Evaluation of performance in the supply chain of t-shirts in the north of Ecuador

Neyfe Sablón - Cossío
Postgraduate Institute
Production and Services Group
Technical University of Manabi
Portoviejo, Ecuador
nsablon@utm.edu.ec and nsabloncossio@gmail.com

Erik Orozco - Crespo
Career Industrial Engineering
North Technical University
Ibarra, Ecuador
erikcopo@gmail.com

José Armando Pancorbo - Sandoval
Equinoctial Technical University
Santo Domingo, Ecuador
pancorbo49@gmail.com

Leonardo Manuel Cuétara - Sánchez
Technical University of Manabi
Portoviejo, Ecuador
leonardocuetara@gmail.com

Sonia Emilia Leyva - Ricardo
Equinoctial Technical University
Santo Domingo, Ecuador
son14@nauta.cu

Andrés Marcelo Moreno - Monge
Career Industrial Engineering
North Technical University
Ibarra, Ecuador
ammorenom@utn.edu.ec

Abstract

This research was carried out in the t-shirt supply chain of Northern Ecuador, which sought to evaluate the performance of the chain through an integral indicator. This was done by working with experts and specialists in this area of Mexico, Colombia and Cuba. Where the main indicators to be controlled in its management were identified. The Flexsim softwares, and their Experfit and Experimenter modules, and the SPSS (Statistical Package for the Social Sciences) were used, which made possible the simulation process

of the integral indicator, and in turn, the evaluation of the chain's performance. The application of the proposed procedure to the case of the supply chain under study demonstrates its practical utility, especially in the absence of historical data that allow the chain to be evaluated. Given this situation, it shows that simulation is a way to avoid empirical evaluation of experts and specialists. This chain is evaluated regularly, determined by the individual cost indicator that results in being the most important, not being the case of the other indicators that resulted in the category of good.

Keywords: performance, evaluation, agrifood chain.

1. Introduction

The current performance of companies is a challenge, from meeting the requirements of production and own services to the analysis of external elements such as competition. In a supply chain, the challenge is even greater due to the number of actors that integrate it, along with its heterogeneity and different objectives. To minimize the risks that these may entail, the Scor Model emerges in 1996 as an international standard (APICS, 2015).

The chains based on this model lead to various contributions in terms of their design, programming, planning, performance evaluation and operation of their processes for the satisfaction of end customers (Le Tellier et al., 2017). On the other hand, the concepts of reengineering of business processes, benchmarking, process measurement, good practices and facilitators of information technology are incorporated into this philosophy, and apply them to supply chains (Lockamy et al., 2004).

However, the supply chain approach and its implementation in the Latin American countries face different challenges, these focus on: the low supply chain approach, resource constraints, the weak support of the technologies of information and communications, cultural and organizational barriers, weak technical and physical infrastructure, the shortage of qualified and experienced professionals, the predominance of obsolete and non-integrated production technologies and the high dependence on imports (Georgise et al. , 2013; Georgise et al., 2016). Together with the complexity of this Model for chains composed mainly of SMEs that have a low organizational level and business development.

Ecuadorian chains are not exempt from the previous challenges to face an effective use of the SCOR Model. However, Alomoto says that much of the success of innovation and expansion to international markets will come from companies that use this approach; although some research highlights that for this to be a success, the chain must be up to global companies, so that they can maintain competitive costs, responses and products (Alomoto et al., 2014).

In the studies of the World Bank and the Faculty of Economics of the University of Turku that measure the Logistics Performance Index, Ecuador is ranked 74th and 7th, with respect to 160 economies worldwide and 23 evaluated globally from Latin America and the Caribbean, respectively (World Bank, 2018). The source itself shows that with an index of 2.88, the country behaves above the value recorded for the region (2.66) and shows a moderate growth compared to 2016.

On the other hand, according to the World Economic Forum (Schwab et al., 2017), the Ecuadorian economy is ranked 91 of 137 countries with a score in the Global Competitiveness Index of 3.91, in the 2017-2018 period. The worst evaluated sub-indices are those of business sophistication and innovation that have an impact on the quality of local suppliers, the development of economic clusters, the breadth of the value chain, the control of international distribution and the sophistication of production processes. In addition, the expenses of the companies in R + D + i, the collaboration University-Company in R + D + i, the contracting of the government of products of advanced technologies and the management of patents.

