Supply Chain Performance Measurement Using SCOR Model in Chemical Industry: A Case Study

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Abstract

Chemical industry is a company that processes the main raw material in the form of pine resin. This company faces the challenge of complexity in the organizational structure, which causes the company to find it increasingly challenging to plan and manage. If it is not addressed, it will impact the difficulty of communication between the company and supply chain partners, which also affects the effectiveness and efficiency of the supply chain in the company. Therefore, an evaluation of the company's supply chain performance is needed, which aims to identify indicators that can represent the company's supply chain flow process and determine the value of supply chain performance in the chemical industry. This study uses the Supply Chain Operation Reference Model (SCOR) method to discuss the supply chain performance measurement. Measurements are made based on 5 core processes, and performance metrics are presented as Key Performance Indicators (KPI). Then, each metric is weighted using AHP. According to the results of the study, it was found that the achievement of the company's performance was 82.42% which was included in the pretty good category.

Keywords
SCOR, Performances, Supply Chain, Core model, Chemical engineering.

1. Introduction

As an actor in the industrial sector, the companies are urged to be able to make improvements in all aspects. The rapid growth in the industrial sector is one of the reasons why. Improving in every aspect, also helps the company to offer their products and develop a wider market, one of which is the chemical industry. Therefore, companies can evade from falling behind in business competitiveness. The complexity of an organizational structure also makes it increasingly difficult for a company to plan and manage. If it is not addressed, it will impact the difficulty of communication between the company and supply chain partners. In addition, it also affects the effectiveness and efficiency of the company's supply chain. If there is ineffectiveness and inefficiency in the company's supply chain, it will increase costs, decrease customer satisfaction and decrease company profits. The greater the challenges the company faces, the more significant the impact on supply chain management (Yao et al. 2022).

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Many methods can measure the supply chain. One of the most well-known and general methods is Supply Chain Operation Reference (SCOR) Model. SCOR Model measurement was established by The Association for Operations Management (APICS), which measured business process and performance. Both process and performance have their metrics to be defined by, such as process is defined from plan, source, make, deliver, return, and enable activities and performance by company reliability, responsiveness, agility, cost, and asset management level. The SCOR model has its uniqueness to be used in several industrial sectors. Several previous studies have discussed the application of the SCOR model to various study objects in the industry, among others; according to Hapsari et al. (2021) SCOR model can be used to measure furniture companies. In several studies, the SCOR model has been used in the food and beverage sector, such as in sugar company (Kusrini et al. 2019), coffee company (Nguyen et al. 2021), and the palm oil industry (Sutopo et al. 2015; Rosyidah et al. 2022). In another research by Kusrini et al. (2019), it can be used in the leather company. Ikasari et al. (2020) stated SCOR model also could be used in a lithium battery factory. Another research by Kusrini et al. (2019) also said that the SCOR model is used in SME companies in Indonesia. Susanto et al. (2021) stated that the SCOR model could be used in batik companies. The SCOR model can also be used in the automobile sector, such as in road freight transportation companies (Gonzalez 2022) and automotive companies (Fauzia 2021).

Chemical industry is a company that processes the main raw material in the form of pine resin into various products, including gum rosin, turpentine, and its derivative products such as rosin, α-pinene, δ-carene, pine oil, cineol, and terpineol. In operating the company, it coordinates with 4 pine resin suppliers and 1 distributor. However, the market for the products produced by this chemical industry has reached the international business market. The challenges facing companies today are changing dynamically and getting more arduous from time to time, coupled with the existence of the ASEAN free market (Nayal et al. 2022). Along with the increasingly global market and the emergence of information technology, competition in the business world is getting tougher. The demands of the company's customers are also getting higher, product variety is becoming more and more important. Customers began to demand aspects of response speed, innovation, and flexibility.

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Companies need performance evaluation with the Supply Chain Operation Reference (SCOR) to reengineer business processes, get an overview of benchmarking, and measure company business processes in achieving supply performance. A chemical industry must be able to compete with its competitors. This study aims to identify indicators that can represent the company's supply chain flow process and determine the value of supply chain performance in the chemical industry using the SCOR model method.

