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Key Performance Indicators for the Supply Chain in Small and Medium-Sized Enterprises based on Balance Score Card

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Abstract

A supply chain is a network of interaction between different actors, and indi-cators govern its behavior. The current research deals with the analysis and ranking of critical indicators for the supply chain in small and medium-sized enterprises (SMEs). To this end, firstly, a systematic review of supply chain management indicators for SMEs was carried out. Using data sources such as Scopus, ProQuest, and Google Scholar, 189 metrics were selected. Then, through practical and methodological filters, this number was reduced to 149. To organize these indicators, both models, the Balanced Scorecard (BSC) and the Supply Chain Operations Reference (SCOR-model), were used to connect company strategies to their performance. Secondly, these measures formed part of a questionnaire answered by 30 SME experts. From their responses, critical indicators were evaluated through Principal Component Analysis (PCA), resulting in 50 key indicators. Finally, these indicators were ranked using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). For SCM in SMEs, findings indicate that the primary key perfor-mance indicators (KPIs) are cash flow, satisfaction rate, inventory rotation, and exchange of information through the supply chain.

***Keywords:**Supply Chain; SME; PCA; TOPSIS; Critical Indicators; SCOR; BSC..*

Introduction

Nowadays, organizations compete in saturated markets. They often seek to gain a competitive advantage by propagating their models, products, and ideas among their partners. This is managed in a Supply Chain (SC) that often involves coordinating materials, information, and the flow of payments among companies. SC has become a central focus for strategy Puffal & Kuhn (2018) and a critical factor in securing a competitive advantage. Prominent companies such as McDonald’s, Amazon, and Unilever recognize the importance of SC, treating it as a top priority due to its variability and process complexity (Boute et al., 2014; F. Georgise et al., 2017; Sellitto et al., 2015). Thus, effective Supply Chain Management (SCM) has become a potentially valuable manner of securing competitive advantage and improving organizational performance since competition is no longer among organizations but among SC (Li et al., 2006).

Several models are currently used to evaluate organizational performance, such as the Supply Chain Operations Reference (SCOR-model) and the Balanced Scorecard (BSC). The former is a process reference model that describes, measures, and evaluates any SC configuration. It is considered a

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"quasi-standard" to support and model SC processes in an integrated manner (F. Georgise et al., 2017). The SCOR-model enables organizations to examine their SC architecture through consistent management parameters to achieve desired results. It is formed by a plan, source, make, deliver, and return (Poluha, 2007). The SCOR-model has been adapted to different circumstances and scenarios as well as to different industries such as manufacturing, construction, service, logistics operations, and collaborative SC networks (Sellitto et al., 2015). The latter was developed by Kaplan and Norton in the early 90s (Kaplan & Norton, 2004). BSC focuses on business strategy from four perspectives: finance, customers, internal processes, and learning and growth (Kaplan, 2009). Many studies combine both models (F. B. Georgise et al., 2012; Holmes et al., 2006; Liu et al., 2018); however, significant results only occur when considering the type of company, industrial sector, organizational culture, and the size of the organization. All of these models focus on supporting a part of an organization to achieve planned goals. Both SCOR-model and BSC have key performance indicators (KPI) that allow companies to achieve their objectives.

In general, companies want to improve SC performance through different KPIs. KPIs represent a set of markers focusing on aspects of organizational performance that are critical for the current and future success of the organization (Alvandi et al., 2012). KPIs 1) provide essential information about an organization, 2) yield insight into the effectiveness of strategies, and 3) identify successes and potential opportunities (Jardioui et al., 2016; Ramaa. et al., 2009). KPIs have been the subject of many publications (Cai et al., 2009; Cunha Callado & Jack, 2015; Monczka et al., 2009; Shafiee et al., 2014), and have been classified as vital and useful within the SC. They have been noted for their contribution to business performance and competitiveness (Shafiee et al., 2014), optimizing cost, quality, and service. Studies have delineated a wide variety of KPIs classes, which has made it difficult not only to implement KPIs but also to improve them as a whole (García-Arca et al., 2018). Furthermore,Lockamy & Mccormack (2004) conclude that only a few studies attempt to empirically link specific SC practices with particular KPIs. Thus, if metrics in SC lack consistency, it is difficult for managers to make the right decisions along the chain.