In studies of the current situation of philosophy in supply chains in Ecuador, (Sablón Cossío, 2017), it is presented as a result that:

• Under chain thinking, only the interiors of each company are analyzed.
• Customers and suppliers sometimes see themselves as the competition and not as our allies.
• Absence in the definition and scope of its supply chain.
• Weaknesses in taking into account the requirements of the clients, including not having well-identified clients or market strategies respectively.
• The belief that technology alone is the solution to an efficiency problem, when the right decision is to optimize processes.
• Assume that cost savings should be the only objective to start a process of optimization of the supply chain.
• High inventories in each company, SME and entrepreneur as a solution to the problems of demand.
• The training and training of personnel is not in correspondence with the needs of the supply chain.
• The need to improve the product and the actors in the chain is induced it.

Due to its importance and the current difficult situation, the specific case of the Ecuadorian textile industry whose corporate purpose is the manufacture of textile products and clothing. According to the figures published by the Business Laboratory in the period from 2013-2017 (INEC, 2017), the number of companies in this industry represent 14.64% of the total number of companies belonging to the Manufacturing Industry Section, where they only generate 3.62% of total sales revenue. In the period analyzed, the Textile Division has shown a considerable decrease with negative average variations in the number of companies, sales revenue and the number of workers employed.
In this context, the T-shirt supply chain in northern Ecuador is studied. The objective of this research is it: to design a comprehensive indicator for the evaluation of the performance of the t-shirt supply chain in northern Ecuador through a procedure. The importance of this work lies in the social and economic contribution to a sector in northern Ecuador, where its main activity is the textile component. A theoretical contribution, due to the consolidation of tools in the calculation of an integral index that facilitates the opportunity for improvements.

2. Materials and methods

A proposed procedure is used to achieve the objective. This consists of three phases: general description of the supply chain, selection of indicators and evaluation of the supply chain.
In the first one, the realization of a general description of the supply chain is included. Where the general functions and basic logistics tasks of the chain are determined, as well as the organizational method and the key policies and procedures. Together with the identification of the links and actors of the same, which in turn allow to establish the limits of analysis and the relationship of the chain with the environment.
In the second, the procedure proposed by (Hernández Nariño, 2010) for the identification of indicators in an organization is taken as a starting point. This focuses on the determination of indicators in a supply chain. This consists of five steps: compile the indicators used in the supply chain, register the indicators proposed by the experts, register the indicators proposed in the literature, reduce the list of indicators, and the selection of the main indicators using the coefficient of Kendal concordance (Siegel et al., 1995). Experts from Mexico, Colombia and Cuba were used it.
In the third, the performance of the supply chain is evaluated, through: the determination of the specific weights for the indicators (Fuller's Triangle Method or Saaty Method), the real behavior of each indicator in the actors of the chain and according to the specialists define their standards, the Integral Indicator is determined (Equation 1).

$$\text{II} = \frac{\sum_{i=1}^{n} w_i * P_i}{P_{max}}$$

Where:
II: Comprehensive indicator for the evaluated supply chain
wi: weighting or specific weight granted by experts to indicator i.
Pi: actual score obtained in indicator i.
Pmax: maximum score to be obtained in indicator i.

The intervals for the evaluation of the supply chain are determined using the simulation, the distribution with the greatest discriminative capacity (linear regression model) is determined, and the performance of the supply chain is evaluated according to the percentiles obtained with the simulation (Table 1).

Table 1. The percentiles evaluated.

Evaluation (E)	Bad	Fair	Good	Very Good	Excellent
II	≤P20	(P20;P40]	(P40;P60]	(P60;P80]	>P80

Source: (Moreno Monge, 2019).

From these results it is possible to grant a quantitative and qualitative qualification to the integral performance of the supply chain, based on the states in which each of the indicators considered is found. This procedure is applied in the textile supply chain of northern Ecuador. This application started in January 2018 and it was completed in June 2019.

3. Results

Of the industries dedicated to garment manufacturing there is a group that focuses on the manufacture of T-shirts. The industries involved in the textile chain that are dedicated to the manufacture of T-shirts have a participation of 9.3%, which are a total of 175 actors with respect to the 1873 actors that make up the manufacture of clothing.

