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Diagnosis of the Initial Situation of Companies in the City of Barranquilla, Colombia, According To Logistics 4.0

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Abstract:
Background: The present study addresses the initial diagnosis of small, medium, and large enterprises in the city of Barranquilla, Colombia, with regards to the knowledge of Logistics 4.0, and elements that make its implementation difficult at an organizational level. For this research, a designated and validated survey applicable to the described enterprise types was used.
Materials and Methods: The methodology utilized for the survey application was as follows: scheduled visits were made to each one of the organizations selected, which facilitated gathering of the desired information; then, the data collected were entered into a software program called SPSS version 25.0, which performed a multivariable statistical analysis and issued conclusions on the knowledge level of the tools related to Logistics 4.0.
Results: Their application level and causes that influence the implementation level of these techniques in the companies under study.
Conclusion: The present research will permit the generation of subsequent studies based on the results found in this document, which will help to evaluate the advance of Logistics 4.0 within the industry of Barranquilla.
Key Word: Logistics 4.0, Industry, Statistic Analisys

I. INTRODUCTION

Throughout history, industry has been changing at an accelerated pace to the benefit of all involved. Along these lines, industry 4.0 and intelligent manufacturing are having significant impact, and are expected to affect all types of companies. Their early adoption is an opportunity to do business[1]. The concepts of industry 4.0 and intelligent manufacturing are relatively new and take into consideration the introduction of digital technologies in the manufacturing industry; such examples include the incorporation into this environment of technologies like the internet, mobile computing, big data, wireless sensor networks, and mobile devices [2]. Industry 4.0 was mentioned for the first time in 2011 in Germany with the purpose of developing a new concept for the application of economic policy strategies in that country. That concept was the starting point from which the basis of an evolution in industrial technology would be built [3]. The term Industry 4.0, also known as the Fourth Industrial Revolution, refers to a wide range of concepts.

Classifying those concepts and relating them to a single discipline, as well as distinguishing them specifically is difficult [4]. However, it is possible to have fundamental concepts to refer to regarding this Fourth Industrial Revolution. The concepts this framework comprises are Intelligent Factories, Intelligent Technology and Smart Intelligence. In this context, it is possible to assert that the main focuses of this Industrial Revolution are located among disciplines like electrical engineering, business administration, computer science, technology, software, business and information, software engineering, mechanical engineering, as well as the field of logistics, manufacturing and services [5]. In general, with the emergence of this Fourth Industrial Revolution, also known as Industry 4.0, it is possible to observe as a condition of a global production network, that companies and countries are more closely connected through a worldwide supply chain and logistics networks [4].

From this perspective, the majority of the publications that make reference to Logistics 4.0 usually center on descriptions of technologies vastly more modern than previous ones, and the application of these technologies to the supply chain. For this reason, perhaps what Logistics 4.0 indicates is better understood not as a revolution in techniques used in the management of the value chain, but rather as a link between current and cutting-edge technologies, and ultimately as a connection between the most advanced solutions and the latest needs [6]. Thus, Logistics 4.0 is not distinguished as the appearance of a new paradigm of elements or capacity of management, but as a connection between technologies [7]. Based on this, there is no doubt that "Logistics 4.0" is a term considerably more limited than "Industry 4.0," despite having a very similar interrelationship with certain factors. Thus, the objective of Logistics 4.0 is the increased efficiency and perfomance of each part of the supply chain [8]. Logistics 4.0, by seeking to improve each part of the supply chain, seeks potential solutions

to the problems that might appear in this field. Against this background, there have been several studies conducted relating to this subject. One example is a study conducted in Veracruz, Mexico in relation to the proposal of a diagnostic and evaluative instrument to measure organizational conditions with respect to Industrial Revolution 4.0 [9]. This study presents its results, specifying that there are currently several organizations which have added to their training plans the idea of being constantly involved in reducing production times and optimizing processes. The study recommends however, that before entering this world, organizations should perform assessments to know just how feasible and necessary adapting to this new generation of technologies is.

