SCOR and ANP Methods for Measuring Supplier Performance with Sustainability Principle of Green Supply Chain Management in Furniture Company PT. XYZ

Pyadasi Widya Hapsari, Haryo Santoso and Denny Nurkertamanda
Industrial Engineering Department
Diponegoro University
Semarang, Indonesia
pyadasi@gmail.com, haryokrmt@gmail.com, and nurkerta@gmail.com

Abstract

Sustainable Green Supply Chain Management (SGSCM) is a development of supply chain management activities with meet 3 main factors in its realization namely economic, social, and environmental. Supply Chain Management is an important strategy that supports in improving the overall performance and key of determinants of competitive advantages for companies. Adds the concept of "Green" to emphasize the importance of environmental issues and the need for environmentally friendly systems. To find out more about SGSCM, an evaluation or measurement must be carried out on it. Moreover, the measurement of supply chain performance in companies becomes very basic as a basis for determining the direction of company improvement. The study was conducted at PT. XYZ, one of the furniture company in Semarang, which so far has never measured supply chain performance. The measurement of supply chain performance is carried out by the SCOR (Supply Chain Operation Reference) method by first looking for the weight value of SCOR performance attributes with ANP (Analytical Network Process) methods.

Keywords
Sustainability, Green Supply Chain Management, SCOR, ANP.

1. Introduction
The industry process has an important role in the Indonesian economy. Some industrial sectors are the main sources of state revenue, one of which is the furniture industry. Indonesia is one of the biggest furniture exporters in the world, along with China, Italy, Vietnam, and Malaysia.
For facing the competition in this industry, it is a challenge for companies to carry out their production activities. Along with increasing government regulations and increasing public awareness in environmental protection, the companies cannot ignore environmental problems if they want to survive in the global market (Van Hoek, 1999).

As one form of the company complies with environmental regulations for the sale of products for some countries, companies need to implement strategies to reduce environmental impacts. Integration of environment, economic, and social performance to achieve sustainable development is a major challenge for today's business competition. Companies are also required to think creatively in implementing competitive strategies by producing goods/services that are of higher quality, cheaper, and faster than competitors.

Implementation of SCM in recent years Improves movement because the environment is becoming a global issue in the manufacturing industry. It cannot be denied because industrial activities also contribute enough to cause environmental pollution that can damage the environment. The development of the industry and consumer's concern for the environment is increasing and the issue of the concept of an environmentally friendly industry has been enhanced by the concept of the green industry in each of its business processes, which later developed into Green Supply Chain Management (GSCM). GSCM is a supply chain management concept integrated with environmental aspects which are complemented by product design, supplier selection, material procurement, manufacturing activities, packaging activities, product delivery activities to 3 consumers, and management of the use of end products (end-of-life products) (Sundarakani et al. 2010). GSCM strives to eliminate or minimize waste (energy, gas emissions,

hazardous chemicals, waste) along with the supply chain network. GSCM can also be approved as green procurement, green manufacturing, green distribution, and reverse logistics (Ninlawan et al. 2010).

Consumer satisfaction is a benchmark in determining whether a company has a good and advanced performance. For this reason, it is necessary to measure performance that is intended to increase competitiveness and customer loyalty. PT. XYZ as one of the furniture companies is also faced with the implementation of SCM that has not been optimal. The company is faced with the uncertainty of demand, supply (delivery lead time, price, quality of raw materials, *etc*.). The company also has problems with custom products, many variant products, small quantity orders, the products consist of some raw materials and short-order lead time. Not all suppliers and vendors are able to fulfill the orders. The supply of raw materials and products becomes late and which causes company losses both in terms of time and cost.

To meet consumer demands on environmental issues and PT. XYZ also has never taken measurements of the supply chain system used and has not applied the concept of green in its business processes, so research is needed to determine the company's performance conditions in terms of green so that improvements can be made to minimize existing problems. For measuring supplier performance with Sustainability Principle of Green Supply Chain Management using SCOR and ANP methods.

