	Internet of Things using Smart Things (Meters, Lamps, Thermostats) to Optimize energy consumption	2020
7.	IoTSICE	Internet of Things using Sensors or internet-controlled cameras to Improve Customer service and Experience	2020
8.	IoTMSTV	Internet of Things using Maintenance Sensors to Track Vehicles or other products	2020
9.	IoTSMAP	Internet of Things using Sensors to Monitor Automate Production processes and logistics	2020
10.	IoTDS	Internet of Things using other Devices or Systems	2020
11.	IoTITD	Internet of Things using one or more Internet of Things Devices	2020
12.	BERDI	Business Expenditure on Research and Development per Inhabitant	2015-2019
13.	GBARDT	Government Budget Allocations for Research and Development – Total	2015-2019
14.	GDERD	Gross Domestic Expenditure on Research and Development	2015-2019
15.	HPII	High-tech Products Imports – Intra-EU	2015-2018
16.	HPIE	High-tech Products Imports – Extra-EU	2015-2018
17.	HPIG	High-tech Products Imports – Global	2015-2018
18.	HPEI	High-tech Products Exports – Intra-EU	2015-2018
19.	HPEE	High-tech Products Exports – Extra-EU	2015-2018
20.	HPEG	High-tech Products Exports – Global	2015-2018
21.	RDPR	Research and Development Personnel and Researchers	2015-2019
22.	RDR	Research and Development Researchers	2015-2019
23.	GTT	Graduates of Tertiary Education – Total	2015-2019
24,	GTICT	Graduates of Tertiary Education – Information and Communication Technologies	2015-2019
25.	GTEMC	Graduates of Tertiary Education – Engineering, Manufacturing and Construction	2015-2019
26.	GBT	Graduates of Bachelor’s or equivalent level – Total	2015-2019
27.	GBICT	Graduates of Bachelor’s or equivalent level – Information and Communication Technologies	2015-2019
28.	GBEMC	Graduates of Bachelor’s or equivalent level – Engineering, Manufacturing and Construction	2015-2019
29.	GMT	Graduates of Master’s or equivalent level – Total	2015-2019
30.	GMICT	Graduates of Master’s or equivalent level – Information and Communication Technologies	2015-2019
31.	GMEMC	Graduates of Master’s or equivalent level – Engineering, Manufacturing and Construction	2015-2019
32.	GDT	Graduates of Doctoral or equivalent level – Total	2015-2019
33.	GDICT	Graduates of Doctoral or equivalent level – Information and Communication Technologies	2015-2019
34.	GDEMC	Graduates of Doctoral or equivalent level – Engineering, Manufacturing and Construction	2015-2019
35.	PESTT	Persons Employed in Science and Technology – Total	2016-2020
36.	PESTH	Persons Employed in Science and Technology – High-technology sectors	2016-2020
37.	PTEESTT	Persons with Tertiary Education and Employed in Science and Technology – Total	2016-2020
38.	PTEESTH	Persons with Tertiary Education and Employed in Science and Technology – High-technology sectors	2016-2020
39.	SET	Scientists and Engineers – Total	2016-2020
40.	SEH	Scientists and Engineers – High-technology sectors	2016-2020
41.	EICTT	Employed Information and Communication Technologies specialists – Total	2016-2020

for any j=1,2,3, …41 KPIs.
where:
θ – the percentage market share of the KPI indicator in relation to the total EU27.
ε – the arithmetic means of the gross unit value of the KPI, for the reference period set.
σ – the total value of the KPI indicator calculated at the level of the EU27.
j – the sequence number of the KPI indicator

To calculate the percentage variation of the KPI against its theoretical potential, it was used the formula (3.3):