Similarly, another study deals with the current environment of global competition, technological development, and innovation. Manufacturing companies especially have been forced to reconfigure their processes. Industry 4.0 and intelligent manufacturing are part of a transformation which integrates production and information technologies in order to create innovative systems of manufacturing, management, and business practices that enable optimization of manufacturing processes with the goals of increased flexibility and efficiency. Additionally, this generates a value proposal for the companies clients, and enables companies to respond to market needs in a timely manner [10]. Another contribution of Industry 4.0 has been to the field of supply chains, presenting uniform information models where everyone involved can collect and process all the information used in the production process in order to carry out successful production planning and focus objectively on still other areas in order to make the best possible decisions [11].

The two studies presented above are similar; initially, they present results recommending the execution of serious and responsible analysis in which evidence is presented regarding companies' ability to implement Industry 4.0. This is supported by a study carried out by the Autonomous University of Baja California called the Fourth Industrial Revolution or Industry 4.0. This study determines that a high percentage of manufacturing companies do not know how to respond to the terminology of Industry 4.0. The main conclusion obtained is that Industry 4.0 is a recent and developing landscape, fed by each innovation and evolving toward digitization with the use of information technologies [12].

A study carried out in Colombia called Importance in the Logistics Process of Last-Mile Distribution, is initially focused on a review of the literature to establish and analyze the contributions of the fourth industrial revolution to the logistics process of last-mile distribution in the last five years, and how said contributions have influenced the level of service for the modern consumer. The study highlighted the applicability of Logistics 4.0 in distribution processes, identifying the need to be aligned not only with the clients' profiles, but also with external factors that affect industries that want to implement this methodology, which will be necessarily subject to the level of investment and financial capacity of the companies in this sector [13]. Another study carried out according to Industry 4.0 concepts indicates that additive manufacturing, also known as 3D, is a tool of Industrial Revolution 4.0 which considers changes in the processes of the supply chain of multiple companies by facilitating the production of customized or changing products, removing enlistment processes, decreasing waste and reprocess costs, applying value to most businesses, and generating utilities; for this purpose, it identifies possible tools that could facilitate the achievement of positive results for the companies. This study considers essential combination of four basic concepts: production, suppliers, storage, and distribution, which must find a logical interrelation while using techniques Industry or Logistics 4.0 to obtain desired success [14].

Governmental studies have also been developed which have projected the logistical development of Colombia. For instance, the National Council for Economic and Social Policy (CONPES), in Document #3982 of the National Logistics Policy, establishes strategies to consolidate an articulated logistics system through the implementation of components such as the use of information and communication technologies (ICT) and the provision of quality services in logistics and transport. Additionally, the National Planning Department designed and implemented the National Logistics Observatory, which is responsible for the consolidation, analysis, and promotion of the different sectors that come into play in the country in the fields of transportation, industry, commerce, and tourism. [15]. Thus, from 2016 a series of reports called national logistics surveys have been developed, the latest of which was presented and communicated in 2018, and includes results according to logistics performance, outsourcing, international trading, perspectives of logistics services and regional competitiveness [16].

Among the important outcomes of these, logistics surveys are the incorporation and use of technologies in logistical processes and services (see Fig.1), which mainly note the low utilization of information technologies applied to logistics processes.