There are several manners and methods to evaluate KPIs, being rank theory among the most effective methods. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is one of the best and most practical of multi-criteria decision-making methodologies in the ranking (Shirouyehzad et al., 2016). With this technique, two alternatives (best and worst) are compared. According to Behzadian et al. (2012), TOPSIS has been applied across a diverse range of fields, including SC, logistics, manufacturing, health, safety, environmental management, and human resources

This paper represents a search for critical factors in the SCs of manufacturing companies through a literature review. These factors were categorized according to the BSC and SCOR models. Then, a questionnaire based on the categorized list of selected critical factors was sent to managers of a variety of manufacturing companies. Answers were analyzed employing Principle Component Analysis (PCA) to delineate a set of factors that can accurately evaluate performance. Finally, these factors were ranked with TOPSIS.

I. RESEARCH FRAMEWORK

Due to the significance of identifying organizations' KPI, a systematic review was developed. Therefore, a list of possible KPI was incorporated into the pilot questionnaire and the final questionnaire. The data collected was analyzed using techniques such as PCA and TOPSIS, thought the following process: development of a literature review, design of a questionnaire, collection of data, analysis of factors, and KPIs selection with TOPSIS method (Fig1).

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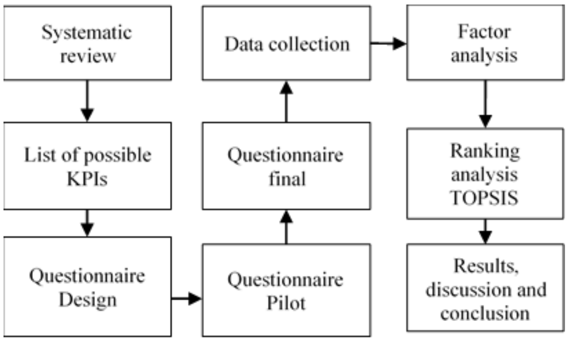

Fig. 1. Research framework for study

Systematic Review

A literature review is a concise summary of the best available evidence that uses methods to identify and synthesize relevant studies on a particular topic (Dyba et al., 2007). The literature review follows the methodology proposed by Fink (1998) that is described in seven main tasks: 1) selecting research questions, 2) selecting databases, 3) choosing search terms, 4) applying practical screening criteria, 5) applying methodological screening criteria, 6) doing the review, and 7) synthesizing the results.

The research questions in the present study include the following: What is the performance KPIs of a SC? What management models do companies use to measure their performance? The initial reading list for the review covered almost 50 articles, all published in different journals about technology, management, and production. These preliminary articles resulted from a search on three scientific digital bases: Scopus, Google Scholar, and Taylor and Francis. Because of the multi-disciplinary nature of the SC and the significant number of findings, it was necessary to delimit the search with the keywords: "optimization," "supply chain," "performance measure," and "SMEs"(Arzu Akyuz & Erman Erkan, 2010).

In the research, a practical screening criterion was used, where articles dealt with indicators from a behavioral systems approach. After a first classification, 19 articles were selected as the basis of the research (Table 2.1). Afterwards, a set of 185 indicators were obtained. In addition, a methodological screening was performed. The whole list was classified based on the BSC framework proposed by Bhagwat & Sharma (2007). Moreover, an approximation using the SCOR-model framework proposed by Sellitto et al. (2015) was developed. The 185 indicators found were classified, based on the BSC perspectives (Kazancoglu et al., 2018). These indicators comprised part of the first list.

Questionnaire Design

Once the list of indicators was divided into subcategories and perspectives, the questionnaire design phase started. Firstly, a pilot questionnaire focused on conducting an online survey and how to answer it. A select group of experts, i.e., ten professors and researchers specialized in SC and BSC, reviewed each indicator. The initial 185 indicators were evaluated, and as a result, a smaller set of 149 indicators was obtained. These indicators formed part of the final questionnaire. The indicators in the final questionnaire were categorized and evaluated using a five-point Likert Scale, with one being the least relevant and five the most relevant. This questionnaire concluded with an open-ended comments section where evaluators could write observations. This questionnaire was sent with an online survey tool, which helped the study in two ways. On the one hand, it made it easier to tabulate answers; and, on the other hand, it allowed to send the survey to experts via email.

