Feasibility in the implementation of 4.0 technologies in the intralogistic activities of Logistic Operators of the Department of Atlántico, a look towards the organizational efficiency

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Abstract

The intralogistic activities of the logistics operators are defined in the grouping of all the processes linked to the reception, storage and distribution of raw materials and final products. Therefore, the study of intralogistic processes as an activity is part of the value chain of a company and, through its management, the result of the operation and an adequate level of customer service will depend on it. The project proposes to evaluate the feasibility of the use of technologies of the industry 4.0 in the intralogistic activities that allow the integration of processes of automation and control for the continuous improvement of the decision making in the processes of storage, load and unload of the logistic operators of the department of the Atlantic - Colombia for the improvement of the enterprise efficiency.

Therefore, a review of the literature is carried out framed in three categories: intralogistics, Industry and Technology 4.0, and the application of an instrument to measure the absorption of technologies 4.0 in the company under study, which was validated as a result the importance of Simulation, Automation and load sensing, Collaborative Robotics, Big Data powered by M2M (Machine to Machine communication) and Predictive maintenance - predictive analysis and M2M communication as a solution to the needs that are represented in the environment of the Logistics Operators of the Department of Atlántico - Colombia, based on the challenges and projections imposed by the dynamics of the international market and especially the free trade agreements that the New Granada nation has signed and framed in recent years with the intention of making its economy and especially the organizations of its different regions more efficient.

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1. Introduction

In order to evaluate the viability of using industry 4.0 technologies in the intralogistics processes of logistics operators in the Atlantic Department of Colombia, we began with a review of the literature and continued with the implementation of the vertical and horizontal integration analysis tool in the framework of industry 4.0 [1]. Preliminary findings indicate that the topic has been developed immersed in the logistics area and in issues related to the management of inbound logistics, technological management of storage and automation in specific aspects such as bar codes, which have become one of the most important tools for companies when capturing data and having control of their products, so much so that 95 percent of 23 million Colombian companies code their items with this modality, in order to have a unique identification [2]. Therefore, in order to satisfy the demands of the environment and the international markets with which Colombia has free trade agreements among the most important of the Pacific Alliance, it is necessary that the processes in logistics operators adopt new tools that promote the continuous improvement of their business efficiency [5]. However, these day-to-day intralogistics needs will require more complex solutions than the simple use of bar codes and can be developed based on the simulation model proposed for intralogistics activities, covering the processes of storage, loading and unloading of raw materials and finished products of logistics operators. These three procedures account for almost 30% of the logistics costs of organizations in Colombia, which, according to the National Planning Department, represent approximately 15% of a company's sales [3]. According to Gaviria[4], since the year "Colombia is Logistics," logistics costs have increased by 37% in transportation, 20% in storage, 17% in supplier management and administration, 10% in sales order processing, 9% in inventory index and replenishment, and 7% in reverse logistics. This establishes as a need for logistics operators in the department of Atlántico to find a tool that allows them to improve decision making in terms of establishing the best technology for Industry 4.0 to use that can be used to increase business efficiency in organizations.

In addition to the factors and variables coming from the environment and dynamics, the literature invites us to review the advances that have been developed on this relevant subject in order to find an adequate solution to the needs, problems and challenges presented by the intralogistics area of logistics operators. Nevertheless, it is worth noting that for a large part of Latin America, and especially for the Neo-Grenadine nation, it is one of the regions that lags behind in the Logistics Performance Index [5]. Improving these figures requires not only the region's governments but also a combined effort in intralogistics in organizations, academia and government, which through technological tools provided by Industry 4.0 can optimize

