

# **INDUSTRY 4.0 AS AN OPPORTUNITY TO ACHIEVE ENVIRONMENTAL SUSTAINABILITY: THE DIFFERENCE BETWEEN SMEs AND LARGE COMPANIES**

Mohamed El Merroun

Department of Supply chain management. University of Sopron, Hungary

## **ABSTRACT**

*The decline of environmental sustainability is undoubtedly one of the biggest problems if not the most severe one that threatens our planet. In the last decade, to overcome this global issue, industries were regulated, events and conferences were organized, objectives have been made, but the high cost of green practices, the fierce competition among firms, and the massive increase rate of production made all these efforts insufficient, in the other hand, the fourth industrial revolution could potentially provide suitable solutions to achieve high environmental sustainability. The present research contributes to the environmental sustainability literature by studying the vision that companies in Europe have on Industry 4.0 and the main objectives that they want to achieve from this transformation. Furthermore, relying on a statistical study, the research identifies the differences between large companies and SMEs in Europe when it comes to the incorporation of environmental sustainability objectives within their Industry 4.0 strategies*

## **KEYWORDS**

*Key words: Environmental sustainability – Industry 4.0 – Large companies – SMEs – technological facilities*

## **1. INTRODUCTION**

After the term Industry 4.0 was launched back in 2011 at the Hanover Fair, it created a wave of opportunities, risks and challenges, the hype that was created was not a surprise since the German government and later on other government encouraged the investment in the Industry 4.0 tools and highlighted their advantages. Industry 4.0 is the time frame that represent nowadays era of the technological development that we are living in, it can be define as a set of technological tools in data management that uses the exchange of information and automation in the context of smart factories and production through the use of several technological facilities, Internet of things is often considered as the main pillar of I4.0 but it also includes; cloud service, Big Data, and its analytic tools, and artificial intelligence (AI) to minimize production errors and over-consumption (Pham et al., 2019). As the name entails, the concept remarking the new era of industrial production, the roots of Industry 4.0 are driven from the time when the manufacturing process was depend totally on human and animal physical force, the transition from this situation into machinery, new chemical factories and iron manufacturing processes, development of waterpower, maximizing the use of steam power, and finally the development of machine tools is considered as the first industrial revolution. The iron and textile sectors presented crucial roles in the first industrial revolution as well (Mohajan, 2019). The second revolution was shaped due to the invention of many new technologies, such as the internal combustion engines, electricity, the chemical industries, alloys, petroleum, and other electrical communication and chemicals

technologies (the telegraph, radio, and telephone), and running water with indoor plumbing.(Gordon, n.d). Followed by the third revolution which is best seen as the combination of digital manufacturing and personal manufacturing: the industrialization of the Maker Movement, the concept "third industrial revolution" refers to a comprehensive upheaval, which was already referred to by other authors as an "efficiency revolution ", "green capitalism" and a fundamental transformation towards "green industrial revolution"(McKinsey 2011). The most important question that could be raised here is why even if the third industrial revolution was a promising movement to help the organizations to adopt green practices and reduce the fingerprints on the environment; the results seem to be the exact opposite? In the last couple of decades, industrial activities have harmed the environment like never before, according to Donovan Alexander in 2020, human activities are the main cause of hundreds of extinctions in the last two centuries, versus the millions of years that natural extinction occurred. As we progress through the 21st century, human activities have changed the world in unprecedented ways. Even with all the efforts that the world organizations are making, from spreading awareness to strict regulations, it seems always not enough, that can be justified by the fact that companies are not willing to risk their competitiveness within the market, respecting the environment and adapting green practices requires in most of the cases a whole transformation of the firm's strategy that might include a change from the traditional energy resources to renewable and environmentally friendly energy, the use of recyclable raw materials, building a reverse logistics chain... These strict requirements might potentially lead to undesirable results, the pressure that firms are facing from world health and sustainability organizations as well as society is pushing them to react and respect the restrictions but sometimes these reactions are not what everyone is hoping for, we can summon different examples in this context of firms that decided to commit fraud and use tricks in order to satisfy the stakeholders; in 2000 in the United States, the Environmental Protection Agency (EPA) launched stricter standards than the restrictions that were applied at that time, including for NOx and PM, which were applied gradually in automobiles and were fully applied at the beginning of 2007. In 2008, Volkswagen invented a new technology that it claimed would achieve high fuel economy and performance while complying with the strict new emission standards, a technology, especially from an engineering point of view, seemed to require "magical thinking," (Dune Lawrence et al. 2015). Volkswagen decided to surpass its dilemma by applying elaborate fraud.