Data Collection

The final questionnaire was conducted from February to April 2019, and 31 responses were obtained. It was addressed to professionals in the industry, such as logistics managers, planning managers, operations managers, and SC experts. Various enterprises from Cuenca, Ecuador, were selected. Respondents experts in the SME SC area had an average of 11 years of experience

Table 2.1. Distribution of the articles according to journals.

Query	***Journal***	Reference

optimization"	*Cluster Computing*	(Xiong et al., 2018)
"supply chain" AND "optimization."	*Computers and Operation Research*	(Fahimnia et al., 2018)
"supply chain" AND "performance measure."	*Benchmarking: An International Journal*	(Gawankar et al., 2017; Thakkar et al., 2009)
"supply chain" AND "optimization" AND "performance measure."	*International Journal of Production Research*	(Sellitto et al., 2015; Sitek & Wikarek, 2015; Wudhikarn et al., 2018)
"supply chain" AND "optimization."	*International Journal of Sustainable Development and World Ecology*	(Caiado et al., 2018)
"supply chain."	*Journal of Industrial Engineering International*	(Golrizgashti, 2014)
"supply chain" AND "performance."	*Decision Support Systems*	(Cai et al., 2009)
"supply chain" AND "performance measures."	*International Journal of Productivity and Performance Management*	(Cunha Callado & Jack, 2015)
"supply chain."	*Handbooks of Management Accounting Research*	(Kaplan, 2009)
"supply chain" AND "optimization."	*Applied Mathematical Modelling*	(Shafiee et al., 2014)
"supply chain" AND "optimization."	*Australian Journal of Basic and Applied Sciences (AJBAS)*	(Azadeh et al., 2010)
"supply chain" AND "optimization."	*13th International Conference on Modern Technologies in Manufacturing*	(Ucenic & Ratiu, 2017)
"supply chain" AND "performance measures."	*Computers and Industrial Engineering*	(Cho et al., 2012)
"supply chain" AND "optimization."	*Supply Chain Management: An International Journal*	(Giannakis, 2011)
"supply chain" AND "optimization."	*Journal of Cleaner Production*	(Kazancoglu et al., 2018)
"supply chain"	*Journal of Cost Management*	(Boute et al., 2014)

The data obtained were tabulated, classified, and ordered in manners suggested by the respondents. The survey was delivered to the Chief Operating Officers (COO's) and/or Chief Executive Officer (CEO's) of each organization in two ways, personally and by email. In the email, a link to the survey was attached, allowing the person to answer the survey online.

The survey with the final questionnaire was divided into four perspectives, based on the BSC model: Financial, Client, Internal Processes, and Learning. Each perspective included all 149 indicators divided into four perspectives. The survey had a Cronbach's alpha of 0.8045, which verifies a suitable internal consistency between the analyzed indicators. Therefore, it can be concluded that no distortions imputed to instrument defects were detected. The responses were analyzed using the statistical package SPSS version 23. In addition, each indicator was rated using a Likert-type scale. Statistical analyses such as mean, standard deviation, and normalization were used. Normalization contributed to the

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selection criteria for the indicators, using only items with normalized values of ≥ 0.5 and with standard deviations of <1 (Fig 2). Using these criteria, 72 indicators were selected.

