Industry Process Practices and their Correlation with the Logistics Performance Index and Cost

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Abstract

Purpose: To establish an analysis of information by comparing two groups of variables taken from the National Logistics Survey of Colombia 2018, to identify the correlation that practices in the logistics processes in the industry have with the results of the logistics performance and cost indexes.
Design/methodology/approach: A review of the literature on industry 4.0 drivers, technology and people was conducted (Arancegui & Laskurain, 2016). Information was taken and analyzed from the National Logistics Survey 2018 to 2738 productive units, characterization of logistics in different types of industry, two groups of variables were established to establish a statistical correlation.
Results: Evidence of high correlations in established variables, other low correlations, relevant information between practices in logistic processes, and indicators of logistic performance and its costs.
Limitations/implications of the research: There is a lack of historical information to strengthen the analysis and its evolution.
Originality/value: There are no methodologies with a statistical correlation that compare the valuations of practices in logistics processes with their logistics performance indicators and their costs. Relevant correlation figures were identified as an explanation of the practices that have greater significance with the logistics performance and cost indicators.

keywords: logistic processes, Logistics Performance Index PLI, correlation, simultaneity.

1. Introduction

A bibliographic review is established to contextualize the logistic processes developed in the industry and supply chains in the world and in the Colombian context, this as an input to identify the conditions that support the valuations of the logistic performance indexes (LPI) against the industry 4. 0, the methodology is reviewed as the World Bank establishes the LPI, for the Colombian context the last National Logistics Survey 2018 is taken to identify a characterization of the different types of industry, identifying especially their practices in the logistics processes, generating an information matrix of the results of these assessments with another group of variables such as the

indicators of logistics performance and of the cost indexes of these practices in the logistics processes. Establishing an information analysis methodology, with the objective of identifying the variables with the greatest correlation and identifying which practices in the logistics processes are most related to each of the established indicators. Two groups of variables were established, the first one of the assessments of the logistics processes with 28 common practices carried out in the industry, the second group of variables are the indicators of logistics performance and cost indicators with a total of 7 variables.

This research seeks to explore how the practices evaluated in the different types of industry have a correlation and explain the results of the logistics performance indicators and likewise what is related to the cost indicators of the macro logistics processes. In the same way, we sought to take advantage of the consolidated information of the National Logistics Survey, which gathers a considerable amount of information and is not analyzed from points of view that can explain different levels of correlation between them, is an opportunity to identify the practices in the logistics processes that have the greatest impact on the final results that evaluate the logistics performance of each country in an international manner. These issues are being analyzed with new technologies for analyzing large data, however, an attempt is being made to identify a structured analysis method that is easy to establish in spreadsheet software where it is possible to identify the group of variables that have the greatest significance between the variables of the two groups. Its results could be the initial matter of new analyses for specific industries and in this way identify peculiarities in the decision-making process to strengthen improvements prioritizing the practices in the logistic processes that give the greatest results of significance in the indicators of logistic performance LPI and of cost indicators.

2. Literature Review

At a global level, the methodology by which the performance of logistics in the different economies is monitored is done through the model developed by the World Bank since 2007, which evaluates service conditions of logistics processes along the supply chain, measures facets in processes such as Customs processes, a competition of logistics services Infrastructure, International shipments, Tracking, Tracing and Punctuality of each country. The score is developed with ratings from 0 to 5, with the lowest being 0 and the highest being 5. In the 2018 report, Germany stands out as the best-rated, with 4.20, followed by Sweden with 4.05, then Belgium with 4.04 according to the World Bank (The World Bank, 2018). The performance of the 10 economies with outstanding performance is of consolidated economies, of these 8 are European and 2 are Asian, as described in table 1.

Table 1 Logistics Performance Index

2018: Best Performing Countries LPI		
Rank	**Country**	**Score (1-5)**
1	Germany	4.20
2	Sweden	4.05
3	Belgium	4.04
4	Austria	4.03
5	Japan	4.03
6	Netherlands	4.02
7	Singapore	4.00
8	Denmark	3.99
9	United Kingdom	3.99
10	Finland	3.97

Source: LPI 2018, Banco Mundial

This topic is established in the theoretical framework due to the relevance of knowing the methodology and the objective of the World Bank in carrying out the monitoring, and evaluation of the logistics services of the different economies in the world, in which different levels of economies are identified, defined in low income countries, middle income countries and high income countries, therefore the Bank

Logistics performance in Latin America in 2018 has a score of (2.66), with 23 countries in the region, 10 performing less well than in 2016 (The World Bank, 2018). Latin America showed improvements in Tracking, Monitoring, and Infrastructure. In relation to Punctuality and International Shipments, with an average similar to 2016 in Customs and