Another case in the same context that happened with H&M, In April 2019, the company launched its environmentally friendly collection, with a claim that all the pieces in this new collection is made from recyclable and sustainable materials, such as 100% organic cotton, recycled polyester or Tencel. However, in Norway, the consumer authority criticized H&M for its deceptive claims about the collection while there a huge difference between the various garments within the products (Regarding the percentage of sustainable fibbers used as an example). The consumer authority stated that the firm provides insufficient data regarding sustainable nature of its sustainable style product that may cause costumers to buy an H&M product that they would otherwise not bought, and thus earning the company more profit. The oldest car manufacturer was not excluded from these chains of frauds as well, a federation of the German consumers under the name VZBV, accused the giant multinational automotive corporation Daimler of tricking its level of emissions by the use of thermal-switching devices, which stopped the emission cleaning device when the ambient temperature was too hot or too cold. VZBV explained in a statement that by deploying such devices, the giant manufacturer can ensure that vehicles meet the permissible limit values for exhaust gases during type approval. In regular road traffic, they clearly surpass these limits.

These examples illustrate clearly that applying strict regulations without finding suitable solutions and alternatives will not solve the problem. In this context, industry 4.0 can play a major role to balance the cost/reward of the engagement in environmental sustainability if it is

presented in the “right way”. Transforming the traditional factories into a smart production chain and business processes and deploying smarter devices and machines may present numerous advantages such as manufacturing productivity, resource efficiency, and waste reduction (Tortorella and Fettermann, 2018). On the other hand, the development of smart factories and automation will potentially results a high increase rate of production that would be associated with a high level of energy consumption and resource as well as elevated gas emission and pollution (Beier et al., 2017; Liu and Bae, 2018). What can be concluded is that Industry 4.0 is a powerful tool that might support organizations to meet global environmental restrictions without missing the internal financial objectives, to achieve that, several papers and studies have to be made to highlight the potentials of industry 4.0 in this context. Therefore, this article provides quantitative research to examine the current perspectives and aspirations of companies In Europe that they expect from Industry 4.0, also the paper examines the correlation between the size of companies and the expected outcome of the investment in Industry 4.0.

## 2. LITERATURE REVIEW

The literature review is “an important chapter in a research, where its main purpose is to provide the background to and justification for the research undertaken”(Norin Arshed, n.d.). Following this definition, the background of this article is the scientific findings that focus on the implementation of supply chain 4.0 or Industry 4.0 in a sustainability context. Since the main concept “Industry 4.0” is still young in the research science field, most of the articles presented herein are dated between 2017 to 2021. The platforms used to conduct this literature review are Google scholar, ScienceDirect, and research gate. The keywords used are “sustainability” “waste management” “green supply chain” sustainable supply chain” “reverse logistics” “curricular economy” combined with “industry 4.0” or “supply chain 4.0”.