Through the mapping of the industries, the analysis of the textile supply chain of Ecuador was carried out and the t-shirt supply chain is selected because it is one of the products most consumed by customers and they are also the most sold by the actors who wish to collaborate with the study (Orozco Crespo et al., 2018). Therefore, the t-shirt chain will be studied and is made up of fives links and 109 actors, it is classified into suppliers of inputs, processing centers, clothing, distribution and customers.
From this step, the indicators used in the supply chain are collected. Raw material suppliers use two indicators. Producers are the ones who use the most indicators for a total of 14 indicators. The distribution centers three indicators. At the client level, the chain only controls one indicator, evens if it is a few actors who control it.
The indicators proposed by the experts are recorded. 9 experts were selected on the subject of supply chains with an average of 19 years in research and from three countries in Latin America and the Caribbean. Of these, 89% are doctors of science in specialties related to supply chains. The rest are trainers of APICS (Association For Supply Chain Management). It is noteworthy how all the experts were with medium and high proficiency coefficients, so all were selected to continue in the study, Table 2.

Table 2: Selection of specialists.

Experts	1	2	3	4	5	6	7	8	9	10	Kc	Ka	K
1										X	1	1	1
2									X		0,9	0,9	0,9
3							X				0,7	0,8	0,75
4							X				0,7	0,8	0,75
5							X				0,7	0,8	0,75
6									X		0,9	0,9	0,9
7									X		0,9	0,9	0,9
8										X	1	1	1
9								X			0,8	0,8	0,8

The experts define a total of 29 indicators and explain that each chain presents specific indicators based on: its products, services, market, type, objective and country.
The indicators proposed in the literature are recorded. Scientific articles, theses of different levels and scientific papers were reviewed, for a total of 20 references of which direct indicators are identified to improve the level of customer service and others to the supply chain in general.
Regarding the level of customer service, 40 indicators are selected within the literature. Of these, 25% (10 indicators) are the most frequently used for decision making in supply chains and result in being the most cited or used by the authors. Regarding the supply chain, 67 indicators are found in the literature, where 23.9% (17 indicators) are the most important for decision-making and employees or cited most frequently by the authors.
On the other hand, the list of indicators is reduced. In this step it is obtained that there is a high coincidence between the indicators proposed by the experts and those found in the literature, not being the case of those that are really determined and controlled in the supply chain and that were mentioned by the specialists. This shows the low control of the chain's performance. This step results in 13 indicators such as those with the highest absolute frequency.
The main indicators are selected, using Kendall's method of agreement, which shows that there are four indicators that are separated from the rest by their level of importance and that reach values in the sum below 34 points, which they are: total process cost (I1), customer service level (I2), lead time (I3) and chain capacity (I4). It is observed how the value of the Kendall concordance coefficient is close to unity, which indicates a high concordance of the experts in the arrangement given to the indicators according to their importance. The above is tested by rejecting the null hypothesis at 5% significance, evidencing that there is agreement in the experts' criteria.

In order to evaluate the real behavior of the indicators, the analysis focused on the links of preparation and distribution, mainly in those actors that are dedicated to the manufacture of t-shirts and that in turn have their own trade. Of the 95 actors, only 10 decided to provide information related to the indicators analyzed. Of these, 2 are medium-sized companies and 8 are small businesses. Information was collected for the months of January and February 2019.
As an approximate unit cost of the chain, the total production cost was divided by the total number of shirts produced in the two months, for a resulting unit cost of $ 2.91 per unit produced. The above regardless of the type of shirt in question.
The level of customer service was determined as the probability that orders will be satisfied on the established date and without return problems due to quality or quantity problems, for a chain reliability of 84.10%. These orders were determined their lead times, from the time the customer makes the order until it is delivered, for an average of 3.15 weeks.
The indicator of the production capacity of the chain was estimated considering: the average annual sales revenue for small and medium enterprises corresponding to the 2013-2017 period; the amount of small and medium enterprises for the same period, the percentage of the total production that is destined to the production of t-shirts and that comes from the surveys applied in Orozco Crespo et al. (2018); and the average sales prices of the 10 actors analyzed. All this contributed to the fact that the analyzed t-shirt production chain has a production capacity of 880766 t-shirts of any nomenclature per year.
Since there is no historical behavior of the selected indicators, it is decided to simulate them to determine their performance intervals. The values of minimum, fashion and maximum stated by the specialists. The models obtained for the triangular (T), lognormal (LN) and weibull (W) distributions are shown, as well as the percentiles and regression models of a variable that each one generates (Table 3 and 4).
H0: B1 = 0 There is no linear regression between the variables
H1: B1 ≠ 0 If there is linear regression between the variables

