Selection of Suppliers using Topsis Method Based on Green Supply Chain Criteria (Case Study: Saipa Alborz Corporation)

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Abstract

During recent centuries, industrial development has been improved by sustainable development. Industrial managers, especially in developed countries, have been seeking new methods which would enhance their organization's performance whilst supporting environment. The coordinated strategy for enhancement of productivity together with green management is called “green productivity” which is known as the key to sustainable development. Adopting investment strategy for improvement of supply chain’s environmental performance brings companies and organizations a lot of advantages such as conservation of energy resources, reduction of pollutants, reduction or elimination of wastes, value creation for customers, and finally productivity promotion. The present study aims to specify and prioritize the effective factors in green supply chain. Therefore, we used Topsis technique to rank the suppliers of Saipa Alborz Corporation and choose the best candidate from the viewpoint of green supply chain criteria. Among the main criteria, green production criteria are defined as great importance for decision makers.

Keywords: Green Supply Chain Management, Supplier Selection, Topsis Technique

Introduction

Economy globalization and information technology development have changed supply-based market to demand-based market and organizations have realized the importance of costumers’ demands satisfaction for their survival and protection. On this basis, supply chain management assumed importance because satisfaction of customers’ demands and interests is achieved not only by the final product but also by superior suppliers. Global organizations always seek to achieve competitive advantage through innovation and creation of modern methods. Some of them achieve such a competitive advantage through improving the environmental performance by
conforming to environmental rules and standards, expanding customers’ knowledge about this topic, and reducing the negative environmental impacts of their products and services (Koplin et al., 2007).

In the past common standpoint, supply chain management included guiding all supply chain members in a unified manner and in accordance with the goal of performance improvement in order to promote productivity and gain greater benefits. Moreover, supply chain managers just sought faster delivery of goods and service provision, costs reduction, and quality enhancement but paid no attention neither to the improvement of environmental performance of supply chain nor to the importance of the environmental destruction and social costs. Nowadays, green supply chain managers try to use green logistic and improvement of their environmental performance throughout entire supply chain as a strategic weapon to achieve competitive advantage by creating environmental satisfaction and desirability throughout the supply chain. They also try to base their goals on three important issues including green design (product), green production (process), and product recycling (Boks & Stevels, 2007).

Green supply chain management unifies supply chain management with environmental obligations during all stages of product design, selection and supply of raw materials, production and manufacturing, distribution and transportation processes, customer delivery, and finally, recycling and re-using management in order to maximize the productivity of energy and resources consumption by improvement of entire supply chain performance (Srivasta, 2007). Evaluation of suppliers is one of the most important activities of factories to achieve the goals of supply chain and survive in competitive market.

Supply chain management, which embraces all of the activities related to conversion of goods flow from raw material stage to the stage of delivery to final customer along with information flow throughout the supply chain, has a significant effect on environment. Dealing with green supply chain is of great importance from the following viewpoints:

- Creation of environmental satisfaction and desirability throughout the supply chain and having access to the new market by supplying the product which are compatible with environment
- Reduction of costs through conservation of resources, fuel cost, work hours of labor, elimination of wastes, and improvement of productivity
- Enjoyment of competitive advantage through creation and offer of a value to customers and their satisfaction and loyalty towards products and finally, enhancement of corporation’s profitability

**Literature Review**

In comparison with traditional supply chain, the green supply chain has the following characteristics:

Greenness of the chain which means emphasizing on the minimum consumption of energy and resources and minimum production of pollutants throughout the supply chain and is achieved by optimization of the systems and environmental improvement of the performance of all supply chain members.
There is a closed loop of materials flow. Unlike traditional supply chain which materials flow does not have any closed loop and starts from raw materials and ends with final product, the green supply chain has added the recycling section, which is in relation with producers or third-party recycling companies, into the chain. Through recycling processes, a part or all of the products is re-used or the energy and resources are recycled leading to the optimization of energy and resources consumption, reduction of pollutants and wastes, and finally reduction of production costs.

There is more integrity compared to traditional supply chain because the strategic goal of entire chain is defined as environment preservation and this requires the integrity of information systems and cooperation of all supply chain members and further coordination of its activities towards realization of this goal (Wang, 2003).

1. Organization’s incentives to accept green supply chain management:

The organization’s incentives to move towards green supply chain are different from the view points of final customer, public organizations, private organizations, and legislator institutions. The main incentive is the regulations which coerce organizations into obeying environmental rules. On the other hands, some organizations follow these rules in order to enhance customers’ profitability or demands (Zhu & Sarkis, 2006). The incentives of green supply chain management are divided to internal incentives and external incentives. External incentives which lead to greenness are (Polonsky & Rosenberger, 2001):

- Satisfying consumers demands and exercising social responsibilities
- Reaction to rivals’ acts and developing green and environmental strategies for retention and extension of market share
- National and international regulations which coerce organizations into execution of green supply chain management
- Increment of environmental pollution
- Environmental activities of non-governmental organizations

Some of the internal incentives are:

- Reduction in the costs as a result of reduction in consumption of input raw materials and energy resources
- Consideration of environmental goals in organization’s missions
- Creation of sustainable competitive advantage in organization