Logistics Services Competition. Leading to efficiency losses, increased time and costs of exchange between the countries of the region (The World Bank, 2018). The best logistics performance was that of Chile, with a position of 34 worldwide (The World Bank, 2018).
The case of Colombia that occupied the position (58) with a score that rose 12.6% and climbed 36 positions with respect to 2016, its indicators stand out in Infrastructure, International Shipping (The World Bank, 2018).
Having discussed the issues of e-commerce and logistics performance indices, their relationship is identified, virtual logistics or cloud logistics, for Ximena and Quispe (2013) virtualization technologies also began to acquire greater importance, because they allowed the implementation of several applications without the customer having to install or configure them, cloud computing allows a variety of new business models based on logistics as a service. Logistics providers can enable and disable modular and customizable cloud services on demand using a pay-per-use approach. This enables highly scalable service and management capabilities without requiring the traditional costs of developing, configuring and maintaining the IT infrastructure itself (Pelekais & Kadi, 2014).
In recent years, logistics providers have begun to adopt cloud logistics because it enables fast, efficient and flexible access to IT services for innovative supply chain solutions, where one logistics provider uses cloud-based services and another plan to do so in the near future (Pelekais & Kadi, 2014). Open, web-based mobile applications will form the basis of modular on-demand cloud logistics services, replacing outdated and legacy communication systems, and perimeter computing will continuously improve cloud logistics by using computing power close to the data, dramatically reducing bandwidth requirements (Yu et al, 2016a), modular cloud logistics platforms provide open, web-based access to a selection of flexible and configurable on-demand IT services related to logistics that can be easily integrated into supply chain processes (Yu, et al., 2016).

Cloud-based transport management systems can assimilate ordering, billing, and tracking and tracing services on a combined platform. Pay-per-use models allow small and medium-sized logistics providers, as well as large companies, to react more flexibly to market volatility, paying only for the services they actually need and use, instead of having to invest in a fixed-capacity IT infrastructure (Pelekais & Kadi, 2014).

Cloud-driven global supply chains virtualize information and material flows by moving all supply chain processes to the cloud (Yu et al., 2016a). With complex and fragmented global supply chains, logistics providers often have to deal with a variety of transactions taking place between multiple parties, using different warehouse and transport management systems (Riveros and Ballesteros, 2007). For Riveros, the cloud allows the coordination and orchestration of this information in an integrated view, making it a key enabler of a virtual 'control tower', providing 360-degree management dashboards, the cloud offers companies more precise control over their global inventory levels and the location of shipments and assets, considering that worldwide e-commerce sales are growing and will continue to do so. According to projections, from 2015 to 2019, retail e-commerce will grow by $1.5 trillion and by 2019 it will close at $3.4 trillion, with growth expected to be 60% by 2019 (BlackSip, 2019).

Urban population growth: Approximately 54% of the population lives in cities today, and is expected to be about 66% in 2050 (Ambrosino et al., 2016). Urban areas require a large number of goods, services, and resources, human activities generate externalities costs and the transport sector is one of the main causes of these. The EU definition of an external cost, called an externality, is a cost that arises "when the social or economic activities of one group of people have an impact on another group and when that impact is not fully accounted for, or compensated for by the first group (Istrate et al., 2019). The main challenge for the delivery of the last mile is to reduce these externalities and provide efficient service, this vision is one of the important issues leading to the new idea of the smart city, where through ICT, Industry 4.0, development of new mobility systems and services, it is possible to create an efficient and sustainable use of resources, in a vision of the smart city (Istrate et al., 2019).

In the Colombian case, the last mile is evident in-home deliveries, Colombians have always used the yellow pages to order their favorite foods, but in 2007 Domicilios.com inaugurated the e-commerce of foods in the country, the Colombian company entered the Frankfurt Stock Exchange in 2017, through its majority partner Delivery Hero. 80,000 is the approximate number of neighborhood stores in Colombia (53% of the market), a figure that makes these establishments the most common in the country, according to the most recent census of Infocomercio (2018), likewise describes that the traditional store has 48% of importance in value, but had its largest drop in volume (-0.5%) according to Nielsen, (2016).
In Latin America, the supply of electronic commerce rose and so did the transactions made in this medium, with comparisons between 2017 and 2016 increased by 22% (NubeCommerce, 2019). For BlackSip's e-commerce report in Colombia (2019), payment methods are becoming a challenge for channel consolidation, where technological

means of payment such as credit or debit cards are required, forcing retailers to provide alternatives to these difficulties. According to data from Euromonitor (2018) in the region there were more than 329 million credit cards by 2017, a per capita of only 0.51, also describes that in the case of debit, the per capita is 0.99 and is 633 million cards. Another challenge in distribution logistics is the high costs and long waiting times that can affect the consumer experience (Riveros et al., 2007). In the Colombian case, the growth of e-commerce identifies that 3 out of every 10 monthly purchases are made through devices (BlackSip, 2019).

