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Description of the State of Sustainability in Industry 4.0: Practices of High-Tech Plants in Ciudad Juarez

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Abstract: Industry 4.0 (I4.0) is largely focused on the digitization of industrial processes, with the potential to procure a sustainable focus to manufacturing processes, which might transform the current production models. In Ciudad Juárez, the manufacturing industry concentrates 41% of the GDP of the state of Chihuahua; this GDP is an indicator that does not consider the damage that industrial manufacturing exerts on natural resources and the environment. It is important to establish the degree of integration of sustainable practices in I4.0. A diagnostic was made through a measurement system that allows self-evaluation in terms of the sustainability integrated into the I4.0 processes based on indicators of the environmental, economic, social, and technological dimensions of sustainability. A questionnaire is responded by a sample of 105 professionals working in related areas in the manufacturing sector of Ciudad Juárez. The results indicate that the electronics-communications industry, although to a limited extent, is the most advanced in the transition to sustainable industry 4.0, in general, large companies are showing an incipient transition towards this integration. Likewise, it is reported that 43.2% of the manufacturing sector does not carry out sustainable practices in their processes, 43.2% carry out some practices manually, 12.6% carry them out semi-automated and only 0.3% have begun to integrate the I4.0 tools in their sustainable practices.

Keywords: Sustainability, Dimensions of Sustainable Development, Sustainable Self-Assessment, Industry 4.0

1. Introduction

The production of goods and services, as well as their consumption, have been two of the driving forces in climate change on the planet; in the loss of natural ecosystems and their biodiversity; the alteration of biogeochemical cycles, the degradation of the ozone layer and the acidification of the oceans (IPCC, 2014; Steffen et al., 2015).

This shows a need for awareness about the seriousness of the degradation of the environment, which has been observed since the middle of the 1900s, by which in 1972 the Stockholm Earth Summit was held, also known as the United Nations Conference on the Human Environment, where the term sustainable development was mentioned for the first time (United Nations, 1972), such as the ability to meet the needs of present generations without compromising the ability of future generations to meet their own needs (UN, 1987).

In the context of the manufacturing sector, according to the International Institute for Sustainable Development -IISD for its acronym in English- (IISD, 1992), sustainable development is the adoption of business strategies and activities that meet the needs of the company and its stakeholders - customers, shareholders, suppliers, creditors, employees, customers and the environment - in the present, while maintaining, improving and protecting the natural and human resources that will be required in the future.

Hence the need for a change in terms of production and consumption (Porter & Kramer, 2018), particularly now that a transition is being experienced in the industry, which is moving towards what is known as Industry 4.0 (I4.0) (Jabbour et al., 2018). This new form of industry raises industrial automation systems that offer innovative functions through their networks and their access to the cyber world, which significantly changes the way of doing things. That is, it projects a transformation of industrial processes towards digitization (del Val Román, 2016).

I4.0 offers benefits such as boosting productivity, income growth, and competitiveness; however, it has failed to solve the ecological problems faced by production processes (Bonilla et al., 2018). But, if we consider their capabilities, it is possible to integrate a sustainable manufacturing process into the I4.0 technologies, based on indicators of industrial activities that have a significant effect on the environment (Jabbour et al., 2018; Argüelles and Torres-Argüelles, 2019).

In the case of the industrial activities of Ciudad Juárez, it is reported that the manufacturing industry is widely developed in this border city, concentrating 41% of the state GDP (Government-Chihuahua, 2017), counting until 2018 with 2,651 active manufacturing companies, which represents 29.15% of the state of Chihuahua (INEGI, 2018), in which the most technologically developed are adopting I4.0 practices. For this reason, it is important to describe the state of sustainability in the I4.0 of high-tech plants in Ciudad Juárez.