2. Green Supply Chain Management (GSCM)

Green Supply Chain Management can integrate environmental management practices into all supply chain management in order to achieve greener supply chain management and maintain competitive advantage and also increase business profits and market share goals. Zhu and Sarkis define GSCM as management that ranges from green purchasing to integrated supply chains from suppliers, to factories, to customers and reverses logistics, which "closes the loop". The following is an example of a green supply chain model (Srivastava 2007) as shown in Figure 1.
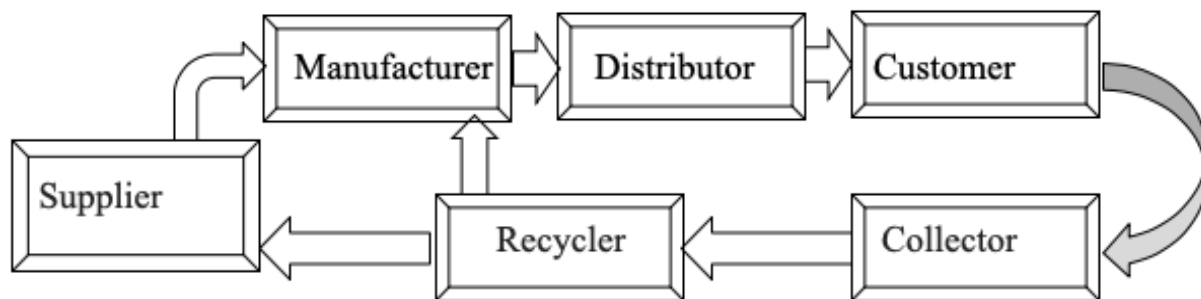

Figure 1. Green supply chain.
(Source: Olugu et al. 2011)

GSCM is integrating environmental considerations into SCM including product and design service, procurement, manufacturing processes, distribution, and end-of-life management of the product to achieve sustainable competitive advantage (Olugu et al. 2007).

GSCM improves work operations by using solutions that pay attention to the environment:
- Increase agility: GSCM helps to reduce risk and accelerate innovation
- Improving adaptation: GSCM analysis often results in innovative processes and continuous improvement
- Promoting alignment: GSCM involves a negotiation policy with suppliers and customers, which results in better alignment of business processes