The context of the industry in Colombia, as the market is, characteristics of this market with the increase of the digital industry, and the commercialization of products and services through e-commerce, in this way an investigation was made of the entities that follow up on the behavior of the market and where relevant information was found for the development of the investigation.
According to the Joint Industrial Opinion Survey developed by Andi (Asociación Nacional de Empresarios de Colombia) (2019), among the obstacles identified by entrepreneurs in 2018, the lack of demand stands out as the main problems in the manufacturing industry with 30.5%, the cost of raw materials 22.7%, aggressive marketing strategies, exchange rate, smuggling, and infrastructure, as described in figure 01.

Figure 1. Main problems of the manufacturing industry in Colombia 2018

Lack of demand	30,5
Cost/Raw Material Supply	22,7
Aggressive pricing strategies	20,2
Exchange Rate	19,3
Smuggling	12,9
Infrastructure and Logistics Costs	10,5
Tax Uncertainty	10,1
Working Capital	6
Legislation	4,4
Portfolio	4,2

Source: Joint Industrial Opinion Survey developed by the ANDI (Colombian National Business Association) (2019)

In the performance of manufacturing activity, the ANDI survey (2019), identifies the projects in which the organizations planned to develop in medium-scale by 2019, among which were announced, 51% with investment projects, 42% without investments and 6.6% with deferred investment projects. Of the productive investments, 63% were oriented towards technological implementations, 32% towards modernization of work equipment, 29% towards changes in processes to reduce costs, 29% towards innovation, 27% towards plant modifications, 15% towards strengthening market processes, 12% towards modifications in logistics processes and the search for alliances, among others (ANDI, 2019).
In the factors that entrepreneurs described as hindering the development of their activities, uncertainty is identified with regulatory issues such as the financing law with 44%, another factor is the exchange rate with 32%, raw material costs with 23%, marketing strategies with 17%, competition, smuggling and dumping with 15%, in this same survey conducted by ANDI (2019), describes how much the business of entrepreneurs has changed, where 42% describe that it has changed and 58% have no change. As for consumer habits of online sales remains very small, just 2.7% where Amazon has been a turning point, whose sales have doubled between 2015 and 2017, reaching 24.1% (ANDI, 2019).

3. Methodology

Correlation techniques are a relevant mathematical tool when information is available, what can explain behaviors under information and data to validate the existence or not of some level of relationship between one and many variables, can be a technique that provides information in time series or taking information as surveys to compare variables within the same surveys.
The proposal is based on establishing the identification of public and recognized data groups such as national data, on the penetration of information technologies of the qualifications established in the practices of logistics processes, the national logistics survey carried out consults 2738 companies of different levels depending on their size, with sampling that in the expansion factor reflects the national group of company time (Matus, 2007). This survey, developed by

the National Planning Department (DNP), allows for the objective of characterizing the logistics of the country's companies, contrasting their logistics operations in a sectorial, national and regional context, and with this, seeking new opportunities and innovations for their businesses (Alonso M. et al., 2018). It should be noted that the data from this survey is numerous and has relevant characteristics to take into account, which are summarized in the following table 2 of information:

Table 2. National Logistics Survey 2018

FEATURES	DESCRIPTION
Type of operation	Survey
Number of surveys	2,738 Business units
Methodology of capture	Face-to-face form completed by the interviewer
No. of questions in the questionnaire	50
Regionalized data	OCAD regions and new proposal for logistical regionalization
Entity that led it	National Planning Department.
Year of the event	2018

Source: Own elaboration, information taken from the 2018 National Logistics Survey.

Two matrices were established that compare two groups of variables, some identified within the consultation established in the national Logistics survey composed of the Logistics Performance Indicators of each of these companies, composed of 5 variables, to which a group of 4 variables of cost indicators of the most relevant processes in the logistics processes was added, identified in table 3.

Table 3. Indicators in the logistic processes of the industry in Colombia and cost indexes of the logistic processes.

INDICATORS IN THE LOGISTICS PROCESSES OF THE INDUSTRY IN COLOMBIA
Distribution of companies by economic activity
Cost of foreign trade
Quality index Orders without damage
Quality index Complete orders in quantity
Quality index Deliveries with perfect documentation
Quality index Timely orders
Perfect order
Storage cost
Transportation Costs
Administrative Costs and Customer Service Costs
Other costs

Source: Own elaboration, information taken from the 2018 National Logistics Survey.

Another group of variables is established from the same survey, which measures the qualification of practices in the logistics processes in the different types of companies, that is, in micro, small, medium and large companies. The group of 28 variables of practices developed in the logistics processes was defined, which were evaluated in the 2738 companies surveyed, where the companies established a questionnaire and from this, a result of the evaluation of each one of these activities was obtained:

Table 4. Practices in the logistic processes of the industry in Colombia.

