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Supply Chain Management Performance Measurement. Case Studies from Developing Countries

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Abstract: Supply chain management is critical for companies (suppliers, distributors, manufacturers, and retailers) and researchers. Supply chain sustainability is important in Developing Countries. To evaluate the performance of supply chains in companies located in Developing Countries like Albania and Kosovo, this article will examine the findings of the Supply Chain Operation Reference (SCOR) model. Utilizing the SCOR model can improve a company's' chances of survival and rivalry in the market. The selection of Performance Attributes appears to be the standard for measuring performance. By contrast, Snorm De Boer normalization equates the importance of Key Performance Indicators (KPIs), the Analytical Hierarchy Process (AHP) calculates the weighted criteria of KPIs, and Objective Matrix (OMAX) analyzes the measurement results of the KPIs. This article identifies unexplored areas for future research that will be beneficial in the field of supply chain management, such as the creation of supply chain performance metrics, creation of a model that is tightly integrated into the supply chain, and handling supply chain-related problems and issues.

Keywords: Key Performance Indicators (KPIs), Supply Chain Management, SCOR model, Snorm De Boer, OMAX, AHP.

1. INTRODUCTION

Currently, the global market is highly competitive. Introducing products with shortened life cycles and increased consumer expectations has compelled companies to invest in and pay close attention to their supply chains. Currently, companies no longer compete individually in the market; instead, they compete as supply chain members. Companies in Developed and Developing Countries are attempting to integrate processes into supply chains more effectively, such as purchasing, production, and distribution.

Concerns about companies and researchers' interest in supply chain management have consistently increased over time. Supply chain management is the administration of product flow, including all processes by which basic materials are transformed into finished products.
Supply chain management is a science that discusses suppliers and customers from upstream to downstream to achieve lower costs and superior customer value (*Boateng A., 2019*). Supply chain management can also be defined as the strategic and systematic coordination of traditional business functions (*Nakov Z. et al., 2014*), facilitate the distribution network between customers and a company's internal activities (*Barraza M. et al., 2016*). Supply chain management has become a factor in the decisions of competitive companies. Successful supply chain management is regarded as one of the most essential factors in enhancing company performance.

According to (*Kazemkhanlou H. & Ahadi H., 2014*), effective supply chain management has several advantages, including increasing customer value, increasing profitability, reducing product cycle time, achieving average inventory levels, and designing better products.
Supply chain management integrates the trading partner's key business processes from the initial raw material extraction to the final or end customer, including all intermediate processing, transportation, storage activities, and final sales to the product customer *(Wisner J. et al., 2012*). Supply chain management is an essential company process planned through systemic coordination, such as procurement, purchasing, conversion, and logistics (*Chakraborty S. & Gonzalez J., 2018*). In general, supply chain management provides consumers with the right product at the right time, place, and price.

Companies in Developing Countries have attempted to establish agreements with similar companies in Developed Countries to work together and share advantages and hazards. Because of current developments, companies in Developing Countries have demonstrated increasing proficiency in modeling, analyzing, measuring, and establishing various models, leading to the growth of supply chain management in Developing Countries. Companies and researchers have used different models to evaluate supply chain performance. This article measures supply chain performance in Developing Countries using the Supply Chain Operations Reference (SCOR) model. The SCOR model was created in the United States of America, and the APICS Supply Chain

Council currently controls it. The SCOR model can be used to explain, disseminate, and develop supply chains. The SCOR model is a reference model with standard terminology and a process that serves as a benchmark for operational measurements by creating a portfolio of priority improvements related to a company's financial statements to improve its performance and revenue (*Meyr H. et al., 2002*). The SCOR model aims to facilitate company communication and interaction between parties, from suppliers to end customers. It is also helpful in developing new supply chain practices and improving existing supply chain activities (*Azari S. et al., 2018*). The SCOR model is the most implemented model for evaluating supply chain performance, and it considers manufacturing adaptability, maintenance, inventory, asset turnover, cost, distribution, and customer service. An essential part of the SCOR model is a collection of Key Performance Indicators (KPIs) that permit the measurement of supply chain performance and promote the achievement of a company's objectives. KPIs are management tools or instruments that allow an activity or process to be followed, controlled (if it deviates, it can be recognized for correction), and ensured to achieve the desired performance *(Setiawan I. & Purba H., 2020).* (*Lestaria F. et al., 2020*), suggesting that the SCOR model is a useful tool for Supply Chain Management.