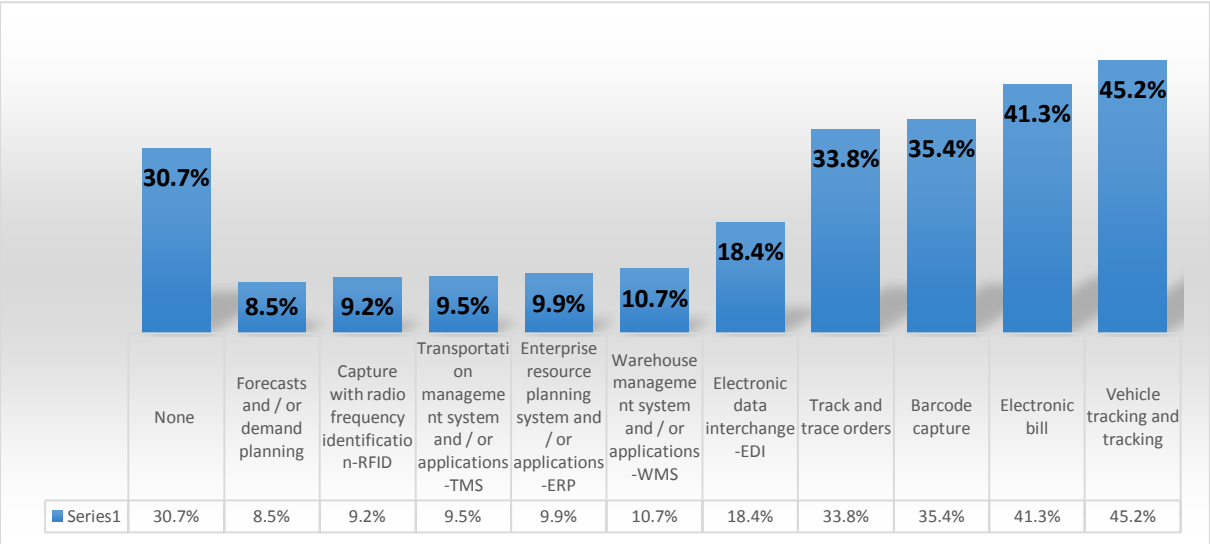


Fig. 1. Use of technologies in the logistics service

Figure 2 shows the level of utilization of technologies in logistics by providing evidence indicative of the low frequency of use of technologies applied in logistics among the companies surveyed, as well as the high percentage of companies which do not use them in their logistics processes.

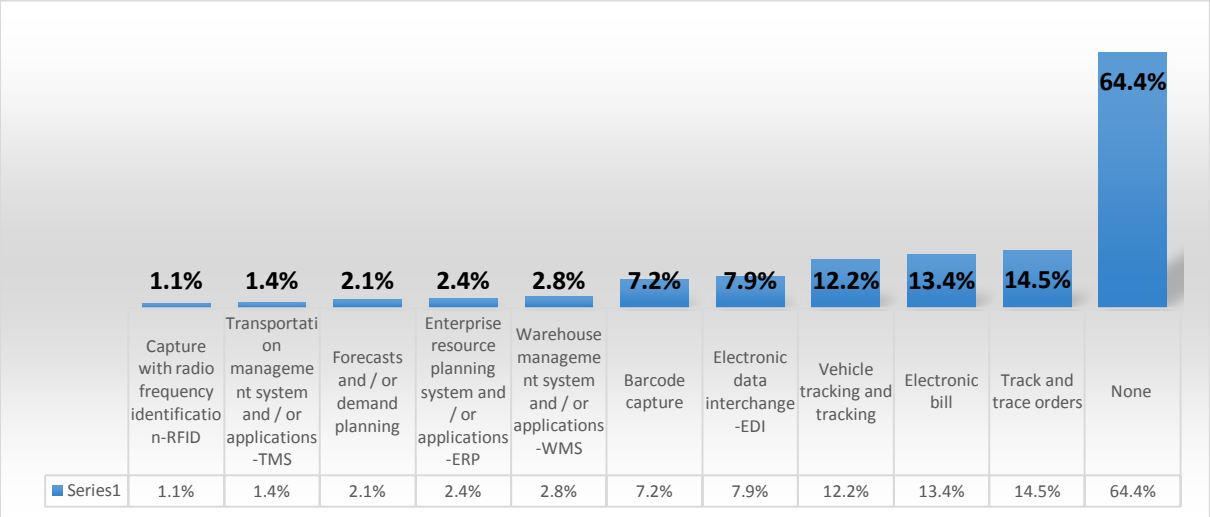
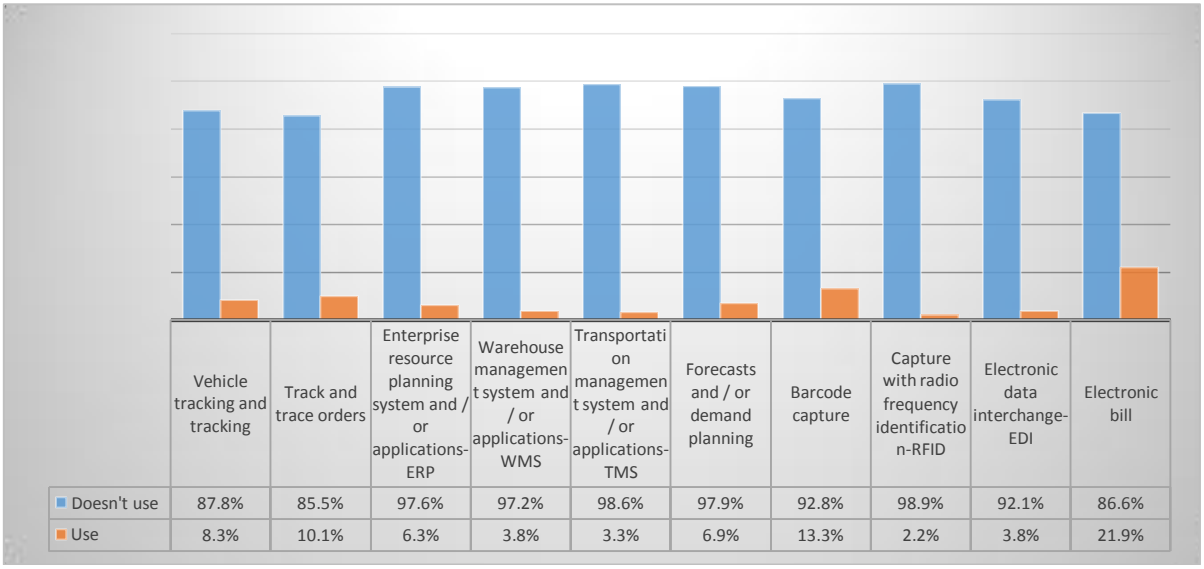