productivity and improve business efficiency [6]. However, according to the Logistics Performance Index established by the World Bank, the country is not advancing in logistics; on the contrary, it is dropping from position 10 to 13 in the region between 2016 and 2017[7]. Therefore, it is stated that studies on this subject are in debt and progress in this area is mainly due to the improvement of the supply chain, so the issue is not developed independently, nor is it given the importance it really deserves, as established by Arsam [8] where it defines that "intralogistic activities the most important thing is that, if properly optimized, can greatly improve the service of a company. However, it is one of the essential elements on which the so-called operates, a concept referred to in order to increase the efficiency of an organization through the use of intralogistics and the use of industry 4.0 technologies, see fig.1...those who are taking over the world [9], these so-called 4.0 technologies are not alien to the field of logistics and specifically to intralogistics activities, their incorporation is beginning to develop to the point already evident in the literature outlines of the concept of intralogistics 4.0 where Schuhmaher [10] defines it as "The control of future-oriented intralogistics systems", most of the material flow control systems currently used in industry depend on centralized material flow equipment and, the appearance of new, efficient and increasingly sophisticated information and communication technologies [11]. The prerequisite for intralogistics 4.0 is transparency of data [12]. Intelligent optimization allows, for example, that all transport orders of a logistics operator can be efficiently allocated to drivers and means of transport [13].
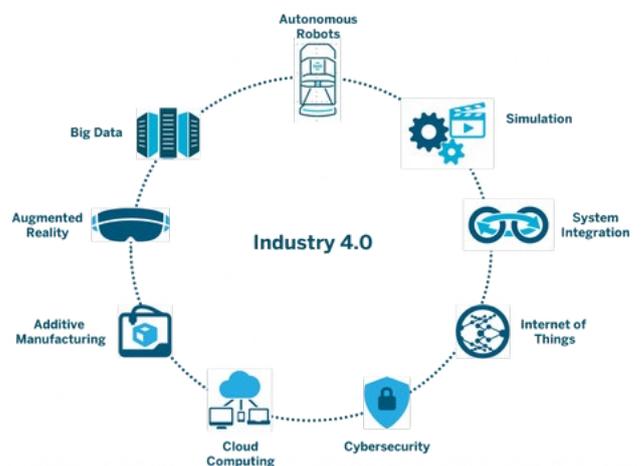

Fig. 1. Technologies and tools of Industry 4.0

The intralogistics framed in the technologies of the industry 4.0, the concept assumed by Maslarić [14] is developed that refines this correlation as the formation of global networks that will include product and storage facilities in the form of Cyberphysical Systems that will communicate independently, will be generated and controlled, that together with the previous concepts allow

a continuous improvement in the decision making for the growth of the business efficiency [15]. Among the authors studied, this is the one that most closely resembles an ideal concept to the solution proposed in this research and complies with some of the characteristics of the solution. However, it does not contemplate the integration of the components of intralogistics according to Bertalanffi's principle, but rather understands them as fragments that are independent of each other and with very minimal or isolated relationships between them.

A special item in the dynamics of the application of the evaluation tool of the vertical and horizontal integration system according to the viability in the implementation of the 4.0 technologies in the logistics operators, is focused on the identification of the factors and variables that will allow the correlation of the concepts developed and analyzed in this article according to the findings of the literature review. Neeraja [16] and Ltifi [17] suggested considering the challenges that must be faced, which is the key to adapt the logistic means and determine its scope. Therefore, logistics and intralogistics should be known as an aspect of great importance in today's organizations [18]. The main objective of this study is to identify opportunities, perspectives and achievements in the application of the various 4.0 tools in intralogistics through critical thinking and the evaluation of scientific resources, in addition to being a review point in future research related to selected categories such as Storage Cargo, Intralogistics and Industry and Technology 4.0. It is important to mention that in the process of reviewing and analyzing the information, no publication was found with a similar analysis with the developed categories. The definitions that correspond to the concepts are the following:

- Kaiser[19], establishes that the value how design (VSD) The approach uses a morphology for the VSD and identifies when alternatives should be taken into account based on the specific requirements of the value chain, impacting processes storage, load and unload the finished product.

- A holistic system of information technologies, people, machines and tools [21], which allows the flow of goods, services and data in a controlled way [22], through the value chain, with operations with a high degree of autonomy[23] and high capacity to transmit useful information to the decision [24]; [25].