This article presents a complete analysis of data collected from a questionnaire on the importance of KPIs according to the SCOR model from Developing Countries, such as Albania and Kosovo, which can be used to design company goals, evaluate company performance, and support future steps in company management. This article aims to evaluate the supply chain's performance in Albania and Kosovo, using the SCOR model to establish a development strategy for the companies, which can lead to their survival and ability to compete with other companies in the marketplace. This article has the following structure. The second section demonstrates the research methodology used in this article. The third section presents the questionnaire, data collection from the questionnaire, Normalization of Snorm De Boer, Analytical Hierarchy Process (AHP), and Objective Matrix (OMAX). The fourth section provides the results of the research in this article. The fifth and final section concludes with the conclusions and perspectives of upcoming researchers.

2. RESEARCH METHODOLOGY

2.1. Performance Measurement Framework for Supply Chain Management

Figure 1 shows the performance measurement framework for Supply Chain Management.

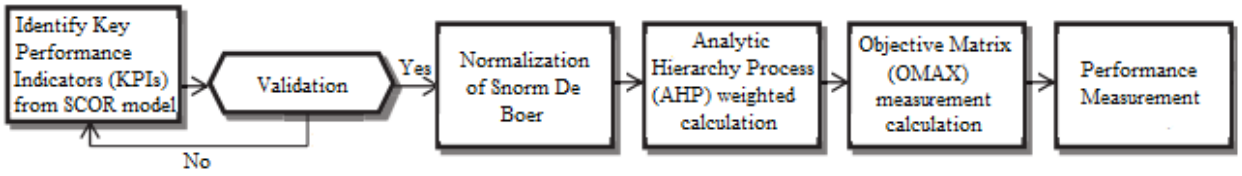


Figure 1: Performance Measurement Framework for Supply Chain Management
Source: Authors, 2023

The *Supply Chain Operation Reference (SCOR)* model is a supply chain, process-oriented reference model. The initial action was to establish *Key Performance Indicators (KPIs*) from the SCOR model. This action will seek out the KPIs that impact the performance of companies in Developing Countries taken into consideration by completing the questionnaire. The second action is validation for deciding whether KPIs have validity and the capacity to obtain necessary data. The third action is the calculation of Snorm De Boer's normalization, which is applied to return various units in one unit (%). The fourth action is the calculation of the *Analytical Hierarchy Process (AHP),* an evaluation method that uses pair-wise comparisons and expert judgments to create prioritization scales. The fifth action is the calculation of the *Objective Matrix (OMAX)*, which makes it possible to connect the productivity criteria in the proposed model. The sixth and final action is the performance measurement using three colors: *Green*- good parameter; *Yellow*- medium parameter; and *Red*- bad parameter.

2.2. Research Background

The specified goals for this article consist of a study conducted on a sample of 200 companies located in two Developing Countries, Albania, and Kosovo. This article is divided into two main sections. The first section identifies KPIs according to the five performance attributes of the SCOR model. The performance of KPIs can be chosen mainly through respondents based on the requirements of the article and accessible data. The second section aims to establish the highest and lowest possible values of each KPI for further OMAX calculations.

2.3. Questionnaire

The questionnaire layout began when an overview of KPIs was completed and divided into two metric levels (level-1 & level-2 metrics). Before it was disseminated to the companies, the pilot questionnaire was reviewed by supply chain management professionals. The questions were both closed and open. The final questionnaire was delivered to managers and owners of the companies: in person and via email.

2.4. Data Collection

From February to April 2023, the questionnaire collected a sample of 200 responses from managers and owners regarding the activity of their company in the 2022 year. Developing Countries, such as Albania and Kosovo were selected for the questionnaire.