Fig. 2. Level of use of logistics technologies

Figure 3 displays a high percentage of companies that do not use these technologies in logistics, and a low percentage of these companies that are aware of the necessity of these technologies to improve performance of their logistics services.



	Vehicle tracking and tracking	Track and trace orders	Enterprise resource planning system and / or applications-ERP	Warehouse management system and / or applications-WMS	Transportation management system and / or applications-TMS	Forecasts and / or demand planning	Barcode capture	Capture with radio frequency identification-RFID	Electronic data interchange-EDI	Electronic bill
Doesn't use	87.8%	85.5%	97.6%	97.2%	98.6%	97.9%	92.8%	98.9%	92.1%	86.6%
Use	8.3%	10.1%	6.3%	3.8%	3.3%	6.9%	13.3%	2.2%	3.8%	21.9%

Fig. 3. Percentage of companies that don't use logistics technologies and need them

Finally, Figure 4 shows a rating per region of the technology use dimension in logistics processes by providing evidence on a scale from 0 to 5. The maximum score is 2.22, which denotes an implementation below fifty percent (50%) of the total score in the region of Antioquia. The Caribbean Central region, where the Atlantic Department and the city of Barranquilla are located, reaches a performance of 2.0, indicating a fulllfilment of 40%.

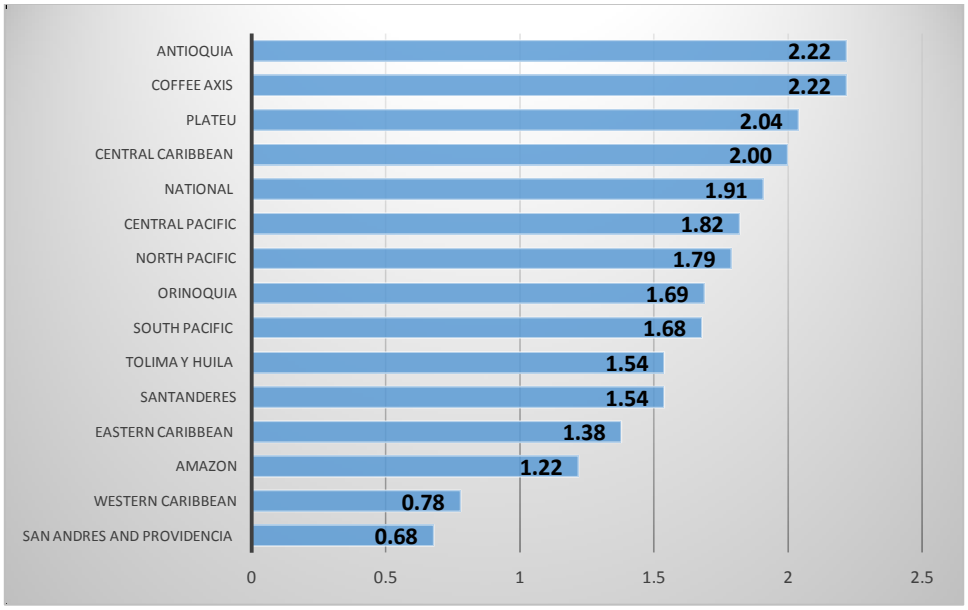


Fig. 4. Score and position of the use of information technologies in logistics processes by regions