2. Literature Review

Supply chain is a network that works together to create and deliver a product to end customers from upstream to downstream. Oliver and Weber first proposed the term supply chain management in 1982. If the supply chain refers to the network, supply chain management is a method, tool, or approach in its management (Pujawan 2010). According to Suparno (2004), Supply Chain Management is a group of approaches applied to efficiently integrate activities from a supply chain network from upstream (inbound) to downstream (outbound) so that products can be produced and distributed in the right quantities, to the correct locations. Right, at the right time, and minimum cost.

Supply Chain Operation Reference Model or commonly abbreviated as SCOR, is a reference model that can be used as a reference in measuring supply chain performance. The SCOR Model can assist management in mapping, improving, and communicating the implementation of supply chain management to relevant stakeholders (Poluha 2007). SCOR is a model developed in 1996 by the Supply Chain Council, which is now part of APICS, as a reference in strategic management, performance, and process improvement tools in supply chain management to achieve customer satisfaction. As a reference model, the SCOR model is based on three main pillars, namely:

a. Process modeling: Reference to identify the supply chain process model for easier translation and analysis.
b. Performance measurement: Reference to measure the performance of a company's supply chain as a measurement standard.
c. Implementation of best practices (best practices): Reference to determine the best practices required by the company.

The SCOR process model is shown in Figure 1. The SCOR Model has three levels or hierarchy of processes in building a good performance, as shown in Figure 2. Following are the definitions of each level:

- Level 1, is the highest level that provides a general definition regarding the scope and content of the 5 core processes described in the SCOR Model. This level is the basis of setting targets on performance measures.
- Level 2, referred to as the configuration level, where a supply chain can be configured based on the operating strategy.
- Level 3, is a process element level that contains process elements, inputs, outputs, and references. At this level, the decomposition process is carried out to a more technical level.

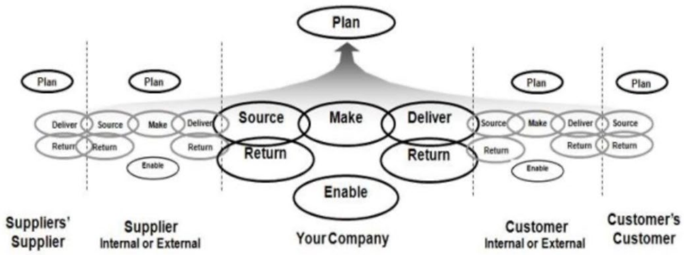

Figure 1. SCOR Process Model

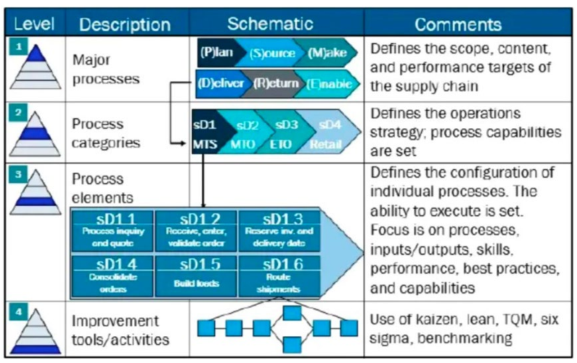

Figure 2. SCOR Process Hierarchy

At level 1 in the SCOR Model, there are 5 core processes in the elaboration of supply chain processes, namely:

a. Plan, a process of balancing supply and demand to decide the optimal course of action for addressing the needs of production, delivery, and purchase.
b. Source, the process of procuring goods to meet demand.
c. Make, the process for transforming raw materials into semi-finished or finished products to meet existing demands.
d. Deliver, the delivery process to meet customer demand
e. Return, the process of returning products for various reasons.

Additionally, the SCOR model outlines the five fundamental supply chain performance dimensions of dependability, responsiveness, agility, costs, and assets management (Susanto 2021). The traits of dependability, responsiveness, and agility are consumer-focused measures. Attributes that measure the supply chain from an internal-supply chain perspective include cost and asset management.

3. Methods

The Supply Chain Council (SCC) established the Supply Chain Operations Reference (SCOR) model. The SCOR model analyzes and enhances the performance of the whole supply chain for the business. Plan, source, make, deliver, and return procedures are all included in the SCOR model's description of corporate operations connected to meeting customer needs. Utilizing the SCOR model entails examining the company's operations as they stand right now and gauging operational performance using a set of agreed-upon measures. Version 12.0 is now accessible through APICS membership association. The steps in the implementation of this research can be seen in Figure 3.