2. Methodology

To describe the state of the high-tech plants in Ciudad Juárez in terms of sustainability and I4.0, a diagnosis was made by applying a measurement system -called "toolbox for self-assessment of sustainability in Industry 4.0" (Argüelles and Torres-Argüelles, 2019)- which allows manufacturing companies to evaluate themselves in the two aspects mentioned. Said measurement system is made up of indicators in the environmental, economic, social and technological dimensions of sustainability measured at four levels of I4.0; where level 1 represents at all times the lack of activity of the parameter being measured; level 2 indicates that the activity of the parameter being measured is performed manually; level 3 represents at all times that the activity of the parameter being measured is carried out using sensors and / or electronic tools / devices that obtain the data, to subsequently perform the analysis of the same manually and, finally, the level 4 always indicates that the activity of the parameter being measured is carried out using sensors and / or electronic tools / devices that provide information, which is uploaded directly to the cloud for automatic analysis.

It was applied to a sample of 105 professionals from the manufacturing sector of different sectors: aerospace, automotive, construction, electronics and communications, computer equipment and office accessories, transport equipment, medical equipment, pharmaceuticals, integrators, electrical machinery, ferrous metals, non-ferrous metals, plastic and rubber, fabricated metal products, suppliers, and chemicals; of different sizes: small, medium and large companies; as well as specific areas of work of these subjects: environmental, finance, production, manufacturing and technology.

Statistical tools are used to analyze the data obtained from the application of the measurement system, and graphs are generated to analyze the situation of the manufacturing industry in Ciudad Juárez in terms of its sustainable practices and its transition to I4.0.

3. Results

Of the subjects involved, 90.48% come from large companies and the remaining 9.52% from micro, small and medium-sized companies -MSMEs- (Table 1).

Table 1. Size of the companies in relation to the sample.

MSMEs	9.52%
Large companies	90.48%

Using statistical tools, tests were carried out to analyze the sustainability in the I4.0 of 105 subjects involved in manufacturing companies of the sectors. Analyzes by levels of I4.0 (Figure 1 - Figure 4) and by size (Figure 5 and Figure 6) are presented.

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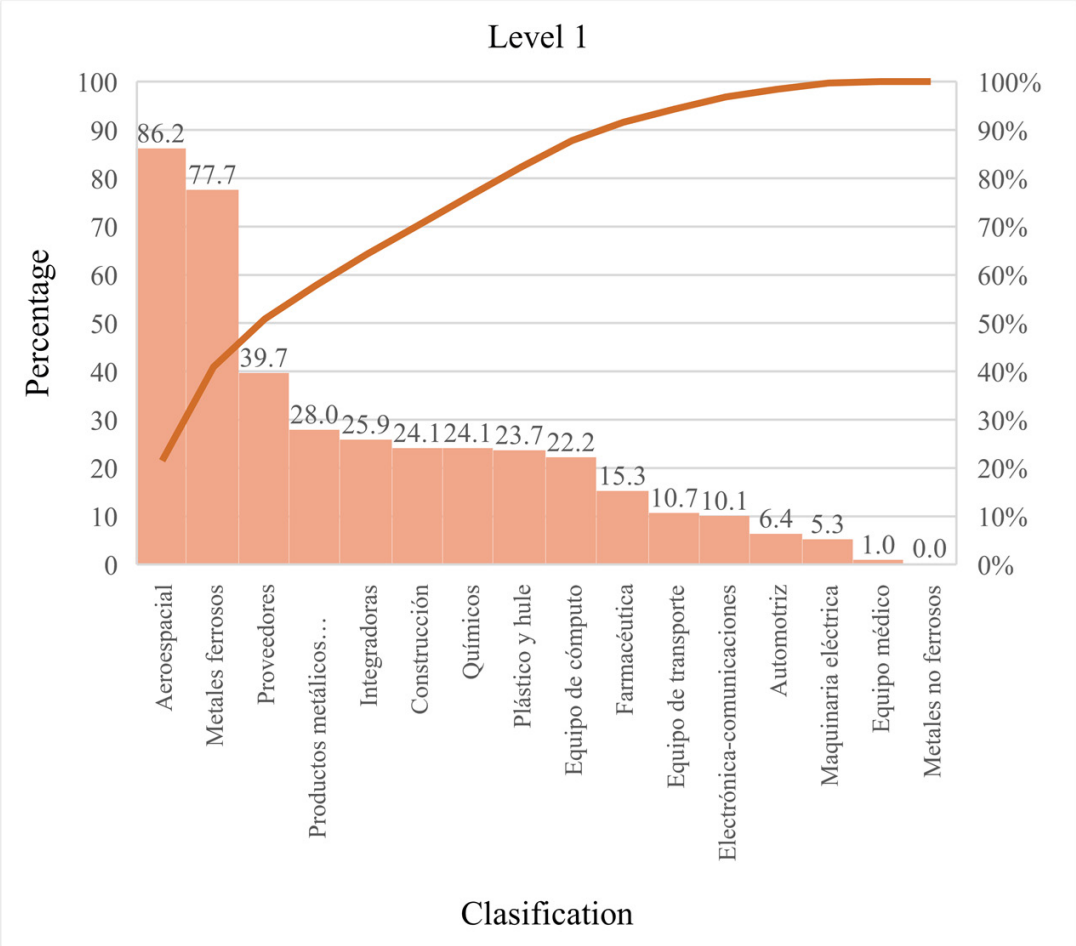