The National Logistics Survey only presents results at the state level, so it is necessary to investigate at the city level to determine the level of ownership and use of technologies in logistics processes and the preparation status in the face of the challenges of Logistics 4.0, as well as to identify what might affect the level of development in enterprises located in the city of Barranquilla. Therefore, the present study is warranted by virtue of the fact that recent publications show Barranquilla as having both a high level of development and of national and international positioning, as reported by the Competitiveness Index of Cities carried out by the Private Competitiveness Council and the University of Rosario [17], which measures the competitiveness of cities in accordance with 97 indicators based on a methodology developed by the World Economic Forum.
Additionaly, this is supported by a study called Cities of the Future 2021, a ranking developed by the Intelligence Center of the British periodical Financial Times (FDI), which placed Barranquilla in the top 10 cities worldwide with the best strategies to attract investment [18].

Therefore, it is possible to conclude that Logistics 4.0 is a topic under construction in Barranquilla, Colombia, and it is necessary to perform diagnostic studies of the current status of the companies which might be able to begin the implementation of the concepts related to this methodology; thus, the present work performs in a general manner an initial study of the organizational status of such companies that are located in the study's target city, which in the future could implement the concept of Logistics 4.0.

II. MATERIAL AND METHODS

As base for the development of this study, the use of direct collection methods through instruments such as surveys is recommended, as they have been demonstrated to be a useful mechanism to develop diagnostic studies, as done by Natalia Szozda, a student from Wroclaw University of Economics in Poland, who performed a study of Industry 4.0 and its impact on supply chains. In this study, she explored the current challenges supply chains experience due to the Fourth Industrial Revolution, and subsequently conducted surveys and interviews with experts who work in production and service companies [19].

Based on the above model, to carry out the present study, a survey designed and validated in February 2020 was used [20]. The survey is structured in sections to look for information from companies about topics related to general information, including a logistics structure component, a process component, a technological component, a raw material handling component, and a demand planning component (see Table 1). The present study used the logistics structure component, which is the main component used to obtain the results and conclusions showed in this document.

Table 1. Description of the components of the collection instrument

COMPONENT	DESCRIPTION
General information	To know the profile of the companies that will participate in the study, in relation to company size, person responsible for filling out the questionnaire and logistics within the organizational chart.
Logistics structure component	This component aims to evaluate logistics management in general, and the knowledge degree regarding Logistics 4.0.
Process component	This component aims to specifically evaluate the management of the four basic logistics processes (purchasing and supplier management, planning and inventory replenishment, storage, and cargo transportation and distribution).
Technological component	This component intends to evaluate the likelihood of the companies' implementation of new technologies for handling information.

For this reason, when applying only the logistics structure component, the sample necessary for its application was based on the data provided by the Chamber of Commerce of the city of Barranquilla (see Table 2).

Table 2. Number of existing companies in Barranquilla

COMPANY TYPE	NUMBER OF COMPANIES
Big company	57
Medium company	46
Small company	116

With the total number of companies, the probability that the i-th sampling unit would appear in the sample was determined by the following calculation:

$$\Pi_i = m_i/M \qquad (1)$$

Where m_i is the total number of the population by company type, and M is the total number of the population. Substituting the values of each variable in the formula, the following is obtained: 0.26 for big companies, 0.21 for medium companies, and 0.53 for small companies. Using these results, the following formula is used:

$$D = B^2 / Z^2 \qquad (2)$$

Where B is an estimated error of 0.08, and Z is the statistical parameter that depends on a confidence level of 95%, which, according to the tStudent table value, is equal to 1.96. Substituting these data in the previous formula, a value of 0.00166 is obtained, resulting in the following equation:

$$M^2 D + \sum m_i p_i q_i \quad (3)$$

Where $p_i q_i$ corresponds to the probability of ocurrence of 50%, obtaining a result of 134.6530, which is applied in equation number 4:

$$n = \frac{(\Sigma mi \sqrt{(p_i q_i)^2})}{M^2 D + \sum m_i p_i q_i} \quad (4)$$

The result of applying the previous equation gives a value of n= 89. The result makes it possible to obtain the minimum sample required for each company type according to the following equation:

$$n_i = n\Pi_i \quad (5)$$

Finally, when applying Equation 5, it is feasible to find the number of companies of each type that should be applied to the respective research instrument (see Table 3).