Adding the concept of Green in resulting in the involvement, influence, and relationship between SCM and the natural environment (Hervani et al. 2005). To achieve GSCM, companies must follow the basic principles set out in the clauses in ISO 14001 that manage the Environmental Management System. The company must develop procedures that concentrate on operations analysis, continuous improvement, measurement, and target goals and programs (Ghobakhloo 2013). GSCM Implementation Process Framework is shown in Figure 2.
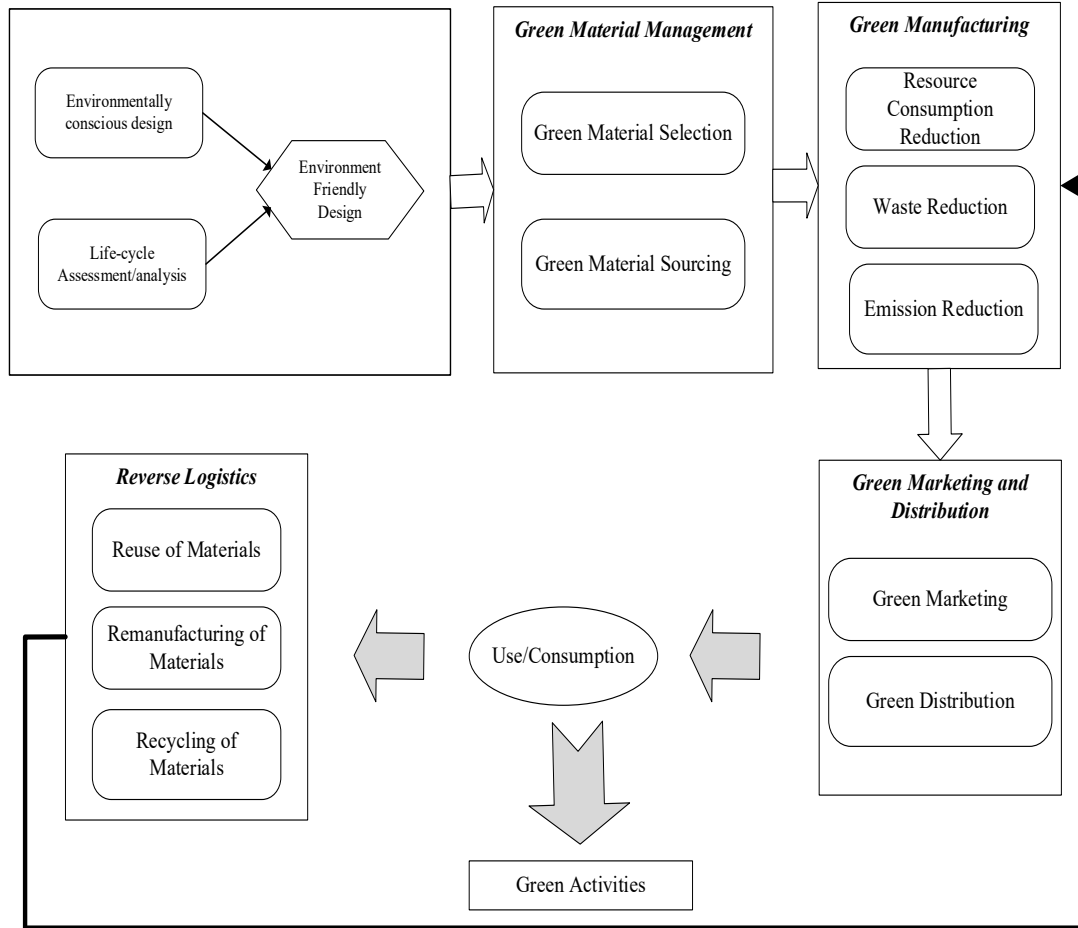
Figure 2. GSCM implementation process framework.

3. Sustainability Supply Chain Management

Sustainability Supply Chain Management is a supply chain of science development. It is said to be sustainable because it fulfills the factors in its realization namely economic, social, and environmental. Each of the objectives of all factors is attempted successfully and strived without effects which in other aspects/dimensions can be directed to the sustainability of a more sustainable Supply Chain Management (Piotrowicz 2011).

a. Economic factors

Several measures of economic factor performance include quality, responsiveness, and efficiency. That quality can be measured for example with such a customer survey. The level of responsiveness is shown how quickly customer needs and changes that occur outside the company can be responded to. This measure of responsiveness is related to product availability along the supply chain. Efficiency is associated with cutting costs, increasing the use of resources, and reducing processing time.

b. Social Factors

Social factors are manifested among others related to health and safety, the impact on workers, and the arising noise. As a measure of health and safety, for example, the number and type of work accidents. The number of workers that can be absorbed, the training that workers receive, and job security can also be a measure of social aspects. A noise that arises is also a social impact that may arise.