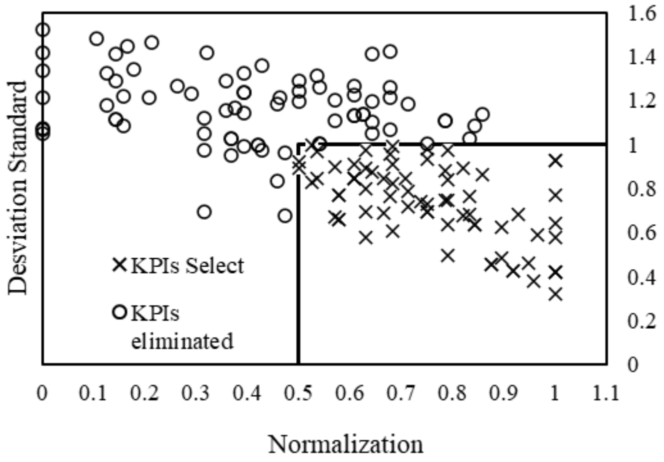

Fig. 2. KPIs selected for factor analysis

Factor Analysis

To reduce study variables, a PCA was performed (Adabre & Chan, 2019; Sánchez-Sellero & Sánchez-Sellero, 2018). According to Jaimeset al. (2018), the criteria for variables reduction are 1) moderate correlations, 2) the Bartlett sphericity test, and 3) the Kaiser-Meyer-Olkin test (KMO). To apply PCA, the Bartlett sphericity test and a KMO test were performed, and the results' significance was tested. These tests were significant since their value was $p < 0.05$, and correlations between the indicators were low ($R^2 = 0.60$). Given this, the Promax method with a kappa of 4 was chosen (Hendrickson & White, 1966). Finally, PCA showed the results of the reduction of dimensions. For each category of the final questionnaire, the main components were reduced to three or four. These components explain more than 75% of the variance of the data (Table 2.2 - Table 2.5).

TOPSIS Selection

TOPSIS is a Multi-Criteria Decision Aid (MCDA). It evaluates, assesses, and ranks alternatives across various criteria. TOPSIS respondents choose between ideal and non-ideal alternatives, according to the shortest distance from the ideal solution and the farthest distance from the non-ideal solution. An ideal alternative includes the maximum advantage, whereas a non-ideal includes the minimum advantage (Ilangkumaran & Kumanan, 2009; Shirouyehzad et al., 2016). TOPSIS evaluates alternatives as matrix $A = \{A_1 + A_2 + \cdots + A_m\}$ and a set of criteria $C = \{C_1 + C_2 + \cdots + C_n\}$. These two matrices work to achieve a set of ordered alternatives. The procedure of TOPSIS involves several steps (Behzadian et al., 2012): Step 1 is about constructing a normalized decision matrix $r_{ij} = x_{ij} / \sqrt{\sum x^2{}_{ij}}$ for i=1 to m; j=1 ton. Step 2 constructs a weighted normalized decision matrix $v_{ij} = w_i r_{ij}$. Weights of each criterion that are involved in the decision are evaluated. Step 3 determines positive and negative solutions $A^* = \{v1^*, \ldots, vn^*\}$, where, $vi^* = \{\max(v_{ij})\, if j \in J\, ; \min(v_{ij})\, if j \in J'\}$ (Positive ideal solution); $A' = \{v1', \ldots, vn'\}$, where $vj' = \{\min(v_{ij})\, if j \in J\, ; \max(v_{ij})\, if j \in J'\}$ (Negative ideal solution). Step 4 calculates Euclidean distance of each alternative with respect to the positive and negative solution, $D_i^+ = [\sum(v_i^* - v_{ij})^2]^{1/2}$ i = 1,…, m (separation from positive ideal alternative), $D_i^- = [\sum(v_i' - v_{ij})^2]^{1/2}$i = 1,…, m (separation from negative ideal alternative). Step 5 compares the distance of the alternative with respect to the negative solution and the positive solution and calculate the solution closest to 1,$C_{Li}^* = S_i' / (S_i^* + S_i')$, 0 <$C_i^*$<1.

TOPSIS was applied in the study to each perspective. The normalized decision matrix was developed per case. To make the weighted normalized decision matrix, each weight was developed per company considering years of experience and the importance of the organization in each market (Table 2.6).