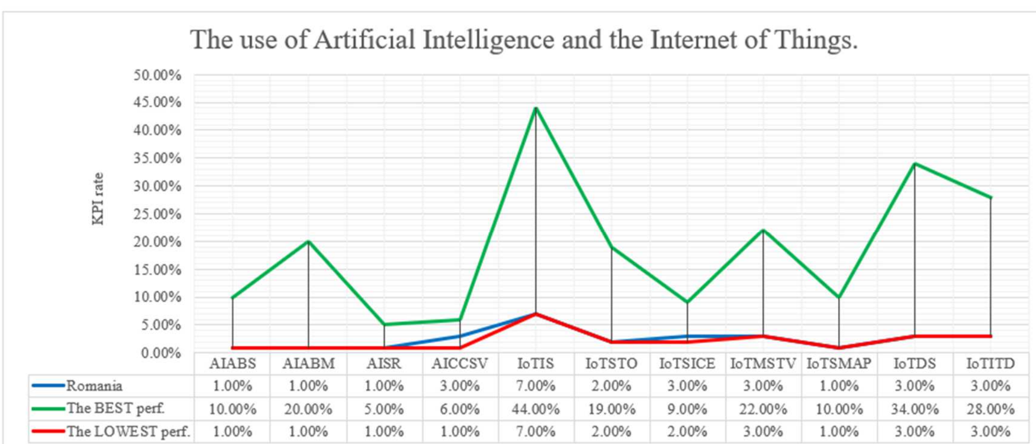
$$\omega_j=(\theta_j-\beta_j)/\beta_j \times 100 \quad (3.3)$$

for any j=1,2,3, … 41 KPIs.
where:
ω – the percentage variation of the KPI against its theoretical potential obtained by reference to the country's Gross Domestic Product (GDP) share or Population Share in the EU27.
θ – the percentage market share of the KPI indicator in relation to the total EU27.
β – the country's GDP share or Population Share, in the EU27 total.

4. RESULTS

4.1. **Artificial Intelligence and the Internet of Things.**

The first area of interest analyzed contains a selection of 11 KPIs represented in Figure 2 that were utilized to determine the percentage of companies in each country using Artificial Intelligence and the Internet of Things, considering the total number of companies with over 10 employees, but excluding from the analysis the companies in the financial sector.
First, the following indicators AIABS, AIABM, AISR, and AICCSV (see table 1) have been analyzed to determine the percentage of companies using Artificial Intelligence for analyzing big data or chat services.
Subsequently, indicators IoTIS, IoTSTO, IoTSICE, IoTMSTV, IoTSMAP, IoTDS, and IoTITD have been analyzed, determining the percentage of companies using the Internet of Things for a wider variety of operations, such as system interconnection, remote control of devices, process monitoring etc.
Considering the topic that this study focuses on, the analysis is mainly concerned with the results obtained by Romania in this area of interest, namely where the country is positioned compared to the best performer and the worst performer in the EU27.



	AIABS	AIABM	AISR	AICCSV	IoTIS	IoTSTO	IoTSICE	IoTMSTV	IoTSMAP	IoTDS	IoTITD
Romania	1.00%	1.00%	1.00%	3.00%	7.00%	2.00%	3.00%	3.00%	1.00%	3.00%	3.00%
The BEST perf.	10.00%	20.00%	5.00%	6.00%	44.00%	19.00%	9.00%	22.00%	10.00%	34.00%	28.00%
The LOWEST perf.	1.00%	1.00%	1.00%	1.00%	7.00%	2.00%	2.00%	3.00%	1.00%	3.00%	3.00%

Fig. 2. The use of Artificial Intelligence and the Internet of Things

It can be seen in Figure 2 that Romania is in the low-performance area for all KPIs analyzed, with percentages ranging from 1 % to 7 % of companies using Artificial Intelligence or the Internet of Things.

4.2. **R&D Expenditure and High-Tech Product Trading.**

Many of the technologies specific to Industry 4.0 are in the development stage, which entails an intense and sustained R&D activity. For R&D processes to lead to the development of useful solutions for the new industrial revolution, firm support is needed in terms of allocation of the necessary resources.

To analyze each country's contribution to R&D expenditure at the EU27 level, Figure 3 shows a graph related to Business Expenditure on Research and Development per Inhabitant (BERDI), calculated as the arithmetic mean for the period 2015-2019 (see the blue columns).