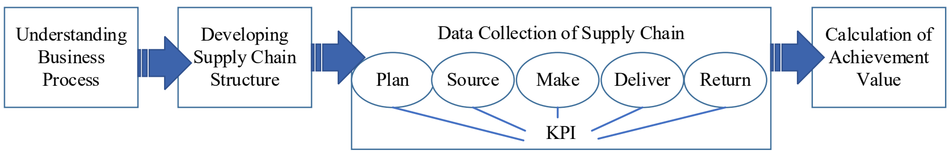

Figure 3. Methods in Conducting Research

4. Data Collection

Data gathering methods and research tools are essential for undertaking data collection. The following data collection methods were used in this study.

a. Observation
   Observations were made by directly observing the production and marketing processes in the chemical industry based on the observation sheet that had been prepared previously.
b. Interview
   The interviews conducted were structured interviews by giving questions to informants according to the interview grid that had been prepared previously to obtain information in the form of data and facts. In addition, interviews were conducted to validate KPIs by the company's business processes. Interviews were conducted with Assistant Managers of PPIC, Inventory, and Supply Chain as well as Planning, PPIC, Systematics, and IT Supervisors to obtain information about the production and company business processes.
c. Documentation
   The documentation data needed by the researcher is related to the company's business processes, including supplier data, production data, and marketing data in the chemical industry. In addition to data collection techniques, it is necessary to determine the research instrument. In this study, the research instrument has several indicators, which include: Research data collection instruments on the performance of the chemical industry's business processes at the gum rosin and turpentine factories, including observation sheets, interview guidelines, and documentation guidelines.

5. Results and Discussion

5.1 Supply Chain Flow Process

The supply chain flow is shown in Figure 4. The supply chain flow process mapping into the SCOR Model is shown in Figure 5.

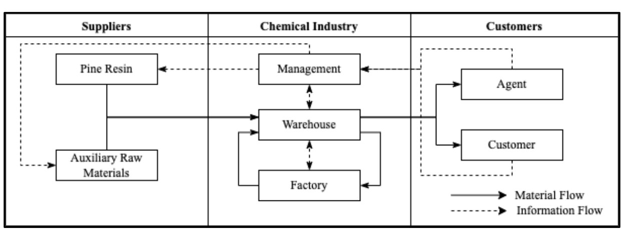

Figure 4. Supply Chain Flow Process

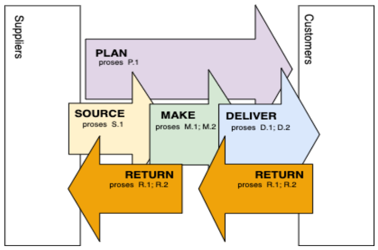

Figure 5. Mapping Supply Chain Flow into the SCOR Model

This study assesses the process of plan, source, make, deliver, and return to the chemical industry. Based on observations and interviews, it is known that this planning process includes the entire process of planning and controlling inventory, planning for gondorukem and turpentine production, preparing for raw and auxiliary materials, capacity planning, and financial planning. The planning process starts with management, then planning data is distributed to the PPIC, Inventory, and Supply Chain Divisions to adjust material requirements and budget costs for production activities. The source process includes the main material procurement process, namely merkusii pine resin supplied from suppliers, and the procurement of auxiliary materials to support production activities such as MFO, oxalic acid, etc. The procurement process includes scheduling deliveries from suppliers, receiving, checking, and authorizing payments for goods sent by suppliers.

The process of making in this research includes all production activities, starting from handling pine merkusii resin, melting the resin, washing the resin solution, cooking soft rosin to become gum rosin, and turpentine, to the canning process with cans. The delivery process in this study includes the delivery of gum rosin to consumers. Gum rosin that has been packaged in cans will be sent through agents to overseas consumers, and can be sent directly to end customers. The return process in this study includes returning products by consumers for various reasons.

5.2 Identification and Validation KPI

Based on the results of direct observations in the chemical industry, Key Performance Indicators (KPI) were determined in each of the 5 categories of the SCOR Model process, namely Plan, Source, Make, Deliver, and Return. Table 1 shows the KPIs identified per each process category.