Practices in the logistic processes of the industry in Colombia	
They consider that customs regulation is safe	Reverse logistics for material recovery
Complexity in urban distribution	Development of packaging or reusable containers
Complexity in national distribution	They check that the packaging
Claims	Advance statement
Theft, crime and criminal activity	Inventory rotation days Raw materials

Availability at the customer to receive goods	Inventory rotation days Finished product
High cost of transportation	They measure Waiting time to load a vehicle
Deficiencies in specialized logistics infrastructure	Time to load a vehicle
Traffic regulations	Measure Waiting time to unload a vehicle
Breaking the cold chain	Measure Time to unload a vehicle
Use of alternative fuels for the transport fleet	Supply Days
Use of alternative vehicles (electric, bicycle, etc.)	Distribution Days
Efficient energy management in distribution centers	Inventory rotation days Raw materials
Reduction of C02 emissions in logistic acts	Inventory rotation days Finished product

Source: Own elaboration, information taken from the 2018 National Logistics Survey.

Given that the Logistics Performance indicators were analyzed, the method used by the World Bank for the collection of information for each of these groups of countries was taken into account, with another relevant condition in relation to their physical and geographical resources, which may or may not have a coastline. A standardized questionnaire consisting of two parts is used: (1) International Logistics (2) Domestic Logistics (Mauritius & Barrera, 2018). For the 2018 edition, the surveys were established between September 2017 and February 2018 as shown in table 5.

The proposal of data analysis is established with statistical correlation levels where a correlation coefficient is a number between -1 and 1. Values close to 1 represent the simultaneity of the behavior of the pair of variables compared. Values close to -1 indicate that an increase in one of the variables implies a decrease in the other variable. Values close to 0 indicate the independence or the theory of behavior between the pair of compared variables. To carry out the mathematical treatment of correlation, the different variables can be analyzed simultaneously, to determine joint variations or covariance between these variables, where it is identified if there are parallel changes between them, that is, if one increases or decreases the other also (Rodrigo, 2016).

The quantity is called covariance (Sxy) and has the following expression:

$$S_{xy} = \frac{\sum_i \sum_j (x_i - \bar{x})(y_j - \bar{y}) n_{ij}}{n}$$

"y" gives the amount of covariation between the variables. If Sxy > 0, there is a tendency for greater observations of X to correspond to greater observations of Y. When Sxy < 0, there is an opposite tendency, where the higher value of X we usually find lower values of Y. The values of the variables depend on this, we use the correlation coefficient (rxy). Thus: if p>0.05 we define that it cannot be excluded as an explanation of this finding and we do not reject Ho (null hypothesis) where it is stated that both variables are not associated or correlated.

In relation to the level of significance, a matrix is established where the coefficients of determination of the crossing of the two groups of variables are identified, X as the grouped variables of the information technologies table 4 and the variables of group Y as the variables of the manufacturing industry.

Table 5. A survey method for establishing the PLI Logistics Performance Index for countries worldwide.

Respondents	Respondents		
	Low-income countries	Middle-income countries	High-income countries

Countries Coastal	The five business partners more important (exports) + The three other partners important.	The three most important trading partners important (exports) + The most important partner. + 4 countries at random, one from each region (a) Africa (b) Asia (c) Latin America (d) Europe (excluding Central Asia and OECD)	Two countries at random from the list of the five most important trading partners (exports and imports) + 4 countries at random, one from each region Africa Asia Latin America Europe (excluding Central Asia and OECD) + Two random countries
Landlocked countries	The four most important trading partners (exports) + The two most important partners (imports) + Two countries that serve as land bridges.	The three most important trading partners (exports) + The most important partner (imports). + Two countries that serve as land bridges. + Two countries at random, one from each region: Africa Asia Latin America	

Source: LPI 2018, Banco Mundial (Mauricio & Barrera, 2018)

4. Data analysis

In order to interpret the importance of the data to be analyzed among the different variables, it is pertinent to identify the descriptive results of the survey, which is why those related to the costs of the logistics components are described in a general way, as well as in detail according to the size of the companies, and by economic activity. Due to its current relevance, the results of the use of the technologies used in the logistics processes are also identified, identifying the percentages of use in the Colombian industry. Other descriptive information to be taken into account are the innovation activities in the supply chains identified in the survey, they are taken as a reference, however their results are data to be taken into account in other investigations where the focus is the relationship between the companies of a supply network.

Relevant information is taken from the survey, such as the cost components in the different logistics processes such as storage, transportation, customer service and other costs, where the one with the greatest impact on storage stands out with 46.5%, followed by transportation with 35.2%, administrative and services with 11.1% and other costs with 7.2%, as described in table 6.

Table 1 Logistics cost components

COST COMPONENT	PERCENTAGE
Storage	46,50%
Transport	35,20%
Administrative and customer service	11,10%
Other costs	7,20%
	100,00%

Source: National Logistics Survey 2018

In a detailed way it is shown how the costs are according to the size of the company, where it is evident that the logistic costs are higher in the small and micro enterprises, the storage in the micro reaches a cost of 57.4% and of the small of 53.5% respectively as it is evidenced in table 7.