To better estimate the theoretical potential for BERDI, it must be taken into consideration the level of economic development of each country, represented by the Gross Domestic Product (GDP) at market prices per inhabitant. According to the EUROSTAT database, in the period 2015-2019, only 1,42% of GDP per inhabitant was allocated, on average at EU27 level, for Business Expenditure on Research and Development.

Thus, calculating 1.42% from the value of GDP per inhabitant, results a theoretical potential of BERDI per inhabitant (see the orange line).

Analyzing the graph from figure 3, it is easy to note that developed countries such as Sweden, Denmark, Austria, or Germany allocate much more than their potential given by economic development, while countries such as Cyprus, Bulgaria, Latvia, or Romania allocate below this potential.

For the following indicators, GBARDT and GDERD, the reference period was chosen as the last five years with data available in the EUROSTAT database, i.e., the period 2015-2019, while for the indicators HPII, HPIE, HPIG, HPEI, HPEE, and HPEG, 2015-2018 was chosen as the reference period, as there is no available information for 2019.

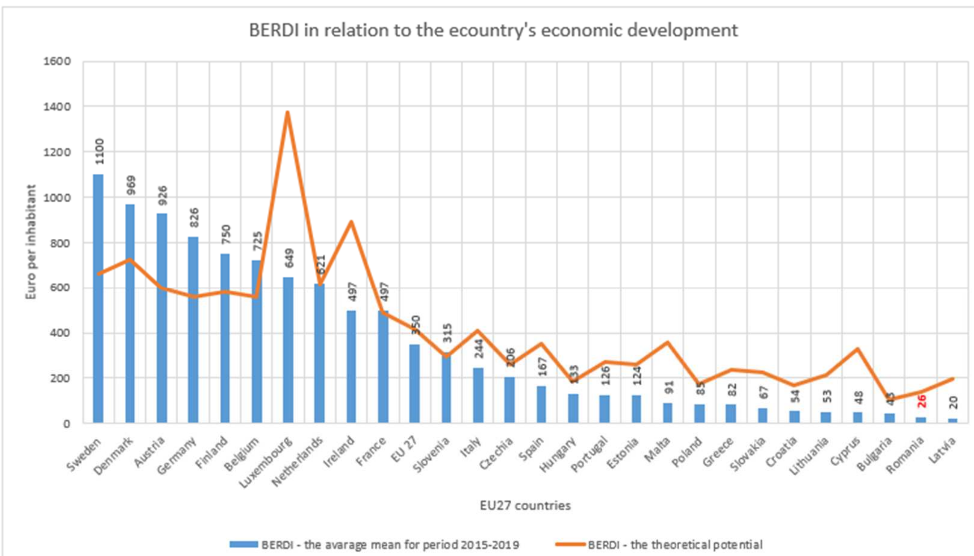


Fig. 3. The Business Expenditure on Research and Development per Inhabitant (BERDI) for EU27 in relation to the country's economic development

Using the formulas (3.1), (3.2) and (3.3) it was possible to calculate the percentage variation of the eight KPIs against their theoretical potential, resulting in the graph shown in Figure 4. For better relevance, the calculation of the percentage variation was related to the relevant country's GDP share in the total EU27.

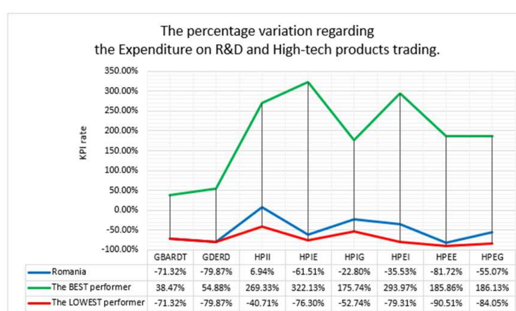


Fig. 4. The percentage variation regarding the Expenditure on R&D and High-tech products trading

The graph from figure 4 shows the results obtained by Romania in this area of interest, and where the country is positioned in relation to the best performer and the worst performer in the EU27. Even if the results show that Romania is rather in the area of poor performance, generally well below its theoretical potential for development, for the indicator High-Tech Products Imports - Intra-EU (HIPEE), a slight overrun of its theoretical potential for development is observed, in relation to the GDP share within the EU27.