Table 1. KPIs Identified

No	SCOR Model	Code	KPI
1	Plan	P.1	% Planning Accuracy
2		P.2	Cost Match
3	Source	S.1	Raw Material Quality
4	Make	M.1	Production Cycle Time
5		M.2	Availability of Direct Labor
6		M.3	% Defective Product
7	Deliver	D.1	Delivery Performance
8		D.2	% Order Suitability
9	Return	R.1	Product Return
10		R.2	Material Return

KPI validation was carried out by interviewing the Assistant Manager of PPIC, Inventory, and Supply Chain as well as Planning, PPIC, System, and IT Supervisors. Out of the 10, KPIs determined, only 8 were selected; this is shown in Table 2.

Table 2. KPIs Validated

No	SCOR Model	Code	KPI
1	Plan	P.1	% Planning Accuracy
2	Source	S.1	**Raw Material Quality**
3	Make	M.1	**Production Cycle Time**
4		M.2	**Availability of Direct Labor**
5	Deliver	D.1	**Delivery Performance**
6		D.2	**% Order Suitability**
7	Return	R.1	Product Return
8		R.2	Material Return

5.3 Identification KPI Property

Identification of KPI Properties is carried out so that there are no differences in perception in the effort to achieve and evaluate a KPI. Table 3 presents a recapitulation of KPI Properties.

Table 3. Recapitulation of KPIs Properties

No	Code	KPI	Definition	Target	Unit	Marking	Formula
1	P.1	% Planning Accuracy	Percentage of accuracy of acceptance planning results with actual raw material receipts	95	%	Higher is Better	[1-((forecast resin receipts-actual resin receipts)/actual resin receipts)] *100
2	S.1	Raw Material Quality	Quality of the tested resin sample (Moisture content and Impurity Content)	10	%	Lower is Better	Average of total moisture content and impurity content
3	M.1	Production Cycle Time	The length of time it takes to do one product processing	0,333	day	Lower is Better	Actual processing time/(Work hours per shift*number of shifts)
4	M.2	Availability of Direct Labor	The number of workers needed to process the product per ton per day	21	person	Higher is Better	(Labor per shift*number of shifts)-average absent workers
5	D.1	Delivery Performance	Percentage of products received by consumers on or before the agreed date	100	%	Higher is Better	[1-(number of late orders/number of orders served)] *100
6	D.2	% Order Suitability	Percentage of conformity of product quantity and quality accepted by customer	100	%	Higher is Better	[1-(the number of orders does not match/the number of orders served)] *100
7	R.1	Product Return	Percentage of orders returned by consumers	5	%	Lower is Better	(number of orders returned/number of orders served)*100
8	R.2	Material Return	Percentage of materials returned to suppliers	5	%	Lower is Better	(amount of material returned/amount of material received)*100

In addition to KPI Property, companies must also have performance achievement criteria that represent the extent to which performance achievements have been achieved, whether bad, moderate, or good. Table 4 shows a monitoring system so companies can more easily monitor and control their performance.

Table 4. Monitoring System Performance

Monitoring System	Performance Indicators
<40	Poor
40 - 50	Marginal
50 - 70	Average
70 - 90	Good
>90	Excellent

5.4 KPI Weighting

The weighting of KPIs is carried out based on priorities and the impact of achieving these KPIs on the company to find out how significant the proportion of the contribution of each KPI to the achievement of company performance is. Table 5 presents the results of the weighting recapitulation for 5 process categories. Table 6 shows the results of the weighting recapitulation for each KPI in each process category.

Table 5. Weight of 5 Process Category

Weight of 5 Process Category	
Plan	0,456
Source	0,196
Make	0,224
Deliver	0,082
Return	0,043
Total	1

Table 6. Recapitulation of KPI Weight in Each Process Category

KPI Weight in Plan Category	
P.1	1
KPI Weight in Source Category	
S.1	1
KPI Weight in Make Category	
M.1	0,25
M.2	0,75
Total	1
KPI Weight in Deliver Category	
D.1	0,833
D.2	0,167
KPI Weight in Return Category	
R.1	0,25
R.2	0,75

Based on the results of the weighting carried out, it can be known as the contribution, commonly referred to as the global weight of each KPI, by multiplying the local weight of each KPI with the weight of the process category. Table 7 shows the results of the global weight recapitulation per each KPI.