Figure 1. Diagnosis of manufacturing companies by line of business at level 1 of I4.0.

In the Graph of Figure 1, it is possible to observe the percentage of each of the turns that do not comply with the sustainability activities proposed in the applied measurement system. Specifically, the aerospace business does not carry out 86.2% of the proposed sustainable activities. It is important to mention that this line of business is evaluated in a small industry. In turn, the ferrous metal turnover does not comply with 77.7% of sustainable practices.

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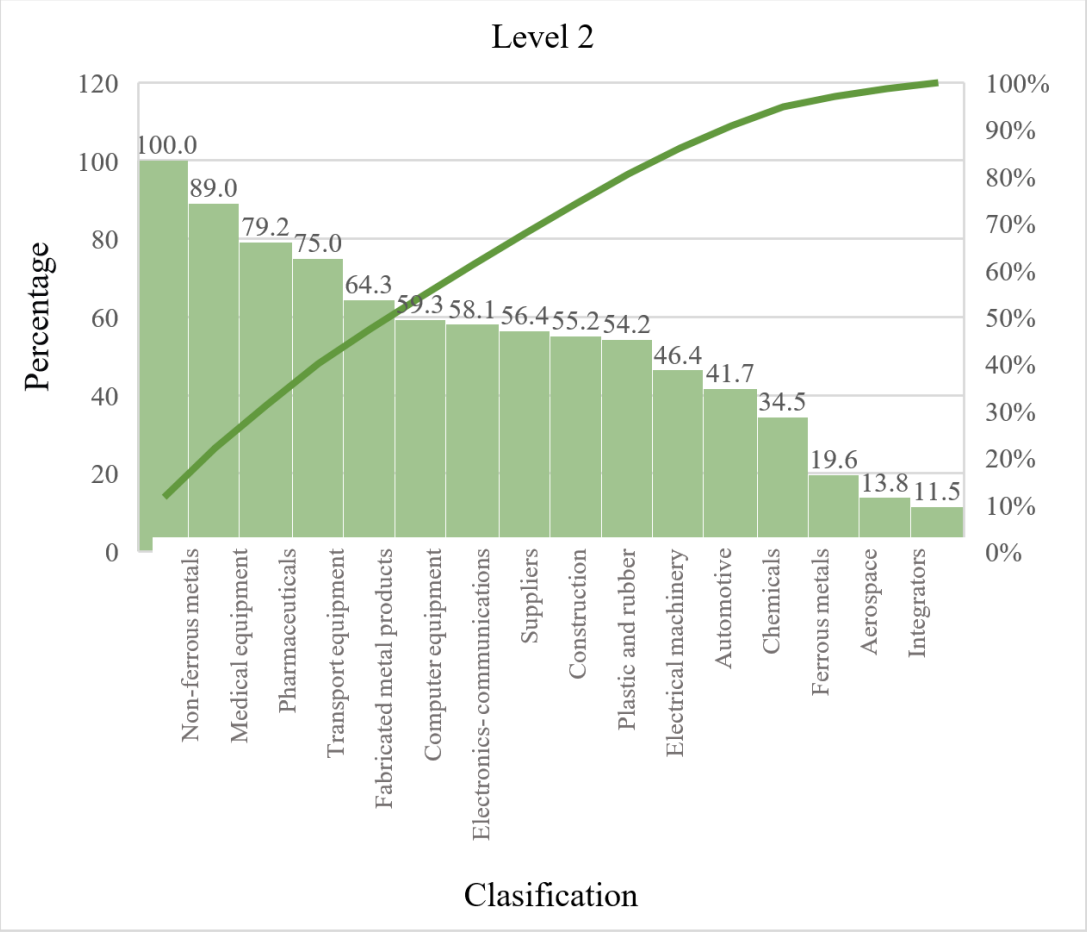