Table 3. Regression model for the t statistic for B1

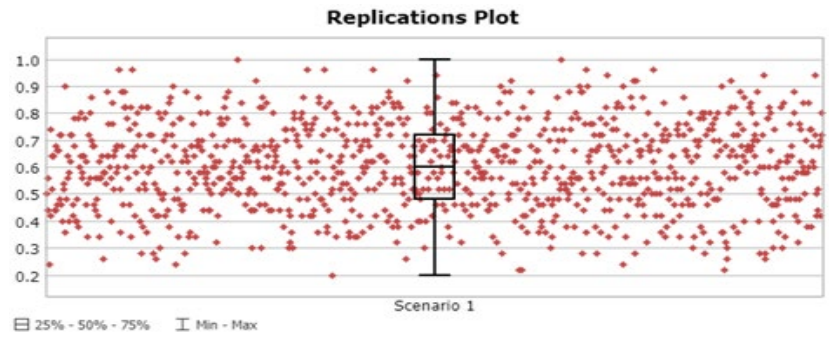
Di	Model	T statistic for B1	Sig.
Triangular	ŷ= -2,068+8,616*X	106,936	0,000
LogNormal	ŷ= -2,043+8,537*X	102,107	0,000
Weibull	ŷ= -2,144+8,692*X	103,633	0,000

Table 4. Summary of the regression analysis

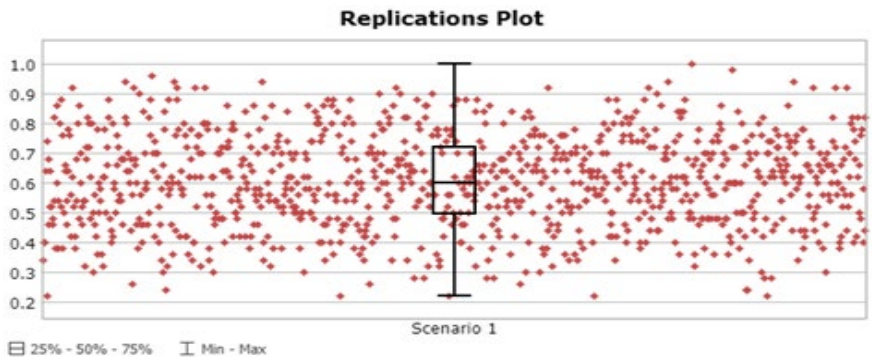
Di	Statistic F	Sig.	R2
Triangular	11435,228	0,000	0,920
LogNormal	10425,930	0,000	0,913
Weibull	10739,706	0,000	0,915

Box diagrams are made for the replicas of the simulation results, Table 5. The FLEXIM software is used.

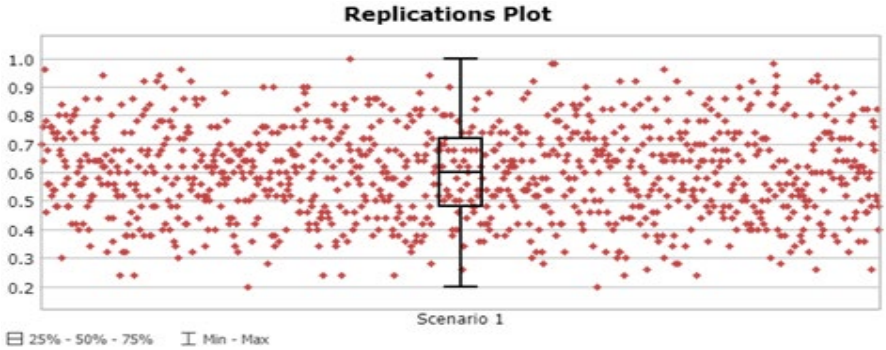
Table 5. Results of replicas by distribution.



Triangular



LogNormal



Weibull

In relation to the above elements, the supply chain is evaluated. The simulation results for the Integral Indicator are obtained. Depending on the analysis, the supply chain is evaluated, Table 6.

Table 6. Results of the Integral Indicator for the Triangular distribution.