Table 7. Recapitulation of Global Weight for Each KPI

Global Weight of 8 KPI	
P.1	0,456
S.1	0,196
M.1	0,056
M.2	0,168
D.1	0,068
D.2	0,014
R.1	0,011
R.2	0,032
Total	1

5.5 Calculation of Achievement Value for Each KPI

The calculation of the achievement value for each KPI is based on a predetermined formula in the KPI Property along with a predetermined performance monitoring system. Table 8 is a recapitulation of the results of the achievement calculation per each KPI.

Table 8. Recapitulation of Achievement Calculation Results for Each KPI

No	Code	KPI	Target		Result		KPI Achievement	Monitoring
1	P.1	% Planning Accuracy	95	%	72,042	%	75,83%	Good
2	S.1	Raw Material Quality	10	%	11,894	%	81,06%	Good
3	M1	Production Cycle Time	0,333	days	0,404	days	78,88%	Good
4	M2	Availability of Direct Labor	21	people	19	people	90,48%	Excellent
5	D.1	Delivery Performance	100	%	99,112	%	99,11%	Excellent
6	D.2	% Order Suitability	100	%	98,521	%	98,52%	Excellent
7	R.1	Product Return	5	%	0,592	%	100%	Excellent
8	R.2	Material Return	5	%	0,687	%	100%	Excellent

To determine the achievement of KPIs based on the process category, multiplication is carried out between the achievements per each KPI, with their local weights representing the priorities in each process category. Table 9 shows the recapitulation of the calculation of the achievement of each process category.

Table 9. Recapitulation of Achievement Calculation Results for Each Process Category

No	SCOR Model	Code	KPI	Local Weight	KPI Achievement	Process Category Achievement	Monitoring	Target
1	Plan	P.1	% Planning Accuracy	1	75,83%	75,83%	Good	100%
2	Source	S.1	Raw Material Quality	1	81,06%	81,06%	Good	100%
3	Make	M.1	Production Cycle Time	0,25	78,88%	87,58%	Good	100%
		M.2	Availability of Direct Labor	0,75	90,48%			
4	Deliver	D.1	Delivery Performance	0,83	99,11%	99,01%	Excellent	100%
		D.2	% Order Suitability	0,17	98,52%			
5	Return	R.1	Product Return	0,25	100,00%	100%	Excellent	100%
		R.2	Material Return	0,75	100,00%			

5.6 Calculation of Company Performance Achievement Value

Calculating the achievement value of the company's performance is done by multiplying the achievement per each KPI with the global weight obtained in the previous section. Table 10 presents the results of the company's supply chain performance achievement.

Table 10. Chemical Industry Supply Chain Performance Achievement Results

No	Kode	KPI	KPI Achievement	Global Weight	Weighted KPI Value
1	P.1	% Planning Accuracy	75,83%	0,456	34,54%
2	S.1	Raw Material Quality	81,06%	0,196	15,88%
3	M.1	Production Cycle Time	78,88%	0,056	4,41%
4	M.2	Availability of Direct Labor	90,48%	0,168	15,18%
5	D.1	Delivery Performance	99,11%	0,068	6,76%
6	D.2	% Order Suitability	98,52%	0,014	1,34%
7	R.1	Product Return	100%	0,011	1,08%
8	R.2	Material Return	100%	0,032	3,23%
Current Achievement of Company Performance					82,42%

Overall, the company's performance can be said to be quite good, namely the achievement of 82.42%. Based on the results of the achievement of the company's performance that has been measured, it can be seen that the company's performance, especially in the upstream sector, which is related to suppliers and processing systems, has not yet reached its expectations. Meanwhile, the downstream performance, closely associated with the customer, can be said to be quite good. It is hoped that with the results of the implementation of this performance measurement system, the company can determine priorities for improvement in its business processes so that the achievement of company performance can increase and can also be used as strategic policy material for companies related to company performance in the following years.

6. Conclusion

Based on the results of the performance measurement system in the company, there are 8 KPIs that have been identified to represent the company's performance. 1 KPI represents the Plan process category, 1 KPI represents the Source process category, 2 KPI represents the Make process category, 2 KPI represents the Deliver process category, and 2 KPI represents the Return process category. KPI identification is made by discussing and adjusting to the SCOR Model. The company's overall performance can be said to be fairly good, namely the achievement of 82.42%. Overall, the company's performance, especially in the upstream sector related to suppliers and processing systems, has not yet met the company's expectations. Meanwhile, the downstream performance, closely related to the customer, can be said to be fairly good.