c. Environmental factor

Environmental factors related to the company's impact on the natural environment include minimizing CO_2 emissions, the use of natural resources and waste, and maximizing its recycling.
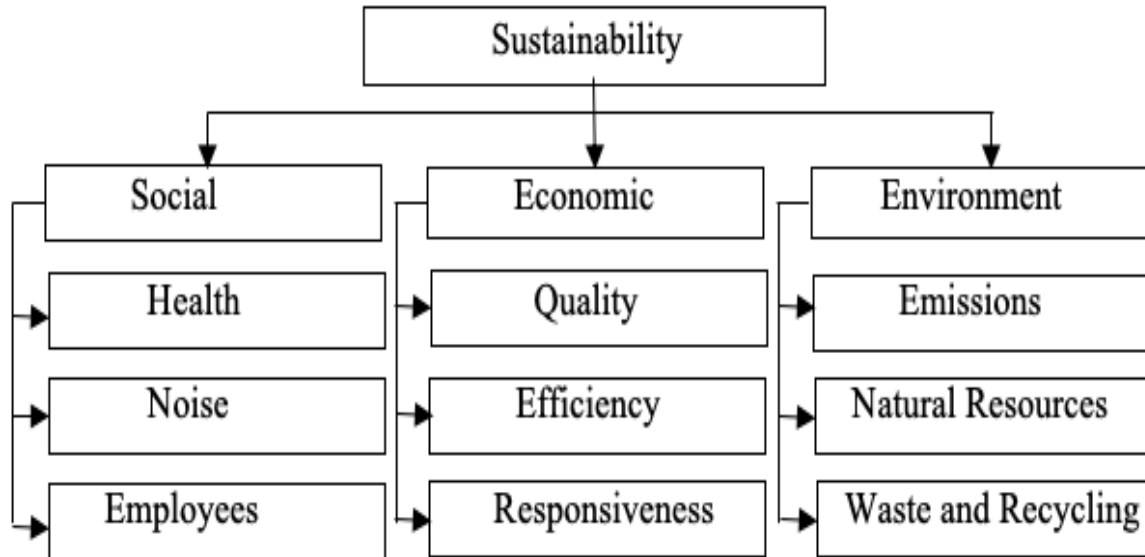
Figure 3. Matric dimensions and sub-dimension of the sustainability supply chain.

Figure 3 above shows the three dimensions in supporting a sustainable supply chain. The success or failure of an industry implementing a management strategy can be seen from the following 4 factors:
- The right company strategy to face the competition
- Supply chain strategy
- How to connect between company strategy and supply chain strategy
- How to make it sustainable

4. Logistic

Logistics management is part of the supply chain process that plans, implements, and controls the flow of goods, services, and information effectively and efficiently from the starting point to the end (consumption) in order to meet customer demand (Stock and Lambert 2001).

The logistic function is part of the supply chain function, where a supply chain itself is a target-oriented process network and storage points that are used to deliver goods and services to customers. Logistics and Supply Chain are two different concepts, in definition and in real practice. The object of logistics management is directly related to logistics activities including the logistics information network. Whereas Supply Chain Management covers broader activities, ranging from the flow of information and material from suppliers, manufactures, distributors, and retailers to end-users.

5. Supplier

In the concept of Supply Chain, the supplier is one of the most important parts and influences the company's existence. To get the right supplier, the company needs to evaluate the supplier. Evaluating suppliers is not easy because the data used are not only quantitative but also qualitative and many factors involved in the supplier evaluation process are conflicting. For example, between the price criteria and quality criteria. Suppliers are an important part in supporting the company's strategy. Supplier management requires good negotiation skills because suppliers are not part of the company's organization but still have an impact on the company's image.

Supplier performance must be monitored on an ongoing basis. This supplier performance appraisal is important because it can be used as an evaluation material that can be used as input in improving supplier performance and as a material consideration regarding the decision to find an alternative supplier. When a company does not only have one supplier, suppliers will be encouraged and compete to improve their performance so that it remains a partner for the company.

6. Supply Chain Operation Reference (SCOR)

SCOR or Supply Chain Operations Reference model is a model developed by groups of companies that join the Supply Chain Council. The SCOR model definition is a framework for describing business activities between components in the supply chain from upstream (suppliers) to downstream (customers) to meet the objectives of the supply chain and meet customer demand. This model has main components in managing a process, namely Plan, Source, Make, Deliver, Return.

SCOR has performance attributes. Performance attribute is a cell attribute used to assess supply chain processes from a variety of different perspectives. The attributes used in the assessment of supply chain performance with the SCOR model are Reliability, Responsive, Agility, Cost, and Asset.

7. Analytical Networking Process (ANP)

Analytic Network Process (ANP) method is a new quantitative method approach. ANP is a generalized form of the widely used multicriteria decision making technique of AHP. ANP is the most comprehensive framework available for group decisions that are in use today.