Table 7. Costs by logistic component and according to the size of the company

COST COMPONENT / COMPANY SIZE	MICRO	SMALL	MEDIUM	LARGE	NATIONAL
Storage	57,4%	53,5%	53,3%	40,1%	46,5%
Transport	23,5%	32,9%	36,5%	40,5%	35,2%
Administrative and customer service	13,2%	10,0%	3,7%	11,1%	11,1%
Other costs	5,9%	3,6%	6,5%	8,3%	7,2%

Source: National Logistics Survey 2018

Understanding the logistics processes according to the supply chain component, the national logistics survey identified costs in the supply stages with a national average cost of 50.2% and 47.3% in the distribution processes. Other costs can be seen in Table 6.

Table 6 Practices in the logistic processes of the Colombian industry.

Practices in the logistic processes of the Colombian industry	Agricultural	Mining	Industry	Construction	Trade	Transport and storage
They consider that customs regulation is safe	66,5%	84,1%	47,8%	66,8%	81,9%	100,0%
Complexity in urban distribution	26,4%	17,5%	27,2%	22,8%	20,3%	18,7%
Complexity in national distribution	1,6%	6,0%	9,1%	7,2%	9,4%	5,7%
Claims	8,1%	2,9%	7,0%	9,8%	9,0%	8,0%
Theft, crime and criminal activity	41,9%	31,9%	34,2%	30,4%	46,7%	37,5%
Availability at the customer to receive goods	6,4%	13,3%	14,5%	24,0%	13,0%	16,3%
The high cost of transportation	44,5%	38,7%	49,5%	41,1%	43,8%	49,2%
Deficiencies in specialized logistics infrastructure	13,7%	34,0%	10,8%	13,4%	9,1%	15,1%
Traffic regulations	2,9%	19,6%	7,9%	6,5%	8,3%	5,2%
Breaking the cold chain	10,8%	0,0%	1,3%	3,3%	2,4%	5,9%
Use of alternative fuels for the transport fleet	12,4%	2,5%	11,6%	6,0%	10,9%	19,4%
Use of alternative vehicles (electric, bicycle, etc.)	12,3%	12,9%	25,9%	26,9%	26,2%	8,9%
Efficient energy management in distribution centers	13,6%	73,8%	19,0%	15,0%	18,9%	32,8%
Reduction of C02 emissions in logistics activities	22,2%	22,6%	16,3%	20,6%	11,6%	15,4%
Reverse logistics for the recovery of waste materials	36,7%	24,0%	33,2%	27,9%	22,8%	17,4%
Development of packaging or reusable containers	24,6%	21,3%	25,5%	20,6%	33,5%	32,8%
verify that the packaging	100,0%	91,2%	77,3%	53,5%	57,0%	0,0%
They measure Waiting time to load a vehicle	24,9%	2,5%	14,9%	9,1%	7,2%	18,1%
Time to load a vehicle	19,4%	15,6%	11,6%	8,8%	6,6%	26,1%
Measure Waiting time to unload a vehicle	18,2%	6,8%	9,8%	7,1%	8,5%	19,8%

Measure Time to unload a vehicle	10,3%	8,1%	10,5%	8,6%	8,5%	25,1%
early statement	5,2%	27,5%	23,3%	34,2%	33,9%	99,8%

Source: National Logistics Survey 2018

The national logistics survey provides a lot of information, but it took into account relevant information to be analyzed for this research, such as the use of technology in service of logistics, which identified the most used technology is the tracking and tracing of vehicles with 45.2%, followed by the electronic invoice, but it is noteworthy that there is 30.7% do not use any technology in the processes of logistics service (Másmela A., 2018). The state of the industry in Colombia was taken into account regarding the use of innovation by economic activity in which it was identified that in the processes to make their logistics operation more efficient the economic activity with the highest percentage is the industry with 54%, followed by transport, the economic activities with the lowest is the agricultural sector with 28.8%, which shows economic activities with high opportunities to improve (Másmela et al., 2018). For the importance of the objectives of this research, the national logistics survey identified the possibility of applying innovation processes in the development of collaborative practices, where mining is the one that presents the highest percentage with 33.4% and the lowest activity is construction with 15.9%, presenting in most cases percentages below 20%, which justifies in part the development of this research.
There is evidence of innovative practices in the different economic activities of the country with low levels of practice, such as the development of open platforms for the exchange of information with percentages below 12%, urban logistics strategies with percentages below 17%, excluding mining with 28.6%. From this analysis, it is interesting to note how night-time logistics activities have very limited practices with better percentages of 6% in general.

Table 7 Percentage of large companies measuring supply and distribution times by economic activity.