4.3. Research and Development Personnel

A key component in the development of the R&D sector is represented by the specialized personnel available in each country, involved in this area of activity. To analyze this aspect, indicators RDPR and RDR were used, considering the period 2015 - 2019, as there is no available information for 2020 in the EUROSTAT database. Thus, using the formulas (3.1), (3.2) and (3.3), for the two indicators shown in Figure 5, the percentage variation against their theoretical potential was calculated. For better relevance, the calculation of the percentage variation was related to the relevant country's Population share in the total EU27.
Analyzing the graph from figure 5, it can be noted that Romania is positioned as the lowest performer in the EU27, with 72.78 % below its potential for development if it refers to RDPR and 78.39 % for RDR, respectively.

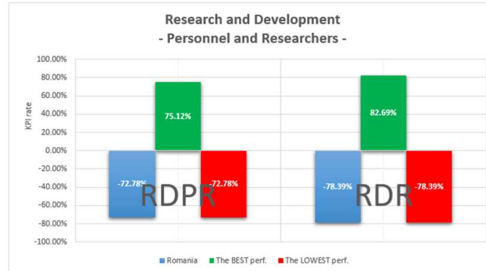
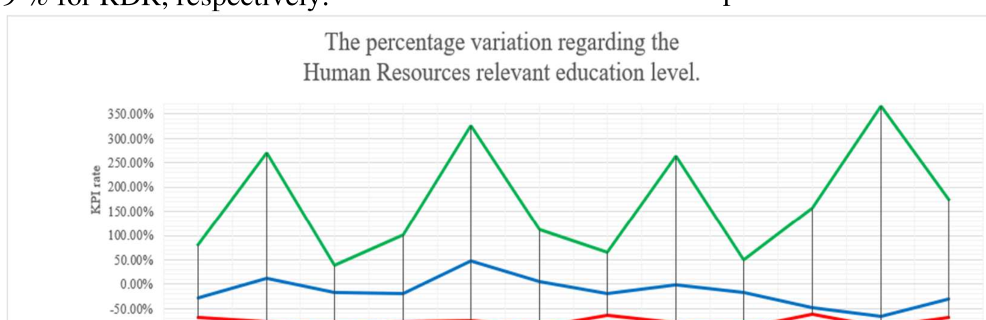


Fig. 5. The percentage variation regarding the Research and Development personnel

4.4. Human Resources education level

Development prospects of Industry 4.0 at the country level are also largely related to the level of general education of the population. A high level of education among the inhabitants represents an important pool that specialists can be drawn from in order to fill the future positions of Operators 4.0, and who can accelerate the research work for the development of the new technologies so necessary for Industry 4.0.
To analyze the level of education, the period 2015-2019 was taken as the reference, as there is no available information for 2020 in the EUROSTAT database. Using the formulas (3.1), (3.2), and (3.3), for the 12 indicators shown in Figure 6, the percentage variation of the indicators, against their theoretical potential, was calculated. As in the previous subchapter, for better relevance, the calculation of the percentage variation was related to the relevant country's Population share in the total EU27, with data being processed as the arithmetic mean of the reference period.



	GTT	GTICT	GTEMC	GBT	GBICT	GBEMC	GMT	GMICT	GMEMC	GDT	GDICT	GDEMC
Romania	-27.36%	11.78%	-17.51%	-18.00%	48.75%	5.15%	-19.58%	-0.22%	-16.69%	-47.46%	-65.81%	-29.75%
The BEST perf.	80.96%	271.31%	39.15%	100.38%	326.13%	113.34%	66.52%	263.39%	49.69%	157.01%	365.65%	174.12%
The LOWEST perf.	-68.40%	-76.44%	-85.64%	-76.68%	-74.09%	-88.63%	-63.24%	-78.74%	-91.03%	-62.10%	-87.83%	-67.38%

Fig. 6. The percentage variation regarding the Human Resources relevant education level

From the analysis of the results presented in figure 6 it can be concluded that Romania is positioned rather in the middle area, between the best performer and the lowest performer, with results above the theoretical potential for the indicators GTICT, GBICT, and GBEMC, but also below the theoretical potential for the indicators GTT, GTEMC, GBT, GMT, GMICT, GMEMC, GDT, GDICT, and GDEMC.