The work is done as follows: Section. 2 explains the literature review, Section 3 develops the Case of Studies and Section 4 the methodology used for the analysis of the information, in the Section. 5, establishes the main elements involved in accordance with Discussion and analysis of information, and finally the results in the Section. 6, reveals the findings and highlights areas of opportunity for future research and the conclusions.

2. Technologies or Tools 4.0

Automation in intralogistic processes, beyond being an option, is a requirement for organizations that want to stay on the sidelines in today's competitive environment. Consequently, automation translates into productivity, speed, precision and control of operations [20]. The range of technologies in the 4.0 industry allows personnel to quickly manipulate valuable information with a high level of quality and speed. Normally they work in the following way: in the Workstations, the workflow cannot be stopped by the fluidity of the operations, so implemented technologies take the product and bring it as close as possible, making it an effective tool, with certainty, speed and precision for decision making

The variability in intralogistic processes is divided into three main areas:

(i) Storage systems: This type of tools allows to place the products organized in a warehouse, but to bring them quickly and precisely to the operator when he needs them.

(ii) Order picking systems: These tools help to make the flow of operations within a workstation more productive. It gives the operation a better decision making, enhances the processes.

(iii) Software: The software used must be linked from where the product is ordered, to the points of storage, distribution, cost, sale, and other priority variables. In the process of intralogistic automation and software there is a precise control of algorithms, which allows to provide valuable information

4.0 technologies such as Simulation, Automation and load sensing, Collaborative Robotics, Big Data powered by M2M (Machine to Machine communication), Predictive maintenance - predictive analysis and M2M communication, among others help in making intralogistic automation productive and improve staff productivity, who may specialize in new areas. Schematized in the above, there are many success stories in the world in the application of automation in intralogistic processes within organizations, which provide solutions to the six main challenges of the sector:

(i) Changes in workflows, Reduced time and costs in the preparation of orders

(ii) Increase in the number of active references and management of reverse logistics

(iii) Relevance of brand identity and flexibility

The implementation of this tool within an intralogistic process generates great advantages such as increased order picking accuracy, speed (productivity) and service level compliance, which is reflected in operational cost savings.

A process that includes some degree of automation can improve average productivity by about 20-30 %. Figures from Kardex indicate that a secure automated storage and order management system achieves up to 85% space optimization, a 60% increase in stock and a reduction in the picking error rate to zero.

2.1. Intralogistics

Noachas[35]defines intralogistics as "the activities of the supply chain that are carried out within the company, in particular all those that have to do with the circulation and storage of goods within the company. the improvements or optimizations in these activities have a high impact on the business of the company".

The control of future-oriented intralogistic systems most of the material flow control systems currently used in the industry depend on centralized material flow equipment [10] the emergence of new, effective and increasingly sophisticated information and communications technologies [11]. The prerequisite for intralogistics 4.0 is data transparency [12] Intelligent optimization allows, for example, that all transport orders can be assigned efficiently to drivers and means of transport.

The Private Competitiveness Council (CPC) stated in accordance with the World Bank's Logistic Performance Index, during the 2018-2019 period. In 2018 Colombia obtained the highest qualification in its history in the Logistics Performance Index see *fig. 3*. It advanced 36 positions compared to 2016 (he went from 94 to 58) and today he is fifth in Latin America [36]. However, there are still challenges in: efficiency and effectiveness of customs, quality of infrastructure, and competition and quality of logistics services [37].
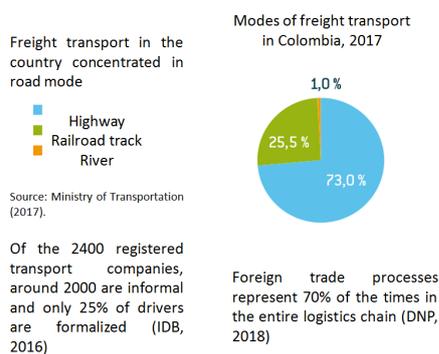
Freight transport in the country concentrated in road mode

- Highway
- Railroad track
- River

Source: Ministry of Transportation (2017).