The questionnaire was administered to managers and owners of the manufacturing sector, including logistics managers, planning managers, operations managers, and general directors. The responses to the questionnaire were used to categorize the collected data.

3. CASE STUDY

3.1. Identify Key Performance Indicators (KPIs) from the SCOR model

The initial step in measuring the supply chain performance is to determine the Key Performance Indicators (KPIs) using the SCOR model. SCOR model 12.0 is the last modern model released in 2017 by APICS.

The SCOR model identifies five performance attributes: reliability, responsiveness, agility, cost, and asset management efficiency (*APICS, 2017*). The SCOR model describes level-1 and level-2 metrics. Level-1 metric is analytic for the whole supply chain (called Key Performance Indicators (KPIs)), whereas the level-2 metric is diagnostic for the level-1 metric. The level-1 metric used to evaluate the five performance attributes of the SCOR model emphasizes the following.

1. **Reliability-** *Perfect Order Fulfillment (RL.1.1),*
2. **Responsiveness-** *Order Fulfillment Cycle Time (RS.1.1),*
3. **Agility-** *Upside Supply Chain Adaptability (AG.1.1), Downside Supply Chain Adaptability (AG.1.2), Overall Value at Risk (AG.1.3),*
4. **Cost-** *Total Supply Chain Management Costs (CO.1.1), Cost of Goods Sold (CO.1.2),*
5. **Asset Management Efficiency-** *Cash-to-Cash Cycle Time (AM.1.1), Return on Supply Chain Fixed Assets (AM.1.2), Return on Working Capital (AM.1.3))* (*APICS, 2017*).

All data obtained for the KPIs level-1 and level-2 metrics received from 200 companies based in Albania and Kosovo are shown in Table 1.

Performance attribute	Level-1 Metric	Level-2 Metric	Score
Reliability (RL)	*Perfect Order Fulfillment (RL.1.1)* [Total Perfect Orders] / [Total Number of Orders] x100%	% of Orders Delivered in Full (RL.2.1)	*87.5%*
		Delivery Performance to Customer Commit Date (RL.2.2)	
		Documentation Accuracy (RL.2.3)	
		Perfect Condition (RL.2.4)	
Responsiveness (RS)	*Order Fulfillment Cycle Time (RS.1.1)* [Sum Actual Cycle Times for All Orders Delivered] / [Total Number of Orders Delivered]	Source Cycle Time (RS.2.1)	*196.5 days*
		Make Cycle Time (RS.2.2)	
		Deliver Cycle Time (RS.2.3)	
		Delivery Retail Cycle Time (RS.2.4)	
		Return Cycle Time (RS.2.5)	