Figure 2. Diagnosis of manufacturing companies by line of business at level 2 of I4.0.

Figure 2 shows the behavior of the turns of the manufacturing sector in the realization of the sustainability parameters proposed manually. In the case of non-ferrous metal turning, it is observed that it complies with 100% of the activities, so it is concluded that all sustainable practices are applied, however, they do not carry out any I4.0 tool.

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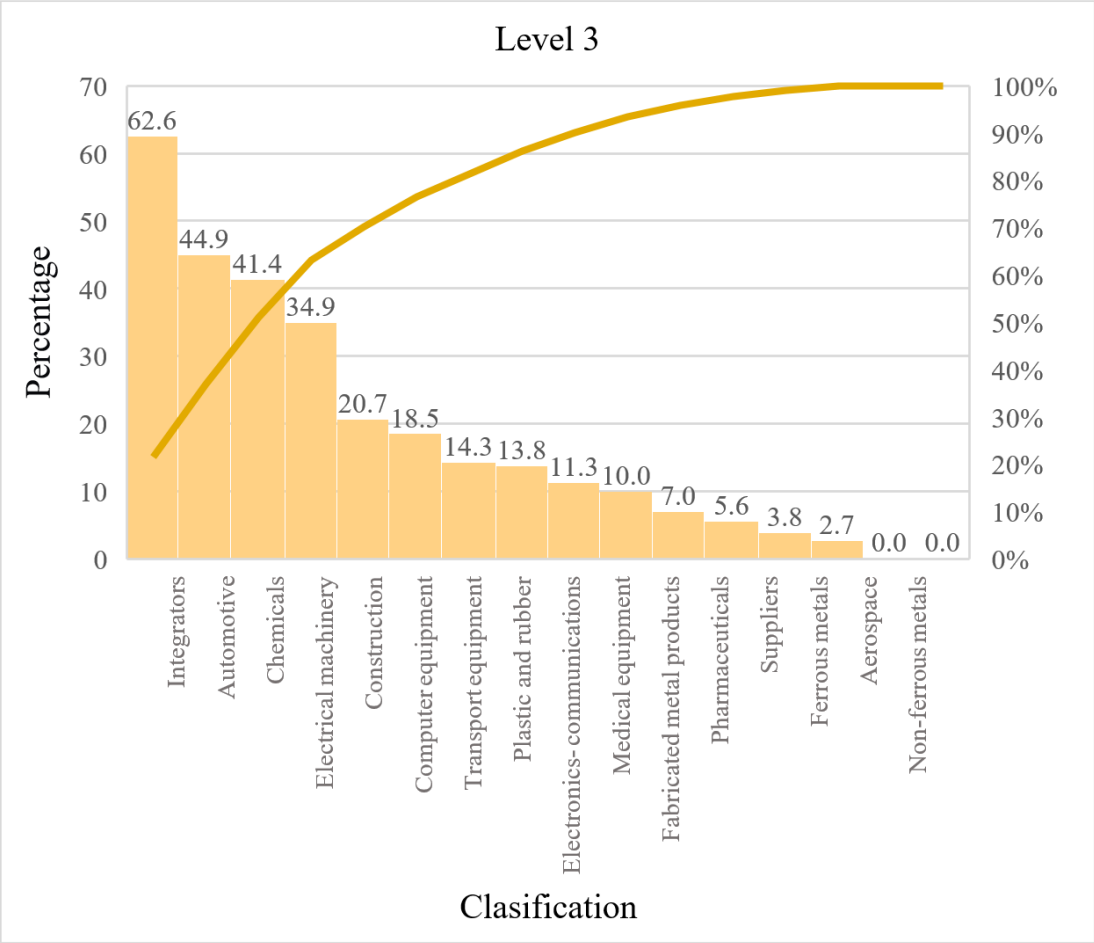

Figure 3. Diagnosis of manufacturing companies by line of business at level 3 of I4.0.