Of the 2400 registered transport companies, around 2000 are informal and only 25% of drivers are formalized (IDB, 2016)

Modes of freight transport in Colombia, 2017

1,0 %

25,5 %

73,0 %

Foreign trade processes represent 70% of the times in the entire logistics chain (DNP, 2018)

Fig. 3. Logistics Performance Index. Colombia and reference countries, 2018.

Over time, the term has developed beyond its original sector and is now fully accepted in the field of logistics. Intralogistics is the last service link in the supply chain within the organization[38].Intralogistic management systems today are compatible with the cloud, making its way to industry 4.0, facilitating the rapid and efficient response to the analyzed data, regardless of location.[39]. The same applies to predictive maintenance, in which large amounts of data are used to obtain valuable information about plant maintenance. [40].

2.2. Industry and technologies 4.0

Throughout history, several industrial revolutions have been defined that have meant, not only changes in industrial processes, but also social, economic and technological [43].

The fourth industrial revolution that is lived today is being called by many names, this is presented by the slope that has been emerging in accordance with what will be one of the greatest impacts in the change of deeper schemes and paradigms and dynamic[44], taking the name of: Industry 4.0, Connected Industry 4.0, intelligent industry, cyber-industry of the future, Industrial internet of things, among others. As in the previous three revolutions, this new revolution is based on the application of new technologies to organizational processes both at the level of machinery and production and throughout the value chain of the industrial process[45].

Since 2011 it is considered the beginning of a new industrial revolution [26]. This is based on cyber-physical systems, industries and smart products, as well as interconnected cities. The new era consists of the combination of physical and tangible scenarios with information systems [27], to the degree of bringing operations to a level of synergy in real time. Technology based on networks and the Internet is considered [28]and the business world is visualized as an integral system under collaboration criteria. The approach considered in this revolution, are intelligent and autonomous operations, however, the higher level must be evaluated by human reason for decision making and sensitivity criteria [29]. This will involve the development of new applications and platforms that will facilitate in a simpler way the inter-connection of the whole service and protagonists of the supply and transport chain[47].

However, the 4.0 technologies analyzed in this literary review were organized into four subcategories: Simulation, Automation and load sensing, Collaborative robotics, Big Data powered by M2M (Machine to Machine communication) [46] and Predictive maintenance - predictive analysis and M2M communication (machine to machine).

Simulation

The word "simulation" is defined as "the imitation of the operation of a real-world process or system over time." [48].Its applications in the current production system relate the shortages networks in a cyber-physical environment and the coordination it must have for the production schedule [49].

Simulation has been used for many years to develop CAD products and to assist in the engineering of CAM production. The novelty in the Industry 4.0 model lies in the use of real-time simulators of plant operators[50]. From the data captured in real time, the physical world is reflected in a virtual world and the following process is simulated to adjust it and optimize the parameters that condition it [51].

Automation and load sensing

As previously mentioned, automation from the point of view of industry 4.0 will be analyzed as: Advanced factory level sensorization, Multistage and flexible manufacturing and Smart Manufacturing (cyber-physical systems (CPS)). The concept of advanced sensorization[52]It refers to the technologies that, through the use of different sensors, allow to analyze and obtain data from different machines, operators or objects, non-invasively.

Collaborative Robotics

One way to visualize and strengthen industrial production is denoted in the processes that involve collaborative robotics, thus reducing errors in simple activities[53].

To achieve the efficiency of this flow, it is necessary to establish relationships in the generation of collaborative robotics actions with information management systems[54].

Big Data powered by M2M (Machine to Machine communication)

The generation of data happens in all the productive processes[55], there are also proposals for autonomous organization and coordination, through an analysis in which the data is managed and filtered to generate useful information, this allows the optimization of the production processes , quality and service[56].

Predictive maintenance - predictive analysis and M2M communication.

Lughofer[57] defines predictive maintenance defines early integration of anomalies or fault detection, diagnosis and reasoning, prediction of remaining useful life (prognosis of failures), prediction of quality and self-reaction, as well as optimization, control and auto repair techniques.