A paper was published by (Julian, et al. 2018) in which they conducted quantitative research in form of a questionnaire that was sent to small and medium enterprises in China and Germany, the sample contains 329 SMEs, 222 from German companies and 107 from Chinese companies. The aim of the paper is to highlight the potentials of Industry 4.0 in a sustainability context including all the three elements of sustainability: Economy, ecology, and society for SMEs. The results showed a few interests regarding Industry 4.0 for these companies, the two main reasons for that are the shortage of expertise and financial limitations, similarly, a study was made in the same geographical location by (Beier et al., 2017), the main difference in this study is that they targeted medium and large enterprises, the results showed a high interest in implementing the Industry 4.0 especially for the Chinese firms with a majority of 91%, for the German firms it was a little bit less, 66% with a sample of 69 companies. (Yadav et al., 2020) presented a set of sustainable supply chain challenges and 22 solutions that can be possible with the implementation of industry 4.0, to make the solutions more credible, the authors tested them in a case of an automotive firm located in India. The most severe challenges that the sustainable supply chain is facing are managerial and organizational challenges, followed by economic challenges, supplier challenges, process challenges, etc. The most important solutions that were identified to develop the supply chain sustainability are the adoption of 6R’s within the firm and environmental product design and life cycle analysis are the top rank solutions that can overcome the SSCM challenges effectively. Another case study was published by (Pham et al., 2019), which presented how Industry 4.0 can contribute to achieving the CE, according to (Geissdoerfer et al., 2017), both CE and sustainability are overlapping and mutually supporting concepts. The result of this study shows that Industry 4.0 could boost the sharing economy within a CE framework. However, it should start from the customer’s needs. (Oláh et al., 2020) studied different scenarios where industry 4.0 can have a positive impact on environmental sustainability and other scenarios where it might present a disadvantage. (Nagy et al., 2018) studied the impact of Industry 4.0 and Internet if things on companies in Hungary by using Porter’s (1985) value chain model, the

results have shown that the sharing of real-time data across companies, given the availability of appropriate analytical tools and methods, can have an important impact on the entire firm. In the case of CPPS, Big Data Technologies and CPS (Cyber-Physical System) firms using them have been evaluated as having a higher level of logistic operations, more efficient when dealing with their partners, improved cooperation between certain logistic departments, and higher competitiveness and market and financial performance. The main challenge that holds back companies from investing in the industry 4.0 according to the same article is the unknown level of cost. (Martínez-Olvera & Mora-Vargas, 2019) explore the value creation process within Industry4.0, with special emphasis on its relationship with the sustainability issue and mass customization. The main outcome of the article is that the sustainability issues come from the fact that creating a business model with a sustainable value proposition is possible when properly addressing the use of high levels of technology. Relying on GRAI methodology, (Dossou, 2018) presents concepts and methods for improving metallurgic SME performance following the figure below.

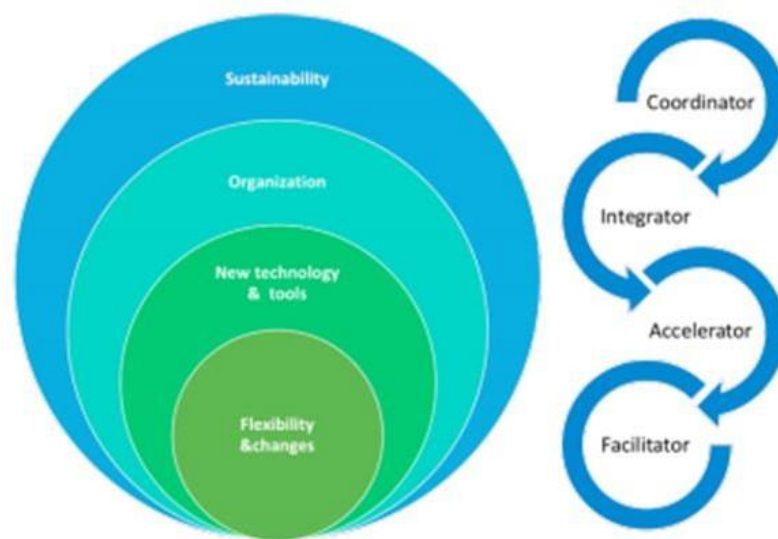


Figure 1 : GRAI methodology

Source: Impact of Sustainability on the supply chain 4.0 performance; Paul-Eric Dossou, 2018.

## 2.1. The Engagement of European Countries in Industry 4.0

The concept of Industry 4.0 was first introduced by Germany to keep its competitiveness within the international market, after a while, countries all over the world started to launch programs that aim to develop the industry 4.0 in their countries, China started an initiative under the name "Made in China 2025" to boost the development of the Chinese economy in the long run. In the USA, the concept is known as the industrial internet of things and is considered a leading country in this context mainly because they treat the industry 4.0 as a revolution and not only as a progressive evolution such as most of their competitors, according to Markets and Markets report, the total Internet of Things (IoT) in the manufacturing industries was worth \$10.45 billion and is expected to reach \$45.3 billion by 2022. That compound annual growth rate (CAGR) of 29%, it expected to be dominated by North America.