Figure 3 shows the behavior of the different lines of business when they apply sustainability activities, beginning to move towards the digitization of their industrial processes. It is observed that 62.6% of the activities carried out by the integrating companies do so through sensors and / or electronic tools / devices that obtain the data, to subsequently perform the analysis of these manually, following the automotive and chemical companies with 44.9% and 41.4%, respectively.

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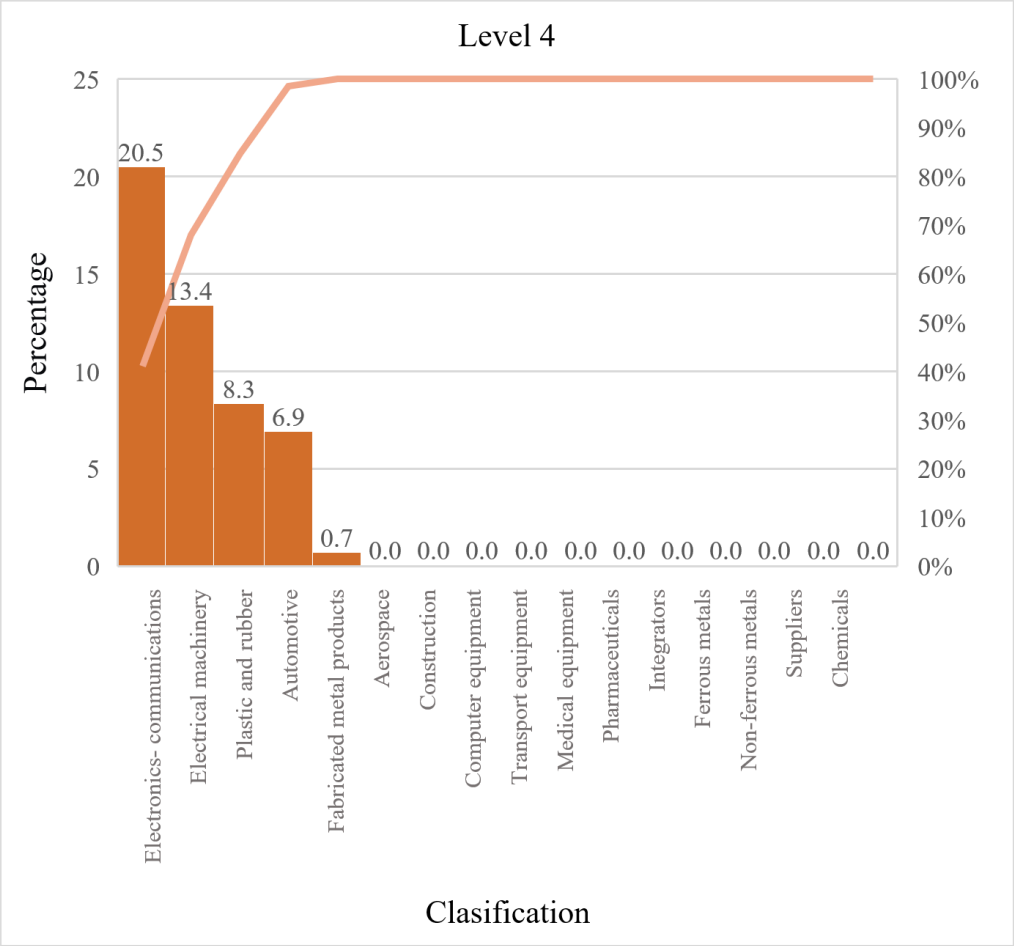

Figure 4. Diagnosis of manufacturing companies by line of business at level 4 of I4.0.