Agility (AG)	*Upside Supply Chain Adaptability (AG.1.1)* The maximum sustainable percentage increase in quantity delivered that can be achieved in 30 days	Upside Adaptability (Source) (AG.2.1)	*980 hours*
		Upside Adaptability (Make) (AG.2.2)	
		Upside Adaptability (Deliver) (AG.2.3)	
		Upside Return Adaptability (Source) (AG.2.4)	
		Upside Return Adaptability (Deliver) (AG.2.5)	
	Downside Supply Chain Adaptability (AG.1.2) Downside Source Adaptability + Downside Make Adaptability + Downside Deliver Adaptability	Downside Adaptability (Source) (AG.2.6)	*0%*
		Downside Adaptability (Make) (AG.2.7)	
		Downside Adaptability (Deliver) (AG.2.8)	
	Overall Value at Risk (AG.1.3) VaR = Probability of Risk Event (P) x Monetized Impact of Risk Event (I)	Supplier / Customer / Product Risk Rating (AG.2.9)	*7.8%*
		Value at Risk (Plan) (AG.2.10)	
		Value at Risk (Source) (AG.2.11)	
		Value at Risk (Make) (AG.2.12)	
		Value at Risk (Deliver) (AG.2.13)	
		Value at Risk (Return) (AG.2.14)	
		Time to Recovery (AG.2.15)	
Cost (CO)	*Total Supply Chain Management Cost (CO.1.1)* TSCMC = Cost to Plan + Cost to Source + Cost to Make + Cost to Deliver + Cost to Return +Mitigation Costs	Cost to Plan (CO.2.1)	*67.1%*
		Cost to Source (CO.2.2)	
		Cost to Make (CO.2.3)	
		Cost to Deliver and / or Install (CO.2.4)	
		Cost to Return (CO.2.5)	
		Mitigation Cost (CO.2.6)	
	Cost of Goods Sold (CO.1.2) Cost to Make = Direct Material + Direct Labor + Direct Product-related Cost + Indirect Product-related Cost	Direct Material Cost (CO.2.7)	*13.9%*
		Direct Labor Cost (CO.2.8)	
		Indirect Cost Related to Product (CO.2.9)	
Asset Management Efficiency (AM)	*Cash-to-Cash Cycle Time (AM.1.1)* Cash-To-Cash Cycle Time = [Inventory Days of Supply] + [Days Sales Outstanding] - [Days Payable Outstanding]	Days Sales Outstanding (AM.2.1)	*72 days*
		Inventory Days of Supply (AM.2.2)	
		Days Payable Outstanding (AM.2.3)	
	Return on Supply Chain Fixed Assets (AM.1.2) Return on Supply Chain Fixed Assets = ([Supply Chain Revenue] – [Total Cost to Serve]) / [Supply- Chain Fixed Assets]	Supply Chain Revenue (AM.2.4)	*40.3%*
		Supply Chain Fixed Assets (AM.2.5)	
	Return on Working Capital (AM.1.3) Return on Working Capital = ([Supply Chain Revenue] – [Total Cost to Serve]) / ([Inventory] + [Accounts Receivable] – [Accounts Payable])	Payables Outstanding (AM.2.6)	*10.8%*
		Sales Outstanding (AM.2.7)	
		Inventory (AM.2.8)	

Table 1: KPIs level-1 and level-2 metrics
Source: SCOR model, APICS, 2017 & Authors, 2023

3.2. Validation

Data were collected from responses received from 200 companies. The questionnaire serves as a database for measuring the performance of supply chain management in 2022 from a sample of 200 companies in Albania and Kosovo. The questionnaire was composed of open and closed questions to validate the KPIs.

3.3. Snorm De Boer

Each KPI, consisting of level-1 and level-2 metrics, was established based on the data collected through the questionnaire results in Table 1. Calculations were performed using the formulas laid out in SCOR Version 12.0's guidelines. For the level-1 metric, % units were used. It is necessary to equalize the units because the level-2 metric uses various units, including %, days, and hours. The order fulfillment cycle time, upside supply chain adaptability, and cash-to-cash cycle time were measured in hours and days, not as %. Snorm De Boer's normalization was applied to return various units to one unit (%).

Snorm De Boer normalization formula is (*Trienekens, J. H, and Hvolby, H. H, 2000*):

Larger is Better $$S_{norm} = \frac{(S_i - S_{min})}{(S_{max} - S_{min})} \times 100\%$$

Lower is Better $$S_{norm} = \frac{(S_{max} - S_i)}{(S_{max} - S_{min})} \times 100\%$$

Where:
S_i = Value of the actual indicator that was achieved;
S_{min} = Value of the worst performance achievement of an indicator;
S_{max} = Value of the best performance achievement of an indicator.
Each indicator in a different unit was converted into a specified unit interval of 0%-100%. 0% is interpreted as the worst value and 100% is interpreted as the best value.

KPIs divided into five conditions are reflected in Table 2.

KPI Value	***KPI Condition***
< 40%	Poor Performance
40%-50%	Marginal Performance
50%-70%	Average Performance
70%-90%	Good Performance
> 90%	Excellent Performance

Table 2: KPIs values and conditions
Source: Kasmari F. et al., 2020

Table 3 shows the results of the normalization according to Table 2.