Part of ANP models are hierarchy control or objectives network and criteria that control the interactions in the system under research; the many sub-networks of influences among the elements and problem clusters one for each control criterion. The ANP has been applied to a large variety of decisions: marketing, medical, political, social, and forecasting many others. Its accuracy of prediction is impressive in applications that have been made to economic trends, sports, and other events for which the outcome later became known.

8. Research Methodology

The methods used to measure the supply chain performance in this research are Supply Chain Operation Reference (SCOR) model and Analytical Network Process (ANP). The research data was collected through direct observation, questionnaires, and interviews with the relevant department at PT. XYZ. The approach used in this research methodology is presented in table 1 below

Table 1. Types, data collection methods, and data sources.

1	Analyzing the supply chain of PT. XYZ	• Primary • Secondary	• Literature Study • Observation • Interview • Questionnaire	• Employees and Management of PT. XYZ • Prior Research • Literature

8.1. Research Methods Flow

The research flow is a framework which functions to build a system, so that research is organized and structured neatly. Following is the research flow used as shown in Figure 4:

```
                          ┌─────────────┐
                          │    Start    │
                          └─────────────┘
                                 ↓
              ┌─────────────────────────────────────┐
              │         Preliminary studies         │
              └─────────────────────────────────────┘
                                 ↓
Stage         ┌─────────────────────────────────────┐
              │ Identification of Problems and      │
Initial       │ Research Objectives                 │
              └─────────────────────────────────────┘
Identification   ↓                         ↓
              ┌──────────────┐      ┌──────────────┐
              │Literature    │      │ Field Study  │
              │Study         │      │              │
              └──────────────┘      └──────────────┘
```

Stage Initial Identification

Questionnaire Design and Distribution

Stage Data Collection

Data Collection :
Choose Pairs in Each Perspective and KPI

Stage Data Processing

Data Processing
1. Scoring System with Snorm Normalization
2. Final SCOR Performance Calculation

Stage Analysis and Conclusion

Data Analysis and Discussion
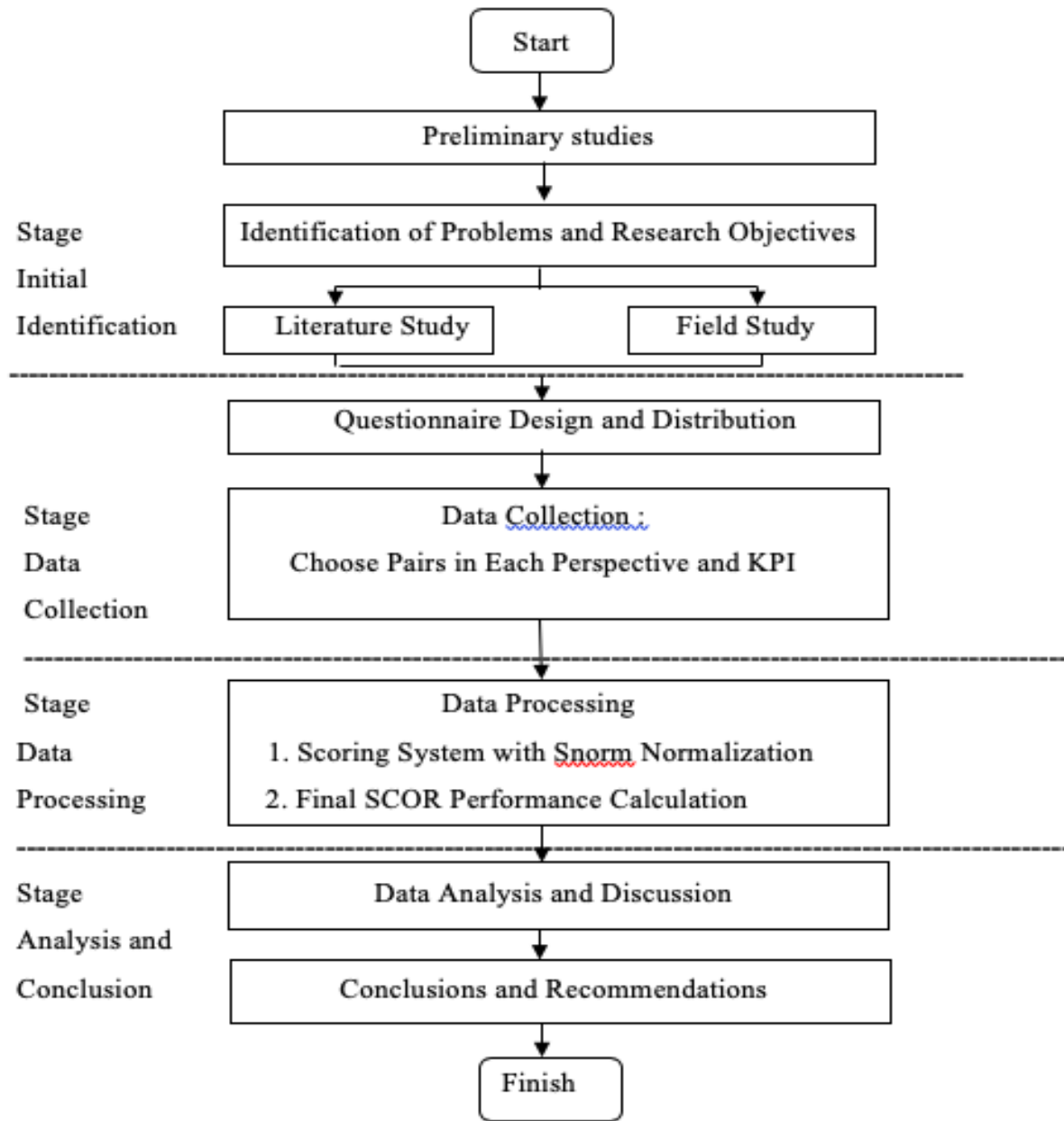
Conclusions and Recommendations