Table 1. Relationship between categories and sub-categories

Categories	Relationship
Intralogistics (A)	*Carvajal*, [1]^{CD} *Cibergenius*, [2]^{CD} *DNP*, [3]^{BD} *Muñ...* .
Industry 4.0 (C)	*construcción*, [36]^{CD} *Investigación*, [37]^{AD} *Mendiet...* *Schuh*, [39]^{AD} *CPC*, [40]^{AB} *CPC*, [41]^{AD} *BID*, [42]^{BD} *U. R.*, [42]^{AB} *Gómez*, [43]^{AD} *López*, [44]^{AD} *Serrano*, [45]^{BD} *Josefine*, [45]^{AD} *Junco*, [46] ^{BD}
Technologies 4.0 (D)	*Cortés*, [47]^{BD} *K*, [48]^{AD} *A B.*, [49]^{BD} *Wolter*, [50]^{AB} *Dombrowski*, [51]^{BD} *Moreno*, [52]^{AC} *Ivanov*, [53]^{AB} *Guilera*, [54]^{AB} *Garell*, [55]^{AC} *Bagheri*, [56]^{CA} *Schut...*

Source: Own elaboration

2.3. Case studies that have successfully implemented 4.0 technologies

Automation in intralogistic processes, beyond being an option, is a requirement for organizations that want to stay on the sidelines in today's competitive environment. Automation therefore means productivity, speed, accuracy and control of operations [30]. The range of technologies of the industry 4.0 allows, in a fast way, that the personnel can manipulate valuable information with high level of quality and speed.

Intralogistics automation case: Capris - Costa Rica

Capris implements in 2018 Kardex Remstar automatic storage and order picking systems, with the aim of storing more than 7,000 units in the same area [31]. As a result, I achieve a positive impact on three major areas of interest: Precision in inventory, Time reduction and Optimization of resources.

Case of intralogistic automation: Arenal - Spain

In the case of automation in Arenal, it is part of a solution to three problems: The need to optimize its order preparation processes [32]. Maintain and increase the availability of the offer in its stores Daily replenishment of all its stores.

Intralogistics automation case: Qclass - Chile

For the case of automation in QClass is framed in giving solution to three critical problems: Expanding to more than 70 stores in Chile, Large amount of SKUs in fixed shelves per store and the need to reduce the size of the stores by high price of properties [33].

Case of intralogistic automation: Kaeser–Colombia

In the case of automation for Kaeser - Colombia is part of providing solutions to the needs of: Increase productivity using automation and technology. Optimize delivery and reception times of materials. Rationalize and optimize storage spaces [34].

3. Case Studies

The success of intralogistic optimization lies not only in space management, but part of the lines of consumption, is in storing less and distributing more and more frequently. In this scenario, the operator who prepares 110 to 170 logistics lines in the order warehouse in one hour is short, the use of technology and automation is a great support that allows to work up to seven times with these yields, reaching levels that cannot be achieved without technological tools.

The optimization of logistics helps transform organizations of different sizes is not only an opportunity for large companies as you might think [35], such is the case of Arenal, a medium-sized European company dedicated to selling perfumes that managed to change its value offer with its slogan 'it's cheaper', thanks to the restructuring of its storage system and automated order management. It currently has more than 25,000 references of Premium brands with affordable costs and a significant and constant level of growth. Colombia [42] is part of this reality and large multinationals are joining this type of solution in various sectors of the economy such as the automotive, aeronautical, mining, pharmaceutical, health and beauty, textile and industrial sectors, among others.

For this, there are several types of tools that are used today to analyze, measure and provide solutions to the problem, according to the characteristics of the needs of the organization, defined as

HADA - Advanced Digital Self-Diagnostic Tool: Evaluates 5 key dimensions divided into 16 levers in the performance of 6 levels (Electronic tool)

The Industry 4.0/Digital Operations Self-Assessment: 6-dimensional assessment, focused on four levels of maturity (Electronic tool access to 3 of 6 dimensions

IMPULS Industries 4.0 Readiness: Provides a 6-dimensional evaluation, including 18 reagents to indicate performance on 5 levels (Electronic tool)

Vertical and Horizontal Integration Systems in the Industry 4.0 Framework: Evaluation and Development [1].