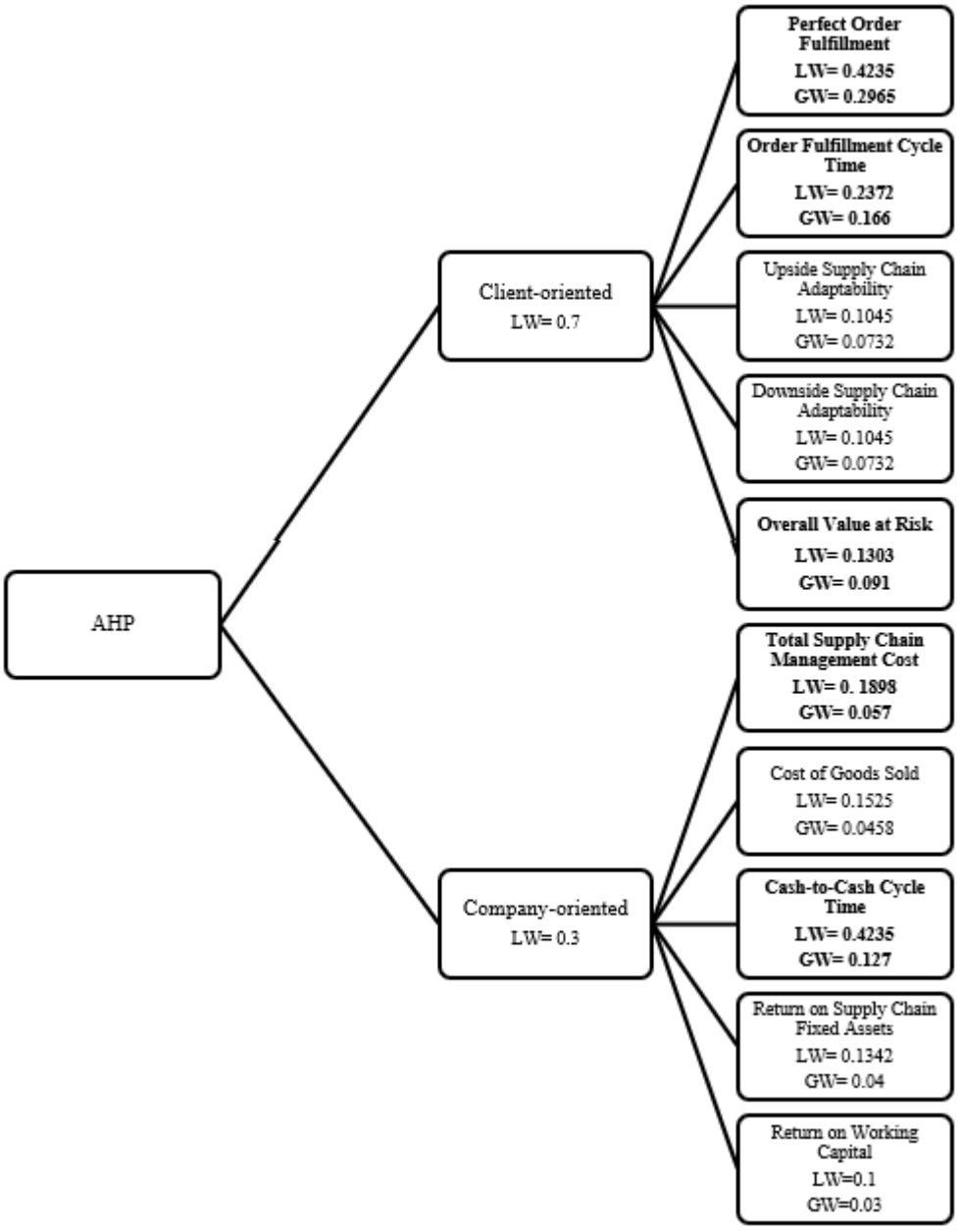
Performance attribute	***Score***	***Performance attribute Condition***
Reliability	**87.5%**	**Good Performance**
Responsiveness	**62.5%**	**Average Performance**
Agility	**84.1%**	**Good Performance**
Cost	**81%**	**Good Performance**
Asset Management Efficiency	**63.7%**	**Average Performance**

Table 3: Normalization Results
Source: *Authors, 2023*

3.4. AHP weighted calculation

The next step is to calculate the AHP weight. Creating and weighing KPIs used AHP, especially pair wise comparison matrix calculations (*Sirous R. et al., 2016*).
Companies that completed the questionnaire compared different viewpoints. *Client-oriented* (Reliability, Responsiveness, and Flexibility) is compared to *company-oriented* (Cost and Asset management efficiency). The results obtained from the AHP weighted for the KPIs level-1 metric are shown in Figure 2.