4.5. Human Resources involved in the Science and Technology sector

The last area of importance analyzed refers to the personnel involved in the Science and Technology sector. In order to analyze the 7 KPIs related to this area, the period 2016-2020 was taken as reference. Next, using the formulas (3.1), (3.2), and (3.3), the percentage variation of the seven KPIs were calculated against their theoretical potential, resulting in the graph shown in Figure 7. The calculation of the percentage variation is also related to the relevant country's Population share in the total EU27.

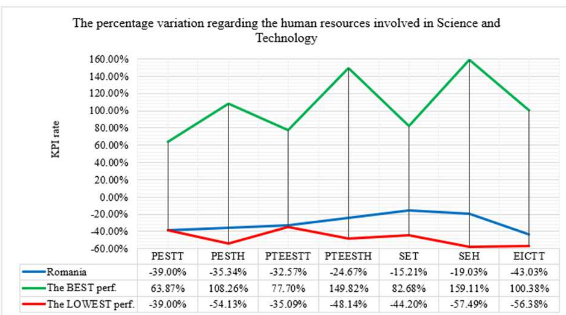


Fig. 7. The percentage variation regarding the human resources involved in Science and Technology

As it results from the graph from figure 7, Romania records results below the theoretical potential for all the KPIs analyzed, being rather in the area of the lowest performer.

5. DISCUSSIONS

Starting with 2020, for two of the very important attributes of Industry 4.0, Artificial Intelligence and the Internet of Things, EUROSTAT has begun monitoring, as a standard statistic, the progress made by each individual country. Of the 11 KPIs used in this study for the analysis conducted in Chapter 4.1, four refer to Artificial Intelligence and seven to the Internet of Things. As can be seen from Figure 2, Romania is in the position of the lowest performer from EU27 for the 9 of the 11 KPIs analyzed, with percentages ranging from only 1 % to 7 % of companies using Artificial Intelligence or the Internet of Things. This indicates that the Romanian industry is still in general, in the early stages of the transition to Industry 4.0.

This situation is also encountered in the cement industry worldwide. In a study published by Boston Consulting Group in 2018, is mentioned that only a few companies in the cement global industry have really started a path of transformation towards Industry 4.0. [22]

On the other hand, the current approach provides organizations with the opportunity to continue to use existing technologies and infrastructure to develop Industry 4.0 [18]. As Romania has a good tradition in industry, including in the cement industry, even considering poor results on the 11 indicators shown in figure 2, there is a significant potential for growth given the positive evolution of the GDP over the last years that will provide financial resources for infrastructure development and modernization, and access to the financial development programs provided by the European Union for digitization.

It can be seen from the data shown in Figure 3 that the difference between GDP per inhabitant and Business Expenditure on Research and Development per Inhabitant (BERDI) is significantly higher in Romania compared to the EU27 average, but this is mainly since Romania still holds a penultimate position in terms of economic development.

The R&D sector is also one of the key areas for Industry 4.0, and its funding is essential for a successful transition process. However, Romania holds the last position in the EU27 for the indicators GBARDT and GDERD. This aspect, in conjunction with the fact that the only indicator in the graph shown in Figure 4, that is found in a positive area is High-Tech Products Imports - Intra-EU (HIPEE), indicates that Romania relies very little on its own R&D resources and prefers rather to import the High-Tech Products it needs.