Innovation	Agricultural	Mining	Industry	Construction	Trade	Transport
Make your logistics operation more efficient	28,8%	34,4%	54,0%	31,7%	44,2%	45,8%
Development of collaborative practices	22,7%	33,3%	19,6%	15,9%	18,9%	16,2%
Development of open platforms for information exchange	8,5%	2,6%	10,9%	12,2%	12,1%	9,9%
Development of sustainability projects	34,7%	11,2%	12,8%	13,7%	13,0%	25,7%
Urban logistics strategies	4,6%	28,6%	15,2%	15,4%	17,7%	15,5%
Nightly logistics activities	0,7%	2,8%	5,0%	6,8%	2,9%	5,7%
Risk Mitigation Projects	30,2%	52,4%	20,2%	48,2%	18,4%	29,5%
None	32,7%	50,3%	41,8%	45,8%	57,9%	36,5%
Others	3,5%	9,8%	2,9%	0,0%	3,2%	0,0%

Source: National Logistics Survey 2018

5. Statistical analysis

Once the descriptive data of the Colombian National Logistics Survey 2018 was identified, the correlation analysis between the two groups of variables defined in the objective of this research was established. There are two sets of variables in the focus of analysis, one composed of the practices in the logistics processes of Colombian industry, composed of 28 variables, the other group of variables are those conformed by the logistics performance indices and the cost indices of the elemental processes of logistics. The consolidated matrix contains the indicators by industrial sectors, i.e. the information consolidated in tables 6 and 7 of the previous chapter. Once the correlation matrix has been established, the following explanatory data can be used to establish many deductions with this correlation matrix, some of which are decreasing, but with levels of explanation, others increasing, and with variables with different levels of explanation.

Once the matrices have been established to carry out a correlation analysis between the variables of two groups of information, one related to indicators in the logistics processes of industry in Colombia and a second group on practices in the logistics processes of the industry in Colombia, this first group of data identifies the indicators in the logistics processes of the industry in Colombia for each sector, which includes the agricultural, mining, industrial,

construction, trade and transport and storage sectors. The sector to which this survey was most taken was the trade sector with 65.7% and at the same time, it is the one that declares higher foreign trade costs with 54.5%. In this information, it can be identified that the indicators with the highest quality are Quality of orders without damage, Quality of complete orders, Quality of deliveries with documentation and orders on time, in the different sectors. The sector with the highest storage and transport costs due to its economic objective is the transport and storage sector.
The other group of variables and their respective data are the Practices in the logistic processes of the industry in Colombia, in each one of the sectors: agricultural, mining, industry, construction, commerce and transport - storage. What we are looking for with this matrix is how these processes explain the qualified indexes in the logistics of the Colombian industry. In the case of some of the practices in the logistic processes there are correlations like the loading and unloading of a vehicle with a percentage of 99% with administrative costs of the client, this same variable of the group of practices with the one of transport costs with 92%. Raw material inventory rotation days with perfect order with a percentage of 93%. Claims explain 93% of the delivery quality index. Finished goods inventory rotation days explain 91% of the full order delivery quality index. There are more explanatory correlations in this matrix which makes up a total of 252 correlation levels. Bearing in mind that the ones that show more levels of correlation can explain the behavior, in this way all of them have some variable that explains it more than the other variables, this can be shown in the Cartesian plane with the different dimensions. Figure 1.
Table 1. Correlation between variables Practice in the logistic processes of the Industry in Colombia and Logistics Performance Index and Cost

Logistics Performance Index and Cost / ***Practice in the logistic processes of the Industry in Colombia***	Quality index Orders without damage	Quality index Full orders in quantity	Quality index Deliveries with perfect documentation	Quality index Orders on time	Perfect Order Index	Storage cost	Transportation Costs	Administrative Costs and Customer Service Costs	Cost of foreign trade
They consider that customs regulation is safe	0,48	0,40	-0,05	0,20	0,33	0,48	0,58	0,57	-0,23
Complexity in urban distribution	-0,61	-0,15	0,34	0,29	0,10	-0,23	-0,37	-0,21	-0,11
Complexity in national distribution	0,38	-0,48	0,03	-0,51	-0,30	0,11	-0,14	-0,29	0,57
Claims	0,08	-0,46	0,93	0,48	0,56	0,73	-0,24	0,20	0,17
Theft, crime and criminal activity	-0,53	0,27	0,19	0,46	0,28	0,17	0,01	0,12	0,12
Availability at the customer to receive goods	0,87	-0,69	0,37	-0,34	0,01	0,50	-0,10	0,01	0,48
High cost of transportation	-0,08	0,42	0,53	0,70	0,72	0,36	0,58	0,64	-0,63
Deficiencies in specialized logistics infrastructure	0,17	0,27	-0,83	-0,52	-0,53	-0,53	0,15	-0,18	-0,03
Traffic regulations	0,19	-0,02	-0,90	-0,82	-0,78	-0,59	-0,04	-0,45	0,32
Breaking the cold chain	-0,43	0,35	-0,48	0,84	0,66	0,27	0,12	0,45	-0,56
Use of alternative fuels for the transport fleet	-0,01	0,53	0,64	0,91	0,93	0,62	0,68	0,86	-0,71
Use of alternative vehicles (electric, bicycle, etc.)	0,04	-0,84	0,24	-0,46	-0,38	0,01	-0,69	-0,62	0,78
Efficient energy management in distribution centres	0,25	0,35	-0,84	-0,52	-0,48	-0,45	0,31	-0,08	0,05
Reduction of C02 emissions in logistics activities	-0,14	0,01	-0,39	-0,20	-0,32	-0,49	-0,22	-0,26	-0,08
Reverse logistics for the recovery of waste materials	-0,75	-0,14	-0,01	0,05	-0,22	-0,55	-0,55	-0,47	-0,01
Development of packaging or reusable containers	0,03	0,38	0,36	0,52	0,57	0,55	0,49	0,56	-0,29
verify that the packaging	-0,75	-0,08	-0,60	-0,41	-0,71	-0,90	-0,63	-0,78	0,22
early statement	0,73	0,31	0,38	0,39	0,66	0,76	0,81	0,84	-0,39
Inventory rotation days Raw materials	-0,10	-0,19	-0,82	-0,89	-0,93	-0,79	-0,35	-0,75	0,47
Inventory rotation days Finished product	0,24	-0,91	-0,05	-0,71	-0,61	-0,17	-0,80	-0,73	0,84
They measure Waiting time to load a vehicle	-0,46	0,46	0,53	0,91	0,74	0,21	0,30	0,55	-0,74
Time to load a vehicle	0,06	0,82	0,06	0,67	0,65	0,21	0,83	0,83	-0,92
Measure Waiting time to unload a vehicle	-0,19	0,71	0,43	0,96	0,87	0,40	0,65	0,84	-0,89
Measure Time to unload a vehicle	0,42	0,58	0,44	0,71	0,86	0,66	0,92	0,99	-0,74