References

APICS., *Supply Chain Operations Reference Model: SCOR Version 12.0*, APICS, Chicago, 2017.

Fauzia, D., and Zamzamy, K. Z., Designing performance improvement strategy in automotive companies using SCOR model and importance performance analysis, *Journal of Physics: Conference Series*, vol. 2089, no. 1, pp. 012054, 2021.

Gonzalez-Pascual, E., Nosedal-Sanchez, J., and Garcia-Gutierrez, J., Performance evaluation of a road freight transportation company through SCOR metrics, *Transport Policy*, vol. 9, no.4, pp.1431-1439, 2021.

Hapsari, P. W., Santoso, H., and Nurkertamanda, D., SCOR and ANP methods for measuring supplier performance with sustainability principle of green supply chain management in furniture company PT. XYZ, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, pp. 2201-2211, Sao Paulo, Brazil, April 5 - 8, 2021.

Ikasari, N., Sutopo, W., and Zakaria, R., Performance measurement in supply chain using SCOR model in the lithium battery factory, *IOP Conference Series: Materials Science and Engineering,* vol. 943, no. 1, pp. 012049, 2020.

Kusrini, E., Caneca, V. I., Helia, V. N., and Miranda, S., Supply chain performance measurement using supply chain operation reference (SCOR) 12.0 model: A case study in AA Leather SME in Indonesia, *IOP Conference Series: Materials Science and Engineering*, vol. 697, no. 1, pp. 012023, 2019.

Kusrini, E., Helia, V. N., and Maharani, M. P., Supply chain performance measurement using supply chain operation reference (SCOR) in sugar company in Indonesia, *IOP Conference Series: Materials Science and Engineering,* vol. 697, no. 1, pp. 012010, 2019.

Kusrini, E., Rifai, M. A. B., and Miranda, S., Performance measurement using supply chain operation reference (SCOR) model: a case study in a small-medium enterprise (SME) in Indonesia, *IOP Conference Series: Materials Science and Engineering*, vol. 697, no. 1, pp. 012014, 2019.

Nayal, P., Pandey, N., and Paul, J., Covid-19 pandemic and consumer-employee-organization wellbeing: A dynamic capability theory approach, *Journal of Consumer Affairs*, vol. 56, no.1, pp. 359-390, 2022.

Nguyen, T. T. H., Bekrar, A., Le, T. M., and Abed, M., Supply chain performance measurement using SCOR model: a case study of the coffee supply chain in Vietnam, *1st International Conference on Cyber Management and Engineering (CyMaEn),* pp. 1-7, Hammamet, Tunisia, May 26-28, 2021.

Poluha, R., *Application of the SCOR model in supply chain management*, New York: Cambria Press, 2007.

Pujawan, I., N., and Mahendrawathi., *Supply chain management*, Surabaya: Guna Widya, 2010.

Rosyidah, M., Khoirunnisa, N., Rofiatin, U., Asnah, A., Andiyan, A., and Sari, D., Measurement of key performance indicator Green Supply Chain Management (GSCM) in palm industry with green SCOR model, *Materials Today: Proceedings*, vol. 63, pp. S326-S332, 2022.

Suparno., Model dan pengukuran kinerja supply chain, *Optima, Jurnal Keilmuan & Aplikasi Teknik dan Manajemen Industri*, vol. I, no.1, pp. 15-27, 2004.

Susanto, N., Purwaningsih, R., Rumita, R., and Septia, E., Supply chain performance measurement with supply chain operation references approach (a case study in a batik company), *Proceedings of the International Conference on Industrial Engineering and Operations Management*, pp. 1928-1938, Sao Paulo, Brazil, April 5 - 8, 2021.

Sutopo, W., Maryanie, D. I., and Yuniaristanto, Y., Evaluation of valuable chain in palm oil industry based on SCOR model: a case study, *International Journal of Logistics Systems and Management*, vol. 21, no. 2, pp. 229-241, 2015.

Yao, F., Parilina, E., Zaccour, G., and Gao, H., Accounting for consumers' environmental concern in supply chain contracts, *European Journal of Operational Research*, vol. 301, issue 3, pp. 987-1006, 2022.

Biographies

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