Table 2.2 Results of PCA for the financial category

Cod	Financial Perspective	Component			
		1	2	3	4
F25	Fixed cost of shipping from the factory to the distributor by type of transport used	0.99	-	-	-
F33	Percentage of the logistics budget	0.94	-	-	-
F32	Inventory Level	0.92	-	-	-
F31	Efficiency of the Sales area	0.79	-	-	-
F24	Percentage of sales completed	0.78	-	-	-
F43	Revenue per customer	0.73	-	-	-
F5	Total cash flow time	-	0.98	-	-
F17	Total inventory cost as out of stock products	-	0.92	-	-
F2	Cycle time from cash to cash	-	0.83	-	-
F12	Total inventory cost as incoming stock level	-	0.76	-	-
F37	Profit versus productivity rate	-	-	0.86	-
F6	Indebtedness	-	-	0.84	-
F1	Final net profit	-	-	0.75	-
F22	Operating cost per hour	-	-	0.73	-
F26	Product demand	-	-	-	0.92
F40	Revenue by-products	-	-	-	0.87

Table 2.3 Results of PCA for the customer category

Cod	Customer Perspective	Component			
		1	2	3	4
C13	Employee Satisfaction	0.95	-	-	-
C18	Delivery lead time	0.94	-	-	-
C19	Customer Retention Rate	0.87	-	-	-
C26	Customer Satisfaction Rate	0.87	-	-	-
C21	Product reprocessing percentage	0.86	-	-	-
C4	Delivery time of the order	0.81	-	-	-
C17	Percentage of orders on time dispatched to the customer	0.77	-	-	-
C14	Average customer order delivery time	-	1.03	-	-
C6	Reliability of orders to serve the customer	-	0.89	-	-
C8	Flexibility of the service system to meet the particular needs of the client	-	0.8	-	-
C5	Quality level of after-sales service	-	-	0.78	-
C25	Value level perceived by the customer about the product	-	-	0.73	-
C1	Percentage of orders delivered to customer	-	-	-	0.81

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Table 2.4. Results of PCA for the Process Internal category

Cod	Process Internal Perspective	Component			
		1	2	3	4
PI5	Percentage of orders accepted from the supplier	0.98	-	-	-
PI9	Average delivery time of the supplier	0.88	-	-	-
PI4	Percentage of deliveries on time from the supplier	0.86	-	-	-
PI26	Reception cycle time	0.83	-	-	-
PI18	Inventory rotation	0.79	-	-	-
PI14	Inventory cost	0.78	-	-	-
PI48	Frequency of delivery from a distributor	-	1	-	-
PI50	Shipping time from the distributor to the customer, depending on the type of transport	-	0.89	-	-
PI38	Preparation time of a shipment	-	0.83	-	-
PI16	Damaged and obsolete inventory	-	0.79	-	-
PI21	Rate of non-dispatched products	-	-	0.93	-
PI52	Flexibility to demand variation	-	-	0.89	-
PI20	Storage space utilization percentage	-	-	0.71	-
PI39	Preparation time or Set up	-	-	-	0.81
PI23	Inventory service level for orders	-	-	-	0.71

Table 2.5. Results of PCA for the Learning category

Cod	Process Internal Perspective	Component			
		1	2	3	4
AP9	Timeliness of the information	0.97	-	-	-
AP3	Percentage of personnel with responsibilities for the position	0.87	-	-	-
AP1	Percentage of trained employees	0.69	-	-	-
AP5	Percentage of staff utilization	-	1.01	-	-
AP11	Level of the motivation of CS staff	-	0.78	-	-
AP6	Exchange of information through the CS	-	-	0.95	-

Table 2.6. TOPSIS in each perspective of the study

Weight matrix Financial Perspective																
	E1	E2	E3	E4	E5	E6	E7	E8	E 9	E10	E11	E12	E13	E14	E15	
Weight	0.138	0.006	0.006	0.062	0.069	0.076	0.069	0.048	0.069	0.138	0.138	0.020	0.138	0.034	0.0484	
Ranking matrix Financial Perspective																
KPIs	F1	F2	F5	F6	F12	F17	F22	F24	F25	F26	F31	F32	F33	F37	F40	F43
Di+	0.014	0.259	0.007	0.031	0.259	0.259	0.015	0.012	0.010	0.025	0.021	0.022	0.013	0.025	0.021	0.024
Di-	0.260	0.031	0.261	0.259	0.023	0.022	0.260	0.261	0.261	0.259	0.260	0.260	0.261	0.259	0.260	0.26