Figure 1. Correlations of the variables of the practices in the logistic processes in the Colombian industry and the variables of the indexes of logistic performance and costs. Source: Authors

198 correlation results are identified, between the two groups of variables, of these 92 are over 0.5 that is with a high correlation index, of these over 0.8 there are 42 data, they are relative those that are in a decreasing and increasing way, it depends on the analysis that is made by each variable of each group. The practices that are most related to each

index are: for the quality index, orders without damage, the availability of goods to the customer is 87%, and the quality index, complete orders in quantity with the use of alternative vehicles (electric, bicycle, etc.).) with 84%, for the Quality Index Deliveries with perfect documentation with Claims with 93%, for the Quality Index Orders on time with measure Waiting time to load a vehicle with 91%, for the Quality Index Orders perfect with measure Waiting time to unload a vehicle with 87%, Cost Storage with check packaging with 90%, for the Transportation Cost with Midden Time to unload a vehicle with 93%, for the Administrative Cost and Customer Service Cost with Midden Time to unload a vehicle with 99% among other analyses that can be established from each index identifying the practices that most influence their correlations.

5. Validation

As a validation of the correlation results in a mathematical treatment is established where it is sought to find the magnitudes of significance by means of absolute values established by the results of the correlations and these elevated to the square obtaining significant values from 0 to +1, these values represent in a certain way the levels of significance of the previous correlations, where those superior to 0.5 stand out, that is to say, they are variables that have an explanatory relevance of the results among the analyzed variables. These can be seen in figure 2.

Logistics Performance Index and Cost / ***Practice in the logistic processes of the Industry in Colombia***	Quality index Orders without damage	Quality index Full orders in quantity	Quality index Deliveries with perfect documentation	Quality index Orders on time	Perfect Order Index	Storage cost	Transportation Costs	Administrative Costs and Customer Service Costs	Cost of foreign trade
They consider that customs regulation is safe	0,23	0,16	0,00	0,04	0,11	0,23	0,34	0,33	0,05
Complexity in urban distribution	0,37	0,02	0,12	0,08	0,01	0,05	0,14	0,05	0,01
Complexity in national distribution	0,15	0,23	0,00	0,26	0,09	0,01	0,02	0,08	0,33
Claims	0,01	0,21	0,87	0,23	0,32	0,53	0,06	0,04	0,03
Theft, crime and criminal activity	0,28	0,08	0,04	0,21	0,08	0,03	0,00	0,01	0,01
Availability at the customer to receive goods	0,76	0,47	0,14	0,12	0,00	0,25	0,01	0,00	0,24
High cost of transportation	0,01	0,18	0,29	0,49	0,51	0,13	0,34	0,41	0,40
Deficiencies in specialized logistics infrastructure	0,03	0,07	0,70	0,27	0,28	0,28	0,02	0,03	0,00
Traffic regulations	0,04	0,00	0,81	0,67	0,62	0,35	0,00	0,21	0,10
Breaking the cold chain	0,19	0,13	0,23	0,70	0,43	0,07	0,01	0,20	0,32
Use of alternative fuels for the transport fleet	0,00	0,28	0,41	0,83	0,86	0,38	0,46	0,74	0,51
Use of alternative vehicles (electric, bicycle, etc.)	0,00	0,70	0,06	0,22	0,14	0,00	0,48	0,38	0,61
Efficient energy management in distribution centres	0,06	0,12	0,70	0,27	0,23	0,20	0,10	0,01	0,00
Reduction of C02 emissions in logistics activities	0,02	0,00	0,15	0,04	0,10	0,24	0,05	0,07	0,01
Reverse logistics for the recovery of waste materials	0,56	0,02	0,00	0,00	0,05	0,30	0,30	0,22	0,00
Development of packaging or reusable containers	0,00	0,14	0,13	0,27	0,32	0,30	0,24	0,31	0,08
verify that the packaging	0,56	0,01	0,36	0,17	0,50	0,81	0,40	0,60	0,05
early statement	0,54	0,10	0,14	0,15	0,44	0,57	0,65	0,71	0,15
Inventory rotation days Raw materials	0,01	0,04	0,68	0,79	0,86	0,63	0,12	0,56	0,22
Inventory rotation days Finished product	0,06	0,83	0,00	0,51	0,38	0,03	0,64	0,54	0,71
They measure Waiting time to load a vehicle	0,21	0,21	0,28	0,82	0,55	0,05	0,09	0,30	0,55
Time to load a vehicle	0,00	0,68	0,00	0,45	0,42	0,04	0,70	0,69	0,84
Measure Waiting time to unload a vehicle	0,04	0,51	0,18	0,91	0,75	0,16	0,43	0,70	0,79
Measure Time to unload a vehicle	0,18	0,34	0,19	0,50	0,73	0,43	0,84	0,98	0,55