In this paragraph, a set of European countries will be examined in the context of Industry 4.0, the aim is to study how these countries approach Industry 4.0 and what is their vision and objectives that they expect to achieve.

The first country that we will start with is Germany since it is the first country that introduced Industry 4.0 officially and is also considered as a leader in the EU. According to Sara Zaske in her article "Germany's vision for Industry 4.0: The revolution will be digitized", Industry 4.0 is the German vision for the future of production and manufacturing, one where smart factories use communications and information technologies to digitize their operations, processes and reap huge advantages in the form of lower costs, improved quality, and increased efficiency. Furthermore, the national hero and leader of Germany Angela Merkel said: "We must - and I say this as the German chancellor in the face of a strong German economy - deal quickly with the fusion of the online world and the world of industrial production. In Germany, we call it Industry 4.0," she said. "Because otherwise, those who are the leaders in the digital domain will take the lead in industrial manufacturing. We enter this race with great confidence. But it's a race we have not yet won." It is obvious that Germany is considering Industry 4.0 a key to success in the near future as they consider it as a "race", their vision is optimistic as they see industry 4.0 as an effective tool to improve all the aspect of organizations. For France, In April 2020, an article was published by Maxime KRUMMENACKE, provided important data that illustrate the great attention given to industry 4.0 by the French governments, as it was publicly announced that Industrial organizations have invested about €25 billion per year in research and development from 2016 to 2020, which is estimated for two-thirds of the total R&D expenses engaged by French companies. The motivation behind this push towards innovation is the automotive industry, with 13% of the total. The transition towards automation and information technology inserted into the production lines is at the heart of the Industry 4.0. Back in 2018, the French government have decided that it would be one of the axes to enhance the French industrial competitiveness, and thus drafted a roadmap for this development. In the UK, according to RBR Staff in 2018, Industry 4.0 in the U.K. is in the process of making a revolution, with wide-scale implications for industries, consumers, and workers. On the supply side, many industries are already seeing the introduction of technologies such as robotics and the Industrial Internet of Things that are disrupting longstanding industry value chains. According to the same report, the Industry 4.0 Revolution is reportedly set to invest £455 billion (\$604 billion U.S.) into the British production sector. Even if these numbers look promising, according to Steve Brambley, deputy director of Gambica, Germany's manufacturing industry is about three times larger than ours (UK), but they invested approximately seven times more in automation and digitalization than British industry. This statement shows the lack of interest in the Industry 4.0 from the UK side, but the awareness of the importance of these technologies is constantly evolving. In the Netherlands, according to an article published by InvestInHolland, with the Industry 4.0 Implementation Agenda, the Dutch are going beyond traditional production processes. Pilot Plants in the Netherlands are a test ground for new technologies and R&D. Organizations and knowledge institutions use Pilot Plants to develop new manufacturing and test technological innovations before introducing them officially to the market.

The second part of this literature review can clearly show the engagement and consciousness level of the importance of Industry 4.0 in Europe, in the other hand, in the first part, we saw different scientific researches that study the effectiveness of the industry to achieve sustainability, for both SMEs and large enterprises, others presented challenges and solutions to achieve CE, (Oláh et al., 2020) presented different scenarios where the industry 4.0 has a positive impact on the environment. In the light of these scientific contributions, none of these researches have examined the correlation between the size of the company and the outcomes that they hope to achieve from this investment. Filling this gap is vital for both decisions makers and researchers to have a clearer vision of the current situation of industry 4.0 in the European markets in an environmental sustainability context. Furthermore, it is also crucial for governments and rulers to have an idea about the underlying reasons of companies to invest in industry 4.0 to make the proper adjustment to include environmental sustainability as one of the main objectives of Industry 4.0.