In the country, different projects have been implemented in companies such as Exxon Mobile, Ingredion, Montecarlo Motors, The American Embassy, Mederi University Hospital, Kaeser [41], among others. In this way, the improvement of intralogistic processes raises the productivity levels of companies, allowing them to face market changes, consumption and mitigate external impacts, as well as achieve operational efficiency that can transform their value offer and even differentiate themselves in increasingly competitive markets that demand flexibility and adaptation to constant change.

In this way, the Logistics Operators in the Caribbean region see in the implementation of 4.0 industry technologies a solution to the needs that the market imposes today; the company under study seeks to improve its efficiency rates, impacting with the search of the ideal 4.0 technology the problems it suffers framed in three main scenarios:

Operational: The purpose of this approach is to improve the processes in the intralogistic activities (storage, loading and unloading) from the suppliers' point of view, which are influenced by the synergy of the pillars of the logistics operators and the performance of their human capital.

Structural: It is an important element for the development of the activities of logistics operators of the objectivity of the organization, based on the use of space for intralogistic processes of raw materials and finished product.

Results: To improve the organizational efficiency by means of the decision making in function of the implementation and fulfillment of the demands of the internal and external clients of the logistic operators object of study, which does not have a clear measurement of its indicators and the evaluation of its factors, obtaining a low index when measuring its organizational efficiency.

4. Methodology

From the above, considering the findings in the literature review and the problems affecting logistics operators, the analysis tool of Vertical and Horizontal Integration Systems in the Industry 4.0 framework is used, resulting in the data specified in figure 2.
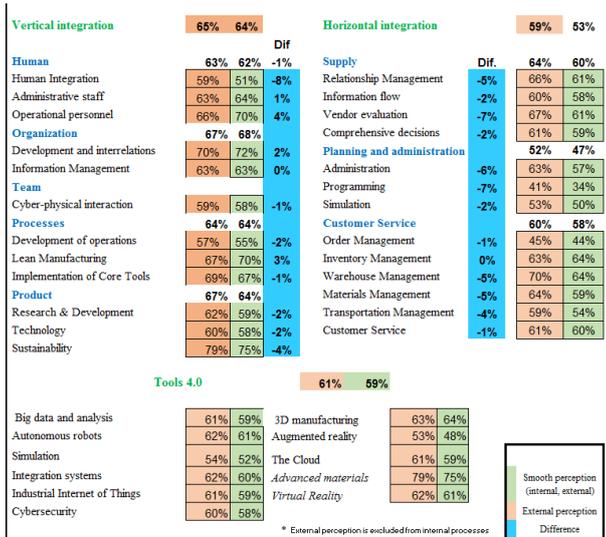
Fig. 2. Application result absorption tool in industry technologies 4.0. Source: Own elaboration.

The application of the analysis of the vertical and horizontal integration of the industry 4.0 to the logistics operator under study indicates that the organization presents a diagnostic perception in the absorption of the technologies 4.0 of 59% of internal perception in the use of the same compared to 61% of the external area that perceives that the organization applies tools 4.0.However, the tool shows us in detail the reality of 4.0 technologies in the organization under study in objectivity with the most important areas of action of the company according to the vertical (Internal 64%, External 64%) and horizontal (Internal 53% and External 59%) parameters respectively.

The vertical integration performs an analysis in the aspects: Human (Internal 62%, external 63%), Organizational (Internal 68%, external 67%), Team (Internal 58%, external 59%), Processes (Internal 64%, external 64%) and products (Internal 64%, external 67%). Horizontal Integration works on the items of: Supply (Internal 60%, external 64%), Planning and Administration (Internal 47%, external 52%) and Customer Service (Internal 58%, external 60%).

From the above, the problems presented by the organizations within their intralogistic processes are determined, defined in the aspects of non-existent value chain, unmanaged storage, low technological investment, lack of human talent and the non-structure of costs vs. income, for which aspects such as high costs of urban centers, increase in the cost of labor, low productivity, the non-adoption of new technologies and organizational efficiency indexes below the standard of the region are derived.