Figure 2. Level of significance between variables of the practices in the logistic processes in the Colombian industry and the variables of the indexes of logistic performance and costs. Source: Authors

An analysis with the table that has the levels of significance can be used from the logistic performance indexes obtained by the industry, and from this analysis which of the practices in the identified logistic processes explains more the obtained result, for example, if it is the one of Cost of Transport, the logistic process that has more

relevance is the one of "Measure Time to unload a vehicle" with 84% then "Measure Time to load a vehicle" with 70% and the third one with "anticipated declaration", In this way, if a policy of improving costs were taken, these are the logistical processes that according to the data are more supportive of the Transport Cost Index.

Logistics Performance Index / ***Practice in the logistic processes of the Industry in Colombia***	Transportation Costs
Measure Time to unload a vehicle	0,84
Time to load a vehicle	0,70
early statement	0,65
Inventory rotation days Finished product	0,64
Use of alternative vehicles (electric, bicycle, etc	0,48
Use of alternative fuels for the transport fleet	0,46
Measure Waiting time to unload a vehicle	0,43
verify that the packaging	0,40
High cost of transportation	0,34
They consider that customs regulation is safe	0,34
Reverse logistics for the recovery of waste ma	0,30
Development of packaging or reusable contain	0,24
Complexity in urban distribution	0,14
Inventory rotation days Raw materials	0,12
Efficient energy management in distribution cer	0,10
They measure Waiting time to load a vehicle	0,09
Claims	0,06
Reduction of C02 emissions in logistics activit	0,05
Deficiencies in specialized logistics infrastructu	0,02
Complexity in national distribution	0,02
Breaking the cold chain	0,01
Availability at the customer to receive goods	0,01
Traffic regulations	0,00
Theft, crime and criminal activity	0,00

Figure 3. Table of major correlations relevant to the cost of transport according to the use of logistic processes practices. *Source: Authors*

In this way, specific analyses can be carried out on each of the indices, whether they are related to costs or to the indices that are qualified in the context of the industry and its logistics processes. This allows an analysis of important information in the decision-making process of the industry in general. Now the construction of a correlation matrix of this style can be established with the industry sector in particular and with the size of the specific industry.

6. Conclusions

A comparison of relevant variables from the groups of variables selected was established and found to be correlated. There is very good and relevant information within the surveys developed by the National Planning Directorate with the National Logistics Survey 2018, which established characterization of the state of the logistics performance indices, classified by the different industrial sectors and with a characterization of the procedures, practices developed in each of them, which can explain the logistics performance indices at different levels of correlation. Correlation techniques are a pertinent mathematical tool when information is available, which can explain behaviors under information and data to validate the existence or not of some level of relationship between one and many variables, it

can be a technique that provides information in time series or taking information as surveys to compare variables within the same surveys.

Classification of information from the 2018 National Logistics Survey was established. By establishing two comparison groups, one of the indices that qualified the logistics performance and another group of the practices developed in the different companies and sectors that could explain the performance indices, it was identified that some of them have a high correlation and explanation, but in a great majority of the variables, low levels of explanation are identified, which could indicate that a revision of the methodology of the national logistics survey would be recommended, Given that it is understood that high indices are self-recognized in the same companies when they have few practices based on technology, and that they could allow good competitiveness and improvement of the indices but that the model reflects low levels of explanation, this also gives an opportunity for new research opportunities in relation to the methodology of identification of the internal logistics performance indices for Colombia, which has been established by the National Planning Department.

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