### **3. METHODOLOGY**

The study aims to assess the differences between SMEs and large enterprises regarding the underlying reasons when investing in industry 4.0 in Europe. The main objective is to find if there are more tendencies to invest in industry 4.0 to achieve environmental sustainability depending on the size of companies. The Hypothesis is that large companies tend to care more about the environmental aspect and thus they will include that in their strategy when investing in industry 4.0. The process of data collection, analysis, and interpretation can be explained in the following steps:

#### **Step 1: Questionnaire Preparation**

At the beginning of the questionnaire, the participants were asked if they are users of industry 4.0, the next question is always according to the previous answer, for example, if they answer NO, the next question is, do you think of investing in industry 4.0 in the future? if the answer is still No, the survey ends, if it is yes, then they will be asked about the challenges and the reasons why they want to invest in it ( the part that we are interested in). to study the objectives that they would achieve from this investment, the underlying reasons questions were operationalized using 6-point Likert scales, from 0 (not interested in this objective) to 5 (one of the main reasons of the investment).

The participants were not asked personal questions or questions about their company, since all the relevant information are available in the database that will be explained in detail in the next step, the only mandatory question is to provide their email to correspond it with the related person in the database. The link to the questionnaire can be found at the end of the article.

#### **Step 2: Emails & Raw Data Collection**

The data collection process was made with the help of freelancers through the website Fiverr, the method used to collect the emails and the requested information is called lead generation, in which the data is collected from LinkedIn or the official website of the companies. The criteria that have been followed for the collection of emails are that the Location of the companies should be UK – Germany – France, and Netherlands. These countries have been chosen for the fact that they are considered leaders in Europe and first investors in industry 4.0. The Email owner should occupy one of the following positions: Production manager – Plant manager – Supply chain manager – Logistics manager – IT agent – CEO (only for SMEs). The data contained the following information: The company name – Location – Industry – Name of the email owner – Position – Email – LinkedIn – Employees number. The sheet contained more than 1000 emails.

#### **Step 3: Mails Sending**

Since there is a huge amount of data, the mails sending was automated relying on a website called Integromat, in which you can enter an algorithm (scenario) that will be executed by the website. The variables that were changing in each mail are the name of the contact and his position. The mails were sent between the 1<sup>st</sup> and 25 of July 2021.

#### **Step 4: Data Collection and Analysis**

The data were collected via Google form in which we received 206 answers with a response rate of 18%, which can be seen as low, but taking into consideration that none of the participants were

contacted prior to the survey, the response rate is acceptable. The data analysis and interpretation were made through SPSS.

## 4. RESULTS

### 4.1. Overview

From the 206 answers, 117 considered as large companies 57% and 89 are SMEs 43%. The responders' positions are 47% Supply chain managers, 16% IT managers, 12% Logistics managers, 11% CEO, 10% plant managers and 4% others. For the company's location: 38% Netherlands, 29% Germany, 14% UK and 19% France.

The results show a high interest in investing in the industry 4.0 for large companies compared to SMEs as the pie charts below show larger.

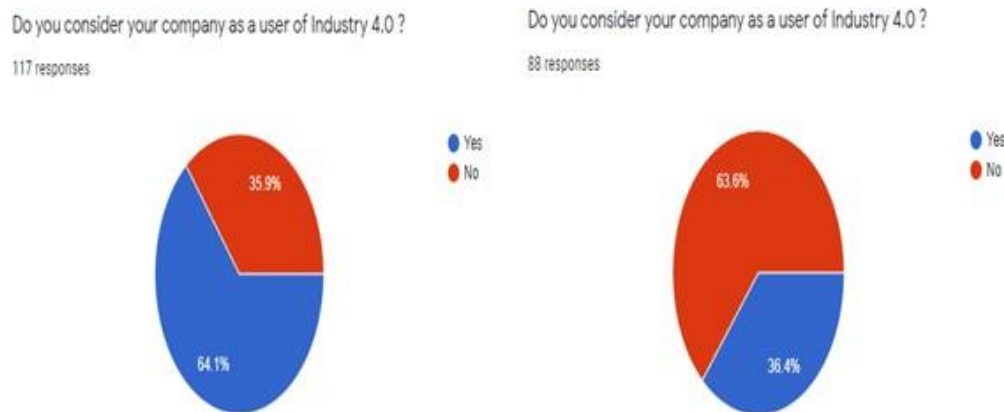


Figure 2 : Industry 4.0 Users

Furthermore, the companies with the answer NO were asked if they have plans to invest in the I4.0 in the future, and again the large companies showed a higher interest than SMEs.