In Figure 4 it is observed that only 5 of the 16 sectors involved in this study already implement some I4.0 technology in their sustainable practices. In the first place, there is the electronics and communications business with 20.5%; secondly, electrical machinery with 13.4%; in third, plastic and rubber with 8.3%; in fourth, automotive with 6.9% and, finally, the turnover of manufactured metal products with 0.7%.

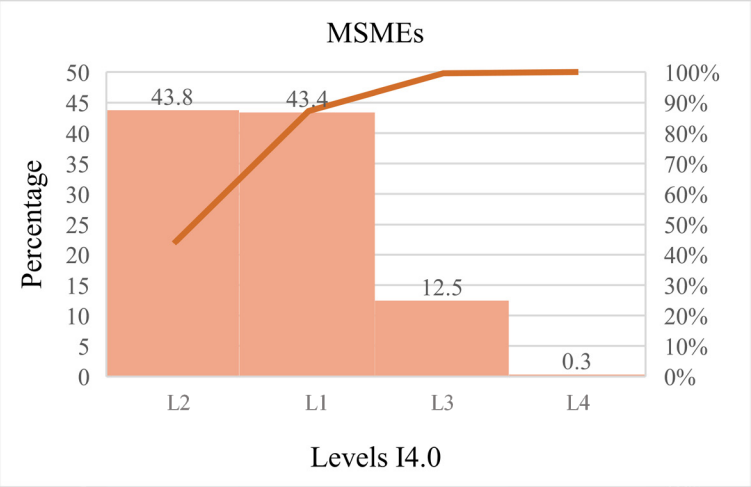

Figure 5. Diagnosis of MSMEs at I4.0 levels.

As can be seen in Figure 5, the MSMEs do not carry out 43.8% of the sustainability activities, 43.4% of the activities that apply they do them manually, 12.5% use some information technology with manual analysis and only 0.3% implement some I4.0 tool.

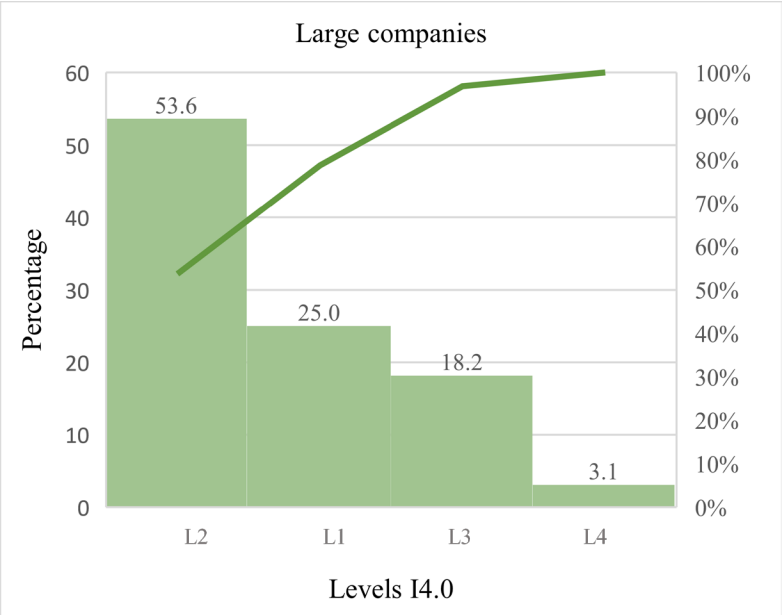

Figure 6. Diagnosis of large companies at I4.0 levels.

In the case of large companies, as can be seen in Figure 6, 75% of sustainable activities are carried out: 53.6% manually, 18.2% semi-automatically and 3.1% with integration of some technology from the industry 4.0. Likewise, it is observed that they do not comply with 25% of the proposed sustainable indicators.

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4. Discussion

It is observed that MSMEs are still in transition to manage sustainable processes and to a greater extent towards I4.0. Likewise, large companies, although to a lesser extent, like MSMEs are in transition towards carrying out sustainable processes; However, although in a small proportion, a path towards the digitization of processes is already beginning to be observed, and in some cases the adoption of sustainable practices. It is considered that, with the digitization of processes, the adoption of sustainable practices will be easier and more viable, since their impacts can be measured instantly and precisely.

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