Table 3. Sample size

COMPANY TYPE	TOTAL NUMBER OF COMPANIES	TOTAL SAMPLE
Big	57	23
Medium	46	19
Small	116	47

III. RESULT

When applying the survey to the defined parameters, and entering the data into the software program SPSS version 25, it yielded specific results related to Logistics 4.0. While the survey used contains various data on the business environment in its database, the results shown are fundamentally based on the logistics structure component. First presented are the results obtained by running the KMO analysis and the Bartlett sphericity test. The KMO value found by the study (0.608) denotes that the correlations between pairs of variables are not explained by any other variables, and that factor analysis may not be appropriate. The value reached in the Bartlett sphericity test of 193.004 is large, which makes it evident that the null hypothesis that the variables are not correlated is rejected.

Table 4. KMO analysis and Bartlett's Test of Sphericity

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.608
Bartlett's Test of Sphericity	Approx. Chi-Square	193.004
	df	15
	Sig.	.000

The results of Table 5 permit that the determination of the variable logistics terms related to Industry 4.0 have a relatively low correlation. An important datum to consider in this table is the existing relationship between the knowledge of Logistics 4.0 and terms of Logistics 4.0 which, having a value of -0.052, shows that they are not related, meaning that the terminology in the subject studied does not apply to the current performance of companies and shows that these terms are currently unknown.

A very different appreciation exists between the variables of logistical cost and knowledge of Logistics 4.0, which is shown by a relationship value of 0.611, denoting that companies have a perception of the term Logistics 4.0, but directly relate it to the costs that may be incurred by applying such a tool.

Table 5. Correlation analysis

Correlation Matrix[a]

		Processes related to Logistics	Knowledge of Logistics 4.0	Terms related to Logistics 4.0	Logistics is managed with independent processes	There are no Logistics indicators	Expensive process	Logistics costing
Correlation	Processes related to Logistics	1.000	-.700	-.318	-.362	-.700	-.362	-.681
	Knowledge of Logistics 4.0	-.700	1.000	-.052	.136	1.000	.136	.611
	Terms related to Logistics 4.0	-.318	-.052	1.000	.322	-.052	.322	.334
	Logistics is managed with independent processes	-.362	.136	.322	1.000	.136	1.000	.257
	There are no Logistics indicators	-.700	1.000	-.052	.136	1.000	.136	.611
	Expensive process	-.362	.136	.322	1.000	.136	1.000	.257
	Logistics costing	-.681	.611	.334	.257	.611	.257	1.000

a. This matrix is not positive definite.

Table 6 shows the results of the total explained variance. The results found make it possible to observe that only two components have a total of 77.833%, evidenced by the subsequent feasibility of performing various types of statistical and sample analysis.

Table 6. Total explained variance

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.510	50.136	50.136	3.510	50.136	50.136	3.141	44.865	44.865
2	1.939	27.696	77.833	1.939	27.696	77.833	2.308	32.968	77.833
3	.954	13.629	91.462						
4	.345	4.935	96.397						
5	.252	3.603	100.000						
6	3.058E-16	4.368E-15	100.000						
7	-9.416E-17	-1.345E-15	100.000						

Extraction Method: Principal Component Analysis.

Table 7 reflects results related to the matrix rotation component. These values determine that the variables for knowledge of Logistics 4.0 and logistics cost, and the absence of logistics indicators should be part of component 1, while showing that the companies studied relate the term Logistics 4.0 with the costs they would incur by the implementation of tools associated with this term. Within component 2, the expensive process variable and other terms related to Logistics 4.0 attain high results, ratifying that which is specified in the variables of component 1.