Finish

Figure 4. Research flow.

A description of the steps in the research flow above is as follows:
1. Collection the data by observation and interview of the research object to get the definition of the problem determining alternative solutions choosing the best marketing strategy and then outlining the problem by determining the clusters and nodes of the problem.
2. Problem compilation with existing criteria into a network structure
3. Pairwise comparisons between each cluster, between clusters with nodes, and between alternatives with clusters and nodes
4. Consistency test on each paired comparison matrix by calculating the CI value and CR value
5. Supermatrix Calculation
6. After the test with ANP method, the next step is to measure the performance and implementation of SCM sustainability at PT. XYZ uses the SCOR method

7. The research results will be suggestions for implementing SCM sustainability at PT. XYZ

8.2. SCM Performance Analysis

Based on the SCOR approach, the steps that can be taken to measure SCM performance are as follows and also summarized in table 2:

1. Identifying the matrix of each level

   Matrix Level 1, SCM processes in SCOR method include a plan (planning process), source (raw materials procurement process), make (production process), deliver (shipping process), and return (return process).

   Matrix Level 2, the dimension for measuring SCM performance. Dimensions used include Reliability, Responsiveness, Flexibility, Cost, and Asset.

   Matrix Level 3, identify the indicators that influence each process and the SCM dimensions of the company.

Table 2. PT. XYZ identification of indicators for each level in SCM performance.

Proces (level 1)	Dimension (level 2)	KPI No.	Key Performance Indicator (level 3)
Plan	Reliability	PR-1	Receive customer order
	Responsiveness	Pre-1	Production scheduling
		Pre-2	Identify product specification
	Asset	PA	Cash to cash cycle time
Source	Reliability	SR-1	Raw material defects
		SR-2	Raw material fulfilment
		SR-3	Delivery reliability
	Responsiveness	SRe	Raw material lead time
	Flexibility	SF	Supplier availability
	Cost	SC	Supplier cost order
	Asset	SA	Daily supplies
Make	Reliability	MR-1	Packing process error
		MR-2	Number of product defects
	Responsiveness	MRe-1	Product lead time
		MRe-2	The responsiveness of producing varied consumer orders
	Flexibility	MF	Production flexibility
	Cost	MC	Production cost
	Asset	MA	Tool and machine life
Deliver	Reliability	DR-1	Supply finish goods level
		DR-2	Out of rate product
	Responsiveness	DRe	Finish goods lead time
Return	Reliability	RR	Customer complaints

2. Key Performance Indicator (KPI) Verification, to find out whether the SCM performance indicators that are designed are correct and in accordance with company needs, namely by checking which indicators have not been included or do not need to be included because of the possibility of similarities with other indicators.