! In AHP are used local and global weights of KPIs. Multiplying the weight of hierarchical criteria by the local weight of KPIs provides the global weight of KPIs.



Where:
LW- Local Weights
GW- Global Weights

Figure 2: AHP weight calculation for KPIs level-1 metric
Source: Authors, 2023

3.5. OMAX measurement calculation

The first step in a scoring system with a factual matrix is to determine the highest and lowest values achieved by each KPI (*Paduloh P. et al., 2020; Yuniarti R. et al., 2013*):

1. Target Calculation;
2. Calculation of Realization (Performance);
3. Optimistic Value.

Table 4 presents a table for evaluating performance, realistic goals, optimistic values, and pessimistic values to be more transparent.

! KPIs selected from metrics level-1 for OMAX measurement are perfect order fulfillment, order fulfillment cycle time, overall value at risk, total supply chain management cost, and cash-to-cash cycle time.

KPI	***Unit***	***Year 2022***			***Measurement Performance***
		Pessimistic value	***Expected value***	***Optimistic value***	
Perfect Order Fulfillment	*%*	80	85	95	87.5
Order Fulfillment Cycle Time	*days*	275	210	180	196.5
Overall Value at Risk	*%*	20	10	5	7.8
Total Supply Chain Management Cost	*%*	85	75	65	67.1
Cash-to-Cash Cycle Time	*days*	85	75	68	72

Table 4: Statistics of selected KPIs
Source: Authors, 2023

After evaluating performance, realistic goals, optimistic values, and pessimistic values, the highest-to-lowest scales were established using the OMAX scoring measurement. Using an interval of 0-10 for each KPI, the objective was to determine the achievement value for each KPI target over a specific period. Below are the measurements of OMAX for the first KPI (perfect order fulfillment). Similarly, is calculated for the other KPIs (order fulfillment cycle time, overall value at risk, total supply chain management cost, and cash-to-cash cycle time).

Measurement level 0 to level 3:

Estimation level 0-level 3:

$\frac{\text{Level 3-Level 0}}{\text{3-0}} = \frac{85 - 80}{3} = 1.67$

Level 2= 85 – 1.67= 83.33
Level 1= 83 – 1.67= 81.33
Level 0= 80

Measurement level 4 to level 10:

Estimation level 3-level 10:

$\frac{\text{Level 10-Level 3}}{\text{10-3}} = \frac{95 - 85}{7} = 1.43$

Level 9= 95 – 1.43= 93.57
Level 8= 93.6 – 1.43= 92.17
Level 7= 91.8 – 1.43= 90.37
Level 6= 90.2 – 1.43= 88.77
Level 5= 88.7 – 1.43= 87.27
Level 4= 86.5 – 1.43= 85.07

The results obtained from the OMAX measurements for the selected KPIs are listed in Table 5.

KPI		***Perfect Order Fulfillment***	***Order Fulfillment Cycle Time***	***Overall Value at Risk***	***Total Supply Chain Management Cost***	***Cash-to-Cash Cycle Time***
Performance		*87.5*	*196.5*	*7.8*	*67.1*	*72*
Optimistic value	10	95	180	5	65	68
	9	93.57	187.35	5.65	66.5	69.4
	8	92.17	192.9	6.02	***67.3***	70.2
	7	90.37	***195.64***	6.93	69.2	71.7
	6	***88.77***	197.8	***7.73***	70.4	***72.3***
	5	87.27	204.55	8.42	72.9	73.9
	4	85.07	208.7	9.06	74.1	74.8
Expected value	3	85	210	10	75	75
	2	83.33	235.9	15.6	79.2	78.9
	1	81.33	257.4	17.4	82.5	82.6
Pessimistic value	0	80	275	20	85	85
SCOR model		***6***	***7***	***6***	***8***	***6***
Weighing		*0.2965*	*0.166*	*0.091*	*0.057*	*0.127*
Value		***1.779***	***1.162***	***0.546***	***0.456***	***0.762***