Table 7. Rotation matrix components

Rotated Component Matrix[a]

	Component	
	1	2
Processes related to Logistics	-.817	-.342
Knowledge of Logistics 4.0	.964	-.043
Terms related to Logistics 4.0	.047	.594
Logistics is managed with independent processes	.126	.939
There are no Logistics indicators	.964	-.043
Expensive process	.126	.939
Logistics costing	.764	.270

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

When carrying out the analysis of the results in Table 8, it is important to clarify the data parameterization to determine if these companies know the term Logistics 4.0. For this reason, a value of 1 was assigned to companies that know the term, and a value of 2 to those who do not know it; therefore, and based on the results achieved, medium and small companies show that they do not know that terminology. In contrast, the value reached by big companies, where a value of 1 was found, reflected a high knowledge of the term Logistics 4.0.

Another important datum to be analyzed is one that shows small companies relate the term Logistics 4.0 to artificial intelligence and the internet, medium-sized companies relate the term to the words internet and information technology, and large companies associate Logistics 4.0 with the term artificial intelligence. The only case in which the three company types coincide is with regards to the fact that the implementation of Logistics 4.0 in their processes would be expensive.

Table 8. Statistical measurements

Group Statistics

Type off company		Mean	Std. Deviation	Valid N (listwise)	
				Unweighted	Weighted
Small company	Number of people linked to Logistics	1.2857	.45723	42	42.000
	Knowledge off Logistics 4.0	1.7143	.45723	42	42.000
	Terms related to Logistics 4.0	4.6667	1.35551	42	42.000
	Expensive process	1.2143	.41530	42	42.000
Medium company	Number of people linked to Logistics	1.7857	.80178	14	14.000
	Knowledge off Logistics 4.0	1.4286	.51355	14	14.000
	Terms related to Logistics 4.0	5.1429	.53452	14	14.000
	Expensive process	1.0000	.00000	14	14.000
Big company	Number of people linked to Logistics	2.4444	.78382	18	18.000
	Knowledge off Logistics 4.0	1.0000	.00000	18	18.000
	Terms related to Logistics 4.0	4.3889	1.33456	18	18.000
	Expensive process	1.3889	.50163	18	18.000
Total	Number of people linked to Logistics	1.6622	.78124	74	74.000
	Knowledge off Logistics 4.0	1.4865	.50323	74	74.000
	Terms related to Logistics 4.0	4.6892	1.24884	74	74.000
	Expensive process	1.2162	.41447	74	74.000

Finally, an important point to consider is Wilk's Lambda analysis. This analysis specifies the significance of the terms related to Logistics 4.0 (0.237) and the significance of the expensive implementation process variable (0.029); that these values are high indicates that there is no difference between them. However, in the variables representing number of people, number of people linked to logistics, and knowledge of Logistics 4.0, when a significance value equal to 0.000 is obtained, it denotes that there is an important difference between those who work in this area and the lack of knowledge of the tools associated with Logistics 4.0.

Table 9. Wilk's Lambda analysis

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
Number of people linked to Logistics	.614	22.282	2	71	.000
Knowledge off Logistics 4.0	.649	19.189	2	71	.000
Terms related to Logistics 4.0	.960	1.470	2	71	.237
Expensive process	.905	3.726	2	71	.029

IV. DISCUSSION AND CONCLUSION

This study presents a preliminary analysis of companies in the city of Barranquilla, Colombia regarding their level of knowledge or progress in the implementation of tools associated with Logistics 4.0. The main results show two important aspects: a high percentage of small and medium-sized companies are unaware of this term or have heard it very little, relating it more to the internet, artificial intelligence and information technology; in contrast, large companies almost entirely associate it with the term artificial intelligence. Additionally, one of the most important reasons for which companies in Barranquilla, regardless of their size, have not implemented processes related to Logistics 4.0, is that they consider it a high cost investment for their organizations.

The company size is directly related to the number of people linked to the logistics area, where it is found that small and medium-sized companies have on average between one and ten employees, while large companies have between 20 and 30 employees. Another important aspect is the correlation between the variables that make up this study, which confirm that despite not being highly related, they reflect considerably adequate values to continue to carry out more detailed analyses, there by allowing for the generation of more conclusive elements within the study, showing that the field of Logistics 4.0 in Barranquilla, Colombia is new and worthy of being widely studied.

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