This section consists of evaluating the entire system of operations of the logistics operators, in which three considerations stand out in the process of characterization: vertical integration, horizontal integration and, as ́ultimo point, the use of the technologies of the industry 4.0, table 2 describes them.

Table 2. Organizational Structure Mapping

Consideration	Description
Vertical integration	It is based on the socio-technical system and the value creation modules.
Horizontal integration	Based on operations management requirements.
Technologies 4.0	Contains the tools studied in the literature analysis.

The mapping defined in table 2 allows us to know the organization in general, that is, it shows the outstanding elements and activities, deficient situations and critical points of the process. Consequently, the ordered form of the instrument used to characterize the logistics operators according to their vertical and horizontal integration systems within the framework of the technologies of the industry 4.0 is detailed.

5. Discussion and analysis of information

The analysis of the information derived from the search in the databases and sites specialized in logistics research, allows a systematic review of the scientific articles assigned to the categories determined in the methodology. Therefore, this section consists of three divisions: Intralogistics, Industry and Technology 4.0. As a result, in the search for literature review, there is no other work with the characteristics presented.

With regard to the application of the analysis of the vertical and horizontal integration of industry 4.0, it is observed that it is viable and feasible to apply tools of industry 4.0 in the logistics operators of the department of Atlántico, which present a great opportunity for the adaptation and absorption of the technologies exposed and therefore impact on the indicators of organizational efficiency.

The above is deduced according to the consolidated result in figure 2 above, contemplating the analysis and application of the tool in 11 individuals, included in the hierarchical levels of the logistics operators using 146 reagents for each one, obtaining as a result a perception in the absorption of the technologies 4.0 of 59% of internal perception in the use of the same compared to 61% of the external area that perceives that the organization applies tools 4.0

6. Conclusion and future work

The intralogistics that begins to break into the scene of the organizations of Latin America, the Caribbean and especially the neo-Granada nation itself in its Caribbean region where its logistics operators are in the continuous search for tools that allow improving business efficiency and They have observed in the aspects of Intralogistics, Industry and Technologies 4.0, a roadmap for the fulfilment of this purpose.

Intralogistics from the literary point of view has much to apply and take advantage of 4.0 technologies to strengthen and improve in logistics operators, to make this leap to the so-called Intralogistics 4.0 a term that has been gaining ground in the studio literary and start-up within organizations as a tool for improving business efficiency.This article shows a heterogeneous literature in terms of resources, concepts and contents, and shows a systematic review of the research on advances regarding Industry 4.0, Intralogistics, including elements of 4.0 technologies. This review included 57 scientific articles and the following findings are presented:

First, three categories of Intralogistics, Industry and Technologies 4.0 studies were identified, where the latter delimited five sub-blocks that are the backbone of incorporation of the 4.0 paradigm in this article. These blocks were the focus of the investigation, so he obtained the panoramic view of his axes, as well as their importance. Second, the articles were assigned to the categories. However, the articles revealed interconnections with the other blocks and sub-blocks, so the systematic review, in addition to identifying the category with the greatest weight, revealed the requirements for successful application.Third, the analysis revealed that the category with the highest growth has been the inclusion of 4.0 Technologies in intralogistic processes and activities, this is due to the fact that it represents the industrial base, this block is considered the base , because they show a slight dependence on the other blocks and sub-blocks.

This review not only revealed the three categories and the sub-categories applications, but also revealed criteria for intralogistics management in terms of industry 4.0. In addition, the essential characteristics observed in the adaptation of the 4.0 environment, looking towards the future, the considerations of the logistics operators sector in terms of intralogistics and their application towards the industry and technologies 4.0 paradigm will be less complicated if the starting point establishes the basic characteristics for its implementation. Determining the existence of an interrelationship between intralogistics of logistics operators in the Atlantic department in which the implementation of industry 4.0 technologies allows to improve the processes allowing to impact organizational efficiency through the improvement of intralogistic processes, by establishing as the backbone of intralogistics.

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