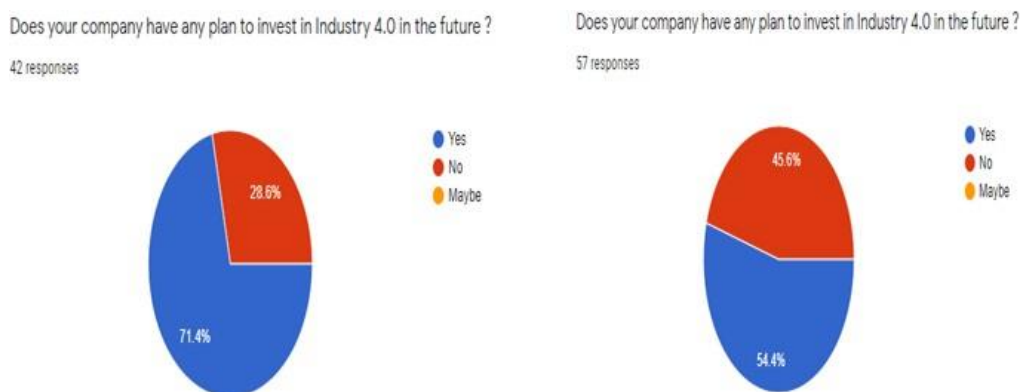


Figure 3 : Future Plans

Out of 7 challenges that were proposed in the questionnaire, the main challenges that perturb SMEs from investing in industry 4.0 are lack of expertise, low return on investment and lack of financial resources.

## 4.2. Analysis And Interpretation

What are the main challenges/reasons that discourage your company to invest in Industry 4.0

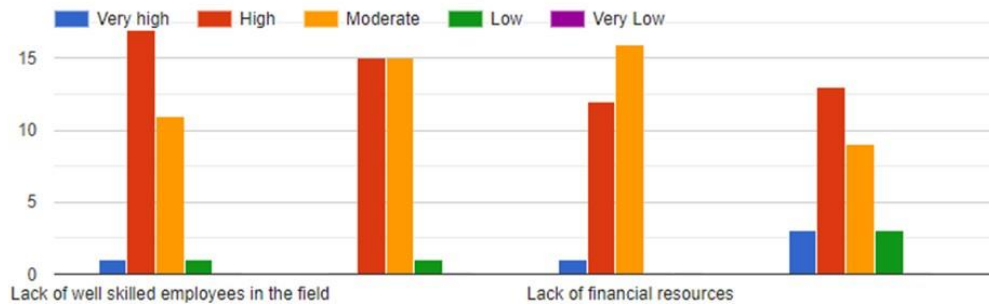


Figure 4 : Challenges of Investing in Industry 4.0

In our research, we are studying the differences between SMEs and large companies when it comes to the objectives of investment in the Industry 4.0. If the responsible of a company answer with yes to the question “Do you consider your company as a user of Industry 4.0?” “Or the question “Does your company have any plan to invest in Industry 4.0 in the future?” (If the answer of the first question is no), then the participant will get a set of choices that represent the potential reasons to invest in the I4.0, the participant should rate each answer from 0 to 5. The list contains 13 choices, only 5 answers are related to environmental sustainability, these answers were distributed randomly with the other choices, for example: Improve reverse logistics (reproduction of used goods, return of packaging ...). Then the mean of the 5 questions was calculated to get one ordinal variable (dependent variable) that we will base our study on.

According to Bruce Weaver and Karl L. Wuensch, correlation won’t answer the researcher’s question when they want to examine the differences between two groups in a given situation, in our case, we want to examine if the size of the company affects the underlying purposes to invest in the industry 4.0. The mean comparison is the most suitable method in this situation; we have chosen the T test to analyze our results.