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CLi	0.076	0.008	0.078	0.071	0.006	0.006	0.076	0.077	0.077	0.073	0.074	0.074	0.076	0.073	0.074	0.07
Rank	**5**	**14**	**1**	**13**	**15**	**16**	**6**	**3**	**2**	**11**	**7**	**9**	**4**	**12**	**8**	**10**

Weight matrix Customer Perspective

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17
Weight	0.007	0.06	0.070	0.003	0.141	0.021	0.02	0.014	0.007	0.070	0.212	0.077	0.070	0.049	0.02	0.14	0.007

Ranking matrix Customer Perspective

KPIs	C1	C4	C5	C6	C8	C13	C14	C17	C18	C19	C21	C25	C26
Di+	0.02	0.02	0.03	0.02	0.038	0.031	0.03	0.025	0.025	0.028	0.025	0.025	0.024
Di-	0.044	0.03	0.036	0.04	0.031	0.035	0.03	0.039	0.039	0.036	0.039	0.040	0.040
CLi	0.08	0.07	0.065	0.08	0.060	0.071	0.06	0.083	0.083	0.076	0.082	0.083	0.084
Rank	**5**	**8**	**11**	**6**	**13**	**10**	**12**	**4**	**3**	**9**	**7**	**2**	**1**

Weight matrix Process Internal Perspective

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16
Weight	0.005	0.051	0.0576	0.002	0.115	0.017	0.011	0.005	0.057	0.115	0.040	0.0634	0.057	0.040	0.017	0.115

Ranking matrix Process Internal Perspective

KPIs	PI4	PI5	PI9	PI14	PI16	PI18	PI20	PI21	PI23	PI26	PI38	PI39	PI48	PI50	PI52
Di+	0.011	0.023	0.023	0.012	0.020	0.010	0.015	0.019	0.020	0.019	0.021	0.015	0.023	0.019	0.019
Di-	0.027	0.020	0.019	0.027	0.018	0.027	0.019	0.024	0.023	0.020	0.017	0.022	0.015	0.017	0.021
CLi	0.087	0.057	0.055	0.085	0.058	0.088	0.068	0.068	0.065	0.063	0.055	0.072	0.049	0.058	0.065
Rank	**2**	**12**	**13**	**3**	**10**	**1**	**6**	**5**	**7**	**9**	**14**	**4**	**15**	**11**	**8**

Weight matrix Learning Perspective

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
Weight	0.0094	0.0845	0.0939	0.0047	0.1878	0.1127	0.028	0.0657	0.1033	0.0939	0.0282	0.1878

Ranking matrix Learning Perspective

KPIs	AP1	AP3	AP5	AP6	AP9	AP11
Di+	0.0441	0.0295	0.0421	0.0177	0.0300	0.0466
Di-	0.0282	0.0333	0.0311	0.0492	0.0428	0.0238

CLi	0.1297	0.1764	0.1412	0.2448	0.1955	0.1124
Rank	**5**	**3**	**4**	**1**	**2**	**6**

Note: E=enterprises; Di+= Distance to positive ideal solution; Di-= Distance to negative ideal solution; CLi= distance calculated.

II. RESULT AND DISCUSSION

One thing that stands out in this study is the respondents' experience; professional experience averaged around 11 years. The survey sent to enterprises had a considerable number of indicators (149), especially in the internal process perspective. An exploratory factorial analysis (PCA) showed that a reduced set of factors satisfactorily represented the first indicators of internal structure (Tables 2.2–2.5). A PCA in financial indicators showed that four factors were obtained accordingly. These factors preserved 78.41% of the variability. The first factor explained that 42.33% of the total variability and contained the most typical indicators of financial perspective. In this perspective, some metrics, like the fixed cost of shipping from the F25, F33, F32, were highly valuable within SC. In the customer's perspective, four factors represented 75.41% of the variability. The first component contributes with 42.82% that are ten indicators. The internal processes perspective began with a large number of metrics (57); the PCA reduced the information to four factors that represent 78.02%. The first factor contributed to 51.137% of the information. In this perspective, metrics about suppliers were selected. In the learning and growth perspective, 11 indicators were reduced to four components to explain 94.57% of the variability.