Indicator	**Current value**	**Evaluation**	Bad	Fair	Good	Very Good	Excellent
			1	2	3	4	5
Cost ($)	2.91	Fair	3,45	(2,81;3,45]	(2,32;2,81]	(1,89;2,32]	≤1,89
Customer service level (%)	84,10	Good	≤77,75	(77,75;81,03]	(81,03;84,51]	(84,51;89,05]	>89,05
Time (weeks)	3,15	Good	4,00	(3,17;4.00]	(2,54;3,17]	(2,00;2,54]	≤2,00

Production capacity (millions of units / year)	0,880766	Good	≤0,7673	(0,7673;0,8366]	(0,8366;0,8902]	(0,8902;0,9517]	>0,9517
Integral Indicator	0,52	Fair	≤0,4519	(0,4519;0,5515]	(0,5515;0,6393]	(0,6393;0,7395]	>0,7395

All this allows the Integral Indicator to be evaluated as follows:
II = (0.4 * 2 + 0.3 * 3 + 0.2 * 3 + 0.1 * 3) /5=0.52

Given this result, it is stated that the performance of the t-shirt production supply chain is regular in relation to the value determined for the Integral Index. Even when individual indicators are not evaluated in the same way. The costs have a regular performance (2.91); the chain cycle is well (3.15), the production capacity is 0.880766 million shirts per year, so it is evaluated as good and the service level is well (84.10). This corroborates the SCOR Model approach that states that an integral indicator can be located in a given performance while its individual indicators have another value (APICS, 2018), due to the interrelation between processes, flows and indicators. In addition, from the mathematical point of view and in the case of this supply chain, the indicator that brings more weight to the integral index is the cost indicator.
These elements leave open future investigations regarding the relationship and interdependence in the processes and flows of the supply chain of T-shirt production. Together with the need for a comparative study among other chains with similar conditions and products, that is, a benchmarking study.

4. Conclusions

For those supply chains that do not record historical data for their indicators and that do not have an integral indicator, this tool allows obtaining performance intervals from a simulation process that are closer to the reality of the system than if these intervals were determined empirically by experts or specialists, which increases the accuracy of the evaluation.
The supply chain under study presents a regular performance evaluation. Individual indicators are evaluated between the regular and good categories. The cost indicator, being the most important, determines the most comprehensive evaluation.

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Biographies

Neyfe Sablón Cossío is a professor and researcher in Industrial Engineering career at the Technical University of Manabi, Portoviejo, Ecuador. She holds a Bachelor's degree in Industrial Engineering from Matanzas University. She is also graduated with a Master degree in Business Administration and PhD in Science Technical Industrial Engineering. All these studies carried out in Cuba. She has published several journals and conference papers. Dra. Sablón has accomplished research project on supply chains in Mexico, Cuba and Ecuador. Her research interests include administrations, business, logistic, operations administrations, supply chain and value chain.

Erik Orozco Crespo is a professor and researcher in Industrial Engineering career at the North Technical University, Ibarra, Ecuador. He has a degree in Industrial Engineering from the Central University "Marta Abreu" of Las Villas, Cuba. In addition, he has a Master's degree in Industrial Engineering at this university. He has published several conference papers related to the operations management and the discrete event simulation, areas that constitute his interests for research.

José Armando Pancorbo Sandoval is a professor and researcher in Industrial Engineering career at the Equinoctial Technical University, Santo Domingo, Ecuador. He has a degree in Accounting from Matanzas University, Cuba. He has a PhD degree in Business Management from University of Leon, Spain. His research interests include administrations, business, logistic, operations administrations, supply chain and value chain.

Leonardo Manuel Cuétara Sánchez is a professor and researcher at the Technical University of Manabi, Portoviejo, Ecuador. He has a Master's degree in Tourism and Hotel Management from Matanzas University. In adition, he has a PhD degree in Economic Sciences at this university. His research area is the evaluation of tourism services, which includes logistics services and supply chains.

Sonia Emilia Leyva Ricardo is a professor and researcher in Industrial Engineering career at the Equinoctial Technical University, Santo Domingo, Ecuador. She has a Master's degree in Environmental Management from Matanzas University. Her research interests include administrations, business, logistic, operations administrations, supply chain and value chain.

Andrés Marcelo Moreno Monge is a graduate of the Industrial Engineering degree at the North Technical University, Ibarra, Ecuador.