Table 1 : Group Statistics

Group Statistics					
	Size	N	Mean	Std. Deviation	Std. Error Mean
Sustainability	SMEs	63	2,4032	,60614	,07637
	Large companies	82	3,3232	,87819	,09698

We can see that the valid answers for SMEs are 63 and 82 for large companies, these are the companies that consider themselves as users of Industry 4.0 or they are planning to invest in it in the future. We can already notice that the “mean” of the large companies is larger than the SMEs with 0.92 which is significant, and there is a high difference in the standard deviation, which means that the variations of our two groups might be different. Let’s look at our T test:



Table 2 : T Test

		Levene's Test for Equality of Variances		Test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Sustainability	Equal variances assumed	11,380	,001	-7,112	143	,000	-.92000	,12935	-1,17569	-.66430
	Equal variances not assumed			-7,453	141,512	,000	-.92000	,12344	-1,16402	-.67597

First, we must verify our null hypothesis which is the variances of the two groups are approximately equal, we can verify that with Leven's test equality of variances, we set our level of significance to 0.05. As we can see in the table, the significance level is lower than 0.05, which means that we will reject the null hypothesis and assume that the variances are not equal. Relying on these results, the second line of the table "Equal variance not assumed" will be taken into consideration.

According to our tables, we can see that there is a significant difference ( $t(141.512) = -7.453, p \leq 0.05$ ) in the score with the mean score for large companies ( $M = 3.3232 / SD = 0.87819$ ) was higher than SMEs ( $M = 2.4032 / SD = 0.60614$ ).

The magnitude of the difference in the means (Mean difference = 0.92, 95% CI: -1.16402 to -0.67597) was significant. Hence, we can accept our hypothesis that the large companies include environmental sustainability goals within their strategy when it comes to investing in Industry 4.0.

## 5. CONCLUSION

Our study reveals several results regarding the investment in Industry 4.0 in Europe, the first thing is that, unlike the theory and the advertisements, companies are still facing multiple challenges to include new technologies in their strategy, especially for SMEs with a rate of 36%. Furthermore, most of the SMEs who are investing or interested to invest in Industry 4.0 have no interest to achieve any environmental sustainability, the main questions that could be raised; are this technological revolution will create a bigger gap between the large companies and SMEs? Can the SMEs keep up with the new EU regulations regarding their fingerprints toward the environment?

The European objective of becoming the greenest and most clean continent is running against the development of small companies, according to Louise Scott and Alan McGill, Acting responsibly is no longer a choice. It is a business imperative that will influence how firms power their processes, introduce new products to the market, source raw materials and tools, and protect their supply chain against global warming and natural disasters. The companies' decisions will affect the well-being of their employees and impact whether they want to work in this firm. Furthermore, their approach on how they run and build the business will be judged by a new generation of consumers who expect sustainable and ethical behavior. What the results are showing is that big companies understood that the future regulations will no longer tolerate

behaviors that harm the environment, as the COP26 will be held in November 2021 and the rejoin of the United States to the agreement, several regulations and limitations are expected to take place. The European countries are launching constantly several programs to boost the investment in the I4.0 since it's considered as the tool to keep the competition in the future but all these programs seem not enough to motivate SMEs to invest in Industry 4.0, which can also be noticed that the objectives promoted by the leaders of these programs are mainly economical goals. This research opens the opportunity to create several studies, the most important one is how can we include the SMEs in the industry 4.0 program and how can we boost their operations to be greener and respect the international regulations.

## 6. RESEARCH LIMITATIONS

Due to the complexity of the research subject and the lack of studies in this area, the paper describes phenomena through quantitative research, but there were no solutions proposed to overcome the gap between the SMEs and large companies both in the investment in the I4.0 and the awareness of the importance of the environmental sustainability, for this reason, further studies have to be made in this area. Furthermore, for a research with this magnitude, taking into consideration that the study included five European countries, the sample should be larger, despite that, the results could be considered credible since the level of significance between the two variables (SMEs and large companies) is high, which means that even if the sample is larger, most probably the results will be the same. Furthermore, the participants were contacted through email to complete the questionnaire; there was no prior contact via phone call or video meeting to explain the purpose of the questionnaire more, that is mainly because of the large database (more than 1000 contact) that would make a prior contact almost impossible.

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