3. Calculate the normalized value (score) for each metric using the Snorm De Boer normalization process. The value scale equation for this research is done by interpolation or normalization models. The weights of the indicators are converted into certain value conversions between 0 and 100.
4. Analytic Network Process (ANP) Weighting is to determine the level of importance each level and KPI. Calculates the total value of SCM performance.
5. The total value of SCM performance can be calculated by multiplying the normalization score value for each matrix with the value of metric weights obtained from the weighting results using ANP.

9. Discussion and Conclusion

The supply chain operations reference model (SCOR) is a management tool used to address, improve, and communicate supply chain management decisions within a company and with suppliers and customers of a company. The model describes the business processes required to satisfy a customer's demands. It also helps to explain the processes along the entire supply chain and provides a basis for how to improve those processes. The model integrates business concepts of process reengineering, benchmarking, and measurement into its framework. Therefore, it is a complete model for corporate's; inbound/outbound logistics, manufacturing, distribution, and after-sales operations.

The ANP method is solved using a super decision package. In this method, benefits, opportunities, costs, and risk factors are considered separately and weightage for each merit is provided based on the company's strategic policies. The measurement of supply chain performance with the case of PT. XYZ providing recommendations for improvement to improve supply chain performance in accordance with the GSCM concept.

References

Ageron, B., Gunasekaran, A., and Spalanzani, A., Sustainable supply management: An empirical study, *International Journal of Production Economics,* vol. 140, no. 1, pp. 168-182, 2011.

Beamon, B.M., Designing the green supply chain, *Logistics Information Management*, vol. 12, no. 4, pp. 332-342, 1999.

Bharti, R., Giri, V., and Jayant, A., Green Supply Chain Management Strategy Selection by Analytical Network Process (ANP) Approach: A Case Study, *Journal of Material Science and Mechanical Engineering*, vol. 2, no. 12,pp. 1-17, 2015.

Charan, P., Shankar, R., and Baisya, R.K., Analysis of interactions among the variables of supply chain performance measurement system implementation, *Business Process Management Journal*, vol. 14, no. 4, pp. 512-529, 2008.

Deif, A.M., A system model for green manufacturing, *Journal of Cleaner Production*, vol. 19, no. 14, pp. 1553-1559, 2011.

Ebru, Y., and Ustun, A.K., Application of Analytic Network Process *:* Weighting of Selection Criteria For Civil Pilots*, Journal of Aeronautics and Space Technologies,* vol. 5, no. 2, pp. 1-12, 2011.

Ghobakhloo, M., Tang S.H., Zulkifli N., and Ariffin M.A., An Integrated Framework of Green Supply Chain Management Implementation, *International Journal of Innovation, Management, and Technology*, vol. 4, no. 1, pp. 86-89, 2013.

Gunasekaran, A., Patel, C., and McGaughey, R.E., A framework for supply chain performance measurement, *International Journal of Production Economics*, vol. 87, no. 3, pp. 333-347,2003.

Hervani, A.A., Helms, M.M., and Sarkis, J., Performance measurement for green supply chain management. Benchmarking, *An International Journal*, vol. 12, no. 4, pp. 330-53, 2005.

Kafa, N., Hani, Y., and El Mhamedi, A., Sustainability Performance Measurement for Green Supply Chain Management, *IFAC Proceedings Volumes,* vol. 46, no. 24, pp. 71-78, 2013.