Table 5: Results from OMAX measurements for selected KPIs
Source: Authors, 2023

The green color (Level 8-Level 10) indicates that the performance attained its maximum level.
The yellow color (Level 4-Level 7) indicates that the performance attained its average level.
The red color (Level 0-Level 3) indicates that the performance attained its minimum level.

The five KPIs selected for OMAX had scores of 6, 7, 6, 8, and 6, respectively. Four KPIs, including perfect order fulfillment, order fulfillment cycle time, overall value at risk, and cash-to-cash cycle time, were classified as yellow, whereas only the total supply chain management cost was classified as green. For the selected KPIs, classified as yellow from OMAX, companies can make improvements to achieve their main goal, which is profit maximization.

The results obtained from multiplication weighting with the values from the model are as follows:
Perfect order fulfillment- 1.779; Order fulfillment cycle time- 1.162; Overall value at risk- 0.546;
The total supply chain management cost- 0.456; Cash-to-cash cycle time- 0.762.

4. RESULT AND DISCUSSION

The SCOR model and Snorm De Boer were used based on the calculations and results presented in Table 3.
a. The performance attributes of Reliability, Agility, and Cost are included in the ***Good category performance.***
b. The performance attributes of Responsiveness and Asset Management Efficiency are included in the ***Average category performance.***

The Responsiveness attribute can be improved as follows:
a. Reduce the order fulfillment cycle time.
b. Provide consistent support experience.
c. Understand the customers.
d. Use canned responses, personalization, and self-support resources.
d. Train the employees.
e. Trust technological development.

The Asset Management Efficiency attribute can be improved as follows:
a. Reduce the processes/ costs of inventory using Just-In-Time Strategy.
b. Create a Strategic Asset Performance Management.
c. Constant Performance Monitoring and Evaluating.
d. Make full use of Asset Data.
e. Perform regular Asset Audits.

The AHP and OMAX methods were used based on the calculations and results shown in Figure 2 and Table 5.
a. KPI, such as Total Supply Chain Management Cost is included as ***Good value performance.***
b. KPIs, such as Perfect Order Fulfillment, Order Fulfillment Cycle Time, Overall Value at Risk, and Cash-to-cash Cycle Time are included as ***Average value performance.***
Overall, the data collected from the companies concluded that the KPIs selected were not too bad or too good, but they were average at level 6 (score 6.6). For KPIs, which are average values, companies must make continuous improvements.

These improvements can be made to the average value performance with the highest value (because the failure rate is lower than the average value performance with a lower value). Therefore, it is important for companies to:
a. Increase order fulfillment in product efficiency/ quality and on time.
b. Decrease the risk in investments with high risk.
c. Increase the speed of transactions/ sales.
d. Increase the value of a client`s lifetime.
e. Increase profit margin.
f. Refine demand forecasts.
g. Motivate the employees.
h. Establish Benchmark.

CONCLUSION

The performance measurement stages included setting KPIs, validation, Snorm De Boer, AHP weighting calculation, and OMAX measurement calculation. Based on the results of KPIs using the SCOR model and Snorm De Boer normalization, the supply chain performance of the companies located in Albania and Kosovo is yet to be maximized because the total value obtained is 75.76% (level-1 metric) or included in the Good category performance. KPIs with low values are Responsiveness and Asset Management Efficiency, with values of 62.5% (Average Performance) and 63.7% (Average Performance), respectively. Based on the results of KPIs using the AHP and OMAX methods, companies located in Albania and Kosovo are not too bad or too good, but they are average at level 6 (score 6.6). The KPIs studied in this article require further improvements to increase the supply chain performance of companies. Future research can integrate the SCOR model or OMAX method with multi-criteria decision analysis to measure overall supply chain performance based on the priority weights of the desired KPIs.

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