From the financial perspective, its 16 indicators could be clustered into four parts. The first refers to distribution, featuring indicators such as F25, F33, F32, F31, F24, F43. These indicators show the shipment cost of the product to the customers. The second is the inventory with indicators, such as F5, F17, F2, and F12 (Monczka et al., 2009). This suggests that inventory, in all SC, is an essential issue because its successful management guarantees product availability throughout the SC. The third refers both to customer's revenues and to the type of product, including indicators F37, F6, F1, and F22. These financial indicators mostly relate to customers in SC. The fourth involves indicators F26 and F40. These indicators refer to customers' demand for each product in the company, in addition to resulting sales revenue.

The customer's perspective involves four parts. The first part refers to shipping to customers with indicators C13, C18, C19, C26, C21, C4, and C17, where shipping time is an indicator. These indicators are vital for a company since they involve relevant information for the client and its products. The second is about the flexibility of services delivered to the customer, described by indicators C14, C6, and C8, which measure the changes that customers make in their orders. The third part refers to quality as perceived by the customer (C5 and C25), which is essential for quality assurance. Finally, the fourth pertains to quality systems, including indicator C1, which indicates how many orders were sent to different clients.

The internal processes perspective also involves four parts. The first deals with suppliers (PI5, PI9, PI4, PI26, PI18, and PI14), where the inventory level and deliveries from suppliers are considered. Suppliers are an essential part of SC. The second is about the distributor, including indicators PI50, PI38, and PI16. The third takes into account delivery delays, which are a problem in SC, including indicators PI21, PI52, and PI20. The fourth refers to orders, another important topic for the SC, with indicators PI39, and PI23. The learning perspective has three parts. The first refers to competence with indicators AP9, AP3, and AP1, while the second part includes motivation indicators AP5 and AP11. The third part refers to information through SC (AP6).

After the dimensional reduction was achieved using the PCA, TOPSIS was applied to rank the KPIs. Closer inspection of Table 2.6 shows how cash flow is the most critical indicator in the financial perspective. This is not surprising since companies depend upon cash flow to address short- and long-term challenges. The customer perspective had some indicators as satisfaction rates. Service quality is related to the ability of the organization to respond to client needs. Perceived service quality is the second indicator in the ranking of this perspective. In the internal process perspective, rotating inventory was the primary KPI. A lack of inventory can cause shortages in the chain, and an excess can cause problems for customers. This shows that inventory turnover is a critical metric. Finally, the learning perspective relates to the exchange of information throughout SC. Some problems are rooted in a lack of communication; it can, for example, result in excess inventory or order delivery problems

III. CONCLUSION

A supply chain has different actors whose behavior is governed by indicators. The main objective of this study was to identify critical indicators in the SC of small and medium-sized companies. A sample of 31 SMEs in the city of Cuenca, Ecuador, were analyzed using descriptive and inferential statistics. Officers of different SMEs evaluated 149 indicators, and a statistical analysis reduced this number of indicators to 50 KPIs. KPIs were grouped into different factors containing different numbers of indicators. Interactions of KPIs were described concerning different dimensions: inventory, distribution, customer, provider, information, personnel. Moreover, this research contributes to improving performance, monitoring costs in the chain, and tracking external behavior with suppliers and distributors. This will allow companies to align strategies with performance. Ranking KPIs in each perspective allows organizations to prioritize these indicators.

Some metrics considered important in the literature, such as the ROI or the level of indebtedness, were not deemed significant in the current investigation. Likewise, large investments or indebtedness were not assigned a high priority. Operating costs and productivity are metrics with a high degree of significance. Additionally, the research demonstrates the importance of inventory and service level in improving the productive model of a company.

The limitations of the research are related to studying only small manufacturing enterprises. Future contributions could compare these SME indicators with indicators of large companies. In addition, it would be helpful to evaluate the effects of these critical indicators as they interact with dependent variables like utility or cost.

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