Linton, J.D., Klassen, R., and Jayaraman, V., Sustainable supply chains: An introduction, *Journal of Operations Management*, vol. 25, no. 6, pp. 1075-1082, 2007.

Min, H., and Galle, W.P., Green Purchasing Strategies: Trends and Implications, *International Journal Purchasing Materials Management,* vol. 33, no. 2, pp.10-17, 1997.

Ninlawan, C. et al., *The Implementation of Green Supply Chain Management Practices in Electronics Industry*, Proceedings of the International Multi Conference of Engineers and Computer Scientist, 2010.

Ninlawan, C., Seksan, P., Tossapol, K., and Pilada, W., The Implementation of Green Supply Chain Management Practices in Electronics Industry. *Proceedings of the International Multi Conference of Engineers and Computer Scientist*, vol. 3, 2010.

Olugu, E.U., Wong, K,Y., and Shaharoun, A.M., Development of key performance measures for the automobile green supply chain, Resources, *Conservation. Recycling*, vol 55, no. 6, pp. 567-79, 2011.

Piotrowicz, W., *Sustainable Supply Chain Management: Practical Ideas for Moving Towards Best Practice* in Cetinkaya B, Cuthbertson R, Ewer G, KlaasWissing T, Piotrowicz, W, and Tyssen C, 2011.

Pochampally, K.K., Gupta, S.M., and Govindan, K., Metrics for performance measurement of a reverse/closed-loop supply chain, *International Journal of Business Performance and Supply Chain Modelling*, vol. 1, no. 1, pp. 8, 2009.

Prakash, S., and Sandeep, et al., Supply Chain Operations Reference (SCOR) Model : An Overview and A Structured Literature Review of Its Application, *International Conference on Smart Technologies for Mechanical Engineering,* 2013.

Rao, P., and Holt, D., Do green supply chains lead to competitiveness and economic performance, *International Journal of Operations & Production Management*, vol. 25, no. 9, pp. 898-916, 2005.

Saaty, T.L, Applications of Analytic Network Process in Entertainment. *Journal of Operations Research*, vol. 1, no. 2, pp. 41-55, 2009.

Saaty, T.L., Decision making — the Analytic Hierarchy and Network Processes (AHP/ANP), *Journal of Systems Science and Systems Engineering,* vol. 13, no. 1, pp. 1-35, 2004.

Saaty, T.L., The Analytic Network Process – Dependence and Feedback in Decision-Making, *Applied Computational Intelligence*, pp. 360–87, 2005.

Saaty, T.L., *Theory and Applications of The Analytic Network: Decision Making With Benefits, Opportunities, Costs And Risks*, RWS Publication USA, pp. 47, 2005.

Salam, M.A., RETRACTED ARTICLE: Corporate Social Responsibility in Purchasing and Supply Chain, *Journal of Business Ethics,* vol. 85, no. 52, pp. 355-370, 2008.

Srivastava, S.K., Green supply-chain management: A state-of-the-art literature review. *International Journal Management*, vol. 9, no. 1, pp. 53-80, 2007.

Stock, J.R., and Lambert, D.,*Strategic Logistic Management* Fourth Edition, New York McGraw – Hill, 2011.

Sundarakani, B., de Souza, R., Goh, M., Wagner, S.M., and Manikandan, S., Modelling carbon footprints across the supply chain, *International Journal Production Economics Int*, vol. 128, no. 1, pp. 43-50, 2010.

Van Hoek, R.I., From reversed logistics to green supply chains, *Supply Chain Management An International Journal*, vol. 4, no. 3, pp. 129-35, 1999.

Zhu, Q., Sarkis, J., and Lai, K., Green supply chain management: pressures, practices and performance within the Chinese automobile industry, *Journal of Cleaner Production,* vol. 15, no. 11-12, pp. 101-1052, 2007.

Zhu, Q., Sarkis, J., Cordeiro, J., and Lai, K., Firm-level correlates of emergent green supply chain management practices in the Chinese context, *Omega*, vol. 36, no. 4, pp. 577-591, 2008.