A report regarding the competitiveness provided by the European Commission showed that Romania has one of the most cost-competitive cement industries, bringing an important economic benefit to the local community [23] Nevertheless, with such a reduced level of government expenditure on R&D, the local cement industry must have limited expectations in terms of support provided by the Romanian government to develop and implement new smart technologies.

The lack of interest in the R&D sector can also be seen from the analysis of the indicators RDPR and RDR, where Romania is also in the last position at the level of EU27.

On the other hand, as Industry 4.0 takes shape, human operators are experiencing increased complexity in their daily tasks, is required to be extremely flexible, and demonstrate adaptability in a highly dynamic work environment [24] From a practical perspective, industrial organizations in the real world may benefit from the digital transformation of the way workplaces are organized through individualization of workstations, online monitoring, or reduced need for physical presence at work [25] Neglecting the human factor in a complex and advanced system such as Industry 4.0 cannot be the way of the future because it has a great impact on the organization's performance and the system's ability to operate safely [26]

It’s a reality that EU27 facing a serious demographic problem, and consequently with the lack of skilled labor available. A solution to solve the issue of demographic decline in industrialized countries, and the increasingly older age of human operators can be found in the fourth industrial revolution [27]

On the other hand, the current way of producing cement is characterized by complex production processes that require a large number of employees who are now so difficult to find in a decreasing labor market like in Romania. That is why Industry 4.0 can be also a solution to this problem of staff shortages, as smart cement factories will need fewer but more qualified employees.

A study published in 2021 in the journal Technology in Society by L.M. Kipper et al. identified a need for continuous development of the relationship between innovation, management, and workforce development for Industry 4.0, which involves, however, the creation of real learning environments, as new skills and abilities relying more on creativity are needed to the detriment of those generated by the performance of repetitive tasks. Since the current learning environment in the industry relies rather on a system based on the correct performance of repetitive tasks, the need to improve education through close collaboration between industrial companies and educational institutions, to reform the training programs of professionals become a clear target [6,28] In their paper, Angelopoulou A. et al. have studied the impact of human error on Industry 4.0, indicating that human operators will continue to make decisions, with the support of cyber-physical systems and not vice versa [26]

The uncertainty determined by the behavior of the human factor and, consequently, of the correct performance of work tasks in the new reality of Industry 4.0, are significant challenges for the safety and quality of processes [29]

It can be said that Industry 4.0 is coming with a radical change in relation to the current situation, by redefining the role the worker in a smart factory has within the operational processes. Thus, by minimizing or even eliminating the tasks considered routine, the focus will be on more creative tasks, such as finding innovative solutions developing new product features. However, this raises another issue that concerns the high level of education required for the future workforce.

In certain circumstances, adjustments to organizational policy and changes in the managerial approach will even be necessary to coordinate the various industrial units with the help of digitized systems, which will further emphasize the importance of the aspects related to the performance of the human operator [30] The new generation of employees, Operators 4.0, is characterized by intelligent and qualified employees who perform the work task with the support of smart equipment and advanced systems, using augmented and virtual reality technologies [31]

It is clear now that the fourth industrial revolution will affect the workforce on various levels, and cement factories need to accelerate their invest in training programs to prepare the workforce for Industry 4.0.

Making human resources more flexible in the allocation of work tasks to different employees in the context of the need to streamline manufacturing processes, is an important step for all industrial organizations [32]

In terms of the level of education, workers in Romania are positioned in the median area in relation to the EU27 countries, with results above the theoretical potential for the indicators GTICT, GBICT, and GBEMC, as it results from Figure 6. This shows the existence of an important pool that future Operators 4.0 or specialists in the industry 4.0 factories can be drawn from and trained. However, the prospects are not as promising if it refers to the pool of potential candidates for the R&D sector, which is also supported by the poor results obtained for the indicators GDT, GDICT, and GDEMC.

There are authors who consider that for a sustainable transition to industry 4.0, industrial organizations should provide in parallel training programs for their existing workforce and adapt technologies so that operators can successfully face new challenges [4]

Considering all these challenges, in order to boost on the medium-term (up to 5 years) the sustainable transition from classic industrial cement production to Industry 4.0, in the case of Romania, the following recommendations should be considered:

- Accelerating the efforts to modernize existing cement production technology to facilitate the transition to Industry 4.0 by accessing available funding programs.
- Intensifying the investment efforts in internal R&D programs, given the poor development of this sector in Romania.
- Organizing training programs to prepare the workforce for transition to Industry 4.0 in close collaboration with the local educational institutions.

6. CONCLUSIONS

The transition to Industry 4.0 is an evolving process whereby current experience and technologies should be adapted to future needs, with the help of innovative solutions that allow organizations to increase their competitiveness considering the need to use existing resources more efficiently, solve socio-economic problems and protect the environment.

The current study showed that Romania is not in a favorable position in terms of the allocation of the necessary financial resources for R&D compared to EU27 countries, having the lowest performance on indicators such as GBARDT or GDERD. The main impediment in this regard seems to be the low level of GDP per inhabitant, which places the country on the penultimate place in Europe, but the underdevelopment of the R&D sector is also negatively influenced by other issues, such as the small number of researchers in relation to the population or outdated research infrastructure.

With such a reduced level of Romanian high decisional factors implication on R&D, the local cement industry must have limited expectations in terms of support provided by the local authorities to develop and implement new smart technologies.

With two of the very important attributes of Industry 4.0 with major importance for R&D, Artificial Intelligence, and the Internet of Things, send Romania in the area of low performance, with only 1% - 7% of companies using these leading-edge technologies. This does not affect the Romanian cement industry since the transition process to Industry 4.0 is still slow. However, the pressure on environmental issues will certainly accelerate all transformation processes in this industry.

The implementation of 4.0 technologies in industrial organizations entails new types of interactions between human factors and equipment. These interactions require a transformation process of the current education and training system of the workforce, with the study showing that Romania is at an average level compared to the EU27, but still below its real potential.

In fact, it can be concluded that the human factor is the most important strength for Romania in terms of the transition to Industry 4.0, as the efficient interaction between operators and the various 4.0 technologies is an important process in smart factories. However, without a plan for training in the relevant field, for the development of the necessary skills and abilities, this competitive advantage Romania has can easily be lost.

Since this study had a limited purpose, the main directions of further research may focus on:

• analyzing the progress made by cement industry organizations in Romania regarding the transformation process towards Industry 4.0.

• analyzing the possible opportunities in terms of educational programs to shape the workforce for future smart cement factories.

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INDUSTRIA 4.0 ÎN ROMÂNIA - O ANALIZĂ PRACTICĂ A POTENȚIALULUI ȚĂRII DIN PERSPECTIVA ECONOMICĂ ȘI A RESURSELOR UMANE PENTRU A SPRIJINI O DEZVOLTARE DURABILĂ A FABRICILOR INTELIGENTE DE CIMENT

Rezumat: Accentul real pe dezvoltarea durabilă bazată pe o economie circulară, s-a mutat într-o nouă eră economică, Revoluția Industrială 4.0. Deși în ultimul deceniu, unele dintre țările UE27 au făcut pași importanți către această nouă transformare industrială, mai sunt încă multe aspecte de clarificat cu privire la modul în care România este pregătită pentru aceste schimbări. Astfel, această lucrare a analizat situația țării noastre din punct de vedere al resurselor economice și umane, în perspectivă pentru Industria 4.0 și modul în care aceasta poate susține o dezvoltare durabilă a fabricilor inteligente locale de ciment. În acest scop, 41 Indicatorii cheie de performanță (KPI), grupați pe cinci domenii de interes, au fost utilizați pentru a analiza informațiile disponibile în bazele de date EUROSTAT. Rezultatele au arătat că România trebuie să își adapteze în continuare strategia de tranziție la Industria 4.0 pentru a rămâne competitivă pe piața industrială europeană, inclusiv pe cea a cimentului, având în vedere necesitatea utilizării mai eficiente a resurselor existente, soluționării problemelor socio-economice și protejării mediului.

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