2. The effective variables in green supply chain management:

Green supply chain management is indeed based on the integration of environmental management with supply chain management to control destructive environmental effects during life time cycle of product through information sharing, coordination, and cooperation of all supply chain members. The parts included in supply chain have mutual relationships so that change of a variable affects numerous variables in supply chain. Green supply chain generally tries to minimize the intangible costs, along with tangible costs, which are not considered in ultimate price of product and have negative impact upon environment and are indirectly afforded
by company (social costs). In other words, managers of supply chain, along with minimizing the usual costs of supply chain (cost of order, cost of stock etc.), also try to minimize the social costs in order to exercise the social responsibility of organization and promote productivity. Doing this, they want to create value and meet customers’ demands (especially those of the customers who feel concern about and support environment), improve or create new demands, have access to new parts of market, and change costs through using new methods of production as the chief resources of innovation. This gradually earns organization competitive advantage. Green supply chain is divided to three parts as in the following:

2.1 Internal logistic:

This includes all of the activities related to receipt, storage, and transportation of raw materials. The important variables of decision making by managers which affect environment are as follows (Trunick, 2006):

- Raw materials purchase
- Selection of seller
- Selection of seller’s location
- Selection of procedure
- Selection of transportation vehicle
- Raw materials control
- Storing

The selection of goods transportation method has a tremendous effect on environment and logistic managers should take this into consideration when making their decisions. Rail transportation is the most suitable option because of lower energy consumption compared to other goods transportation methods, more efficient use of land, and lower air and noise pollution. Selection of transportation vehicle, from the viewpoint of pollution, is another variable which should be considered by managers. Transportation can affect environment by three factors:

- Structure of transportation networks
- Transportation vehicle
- Spare parts accessibility

Logistic managers should use other types of fuels (natural gas, catalyst, electricity etc.) for their transportation fleet and try to use energy more efficiently and produce less pollution by employing vehicles of high fuel combustion yield. In addition, logistic managers may reduce the number of travels by regulating and improving transportations. Existence of a suitable information system can reduce pollution and traffic through employing efficient lading, scheduling vehicles departure, and choosing more efficient transportation routes. Nowadays, most of the transportation vehicles are equipped with different computer models which, aside from solving the problems related to determination of driving routes, helps retailers to reduce their stocks through on-time delivery of goods.

A higher lading capacity of vehicles leads to the reduction in number of empty trucks in roads as well as a reduction in traffic and subsequently, environment pollution. Repair and maintenance of vehicles is another main environmental problem. Use of more appropriate maintenance
programs may lead to the retention of vehicles’ function in safer conditions, increase of their activity duration, and reduction of accidents rate which, in turn, not only results in the conservation of operational costs, but also reduces the destructive environmental effects. Raw materials transportation operations bring organizations about economic and environmental advantages. Any improvement in raw materials transportation operations will make it so economic for distribution channel members and will also be so useful for environment since the consumption of natural resources decreases. Further use of containers and preliminary envelopment in stores along with reduction in costs of storing and materials re-movement in store, will also be so economic from operational costs viewpoint. A new procedure has recently been employed in supply chain that stores are considered as an operational point for raw materials transportation and information exchange. The members of distribution channel, without accumulating goods in their stores, obtain the maximum efficiency by exact programming, exchange of sales information, and elimination of the activities which brings no value added in supply chain. Such acts are so beneficial for environment because of reduction in required space of stores and in movements inside stores. Generally, green purchase effectively facilitates pollution reduction through recycling, re-use of packing, wastes elimination, separation of non-toxic packing from degradable ones. It also seeks to discover the preliminary frameworks for making a change in order to enhance the effect of green purchase on environment. The most important obstacles to green purchase are uncommitted management, unawareness of buyers, deficiencies in environmental standards or organization-level audit programs, and weakness of governmental rules.

2.2. Green production:

Production means the entrance of raw materials and conversion of them to the final goods through assembly, manufacturing, and packaging activities. Stock management is one of the important topics of entire supply chain process and most of its decisions do not account for environmental costs and potential social costs. For instance, the stock management technique of JIT which is used by companies has some deficiencies from the view point of environment. Extra transportation, causing extra road traffic, air and noise pollution for environment are some of these deficiencies. Companies, in short term, need to exploit the maximum inactive capacity of stores. They need to choose the transportation routes which have lighter traffic. They are also required to re-design their transportation trucks so that the resulted improvement of transportation brings them about improved efficiency.

In long term, companies should assess their location, location of other supply chain members, technology, and structure of distribution channel. All product, except a little part, need packaging. Packaging is generally divided to three types: primary packaging, secondary packaging, and packaging for product transportation. It is one of the most important issues which have direct influence on environment. Application of environmentally-compatible and degradable packaging will increase the companies’ market share. In packaging, factors such as size, shape of packaging, and type of the used materials have direct influence over supply chain costs since they affect properties of product transportation, suitable arrangement of products in store, easy access to product information, reduction of storing costs, and correction delays. Companies can achieve considerable conservation of packaging, storing, and product transportation through the variation of product size, primary and secondary packaging, size of
product transportation pallets, and also, by employing computer software for optimization of packaging. A better packaging together with variation in product carrying pallets results in the reduction of material consumption and product transportation as well as in the increase of exploitation of store space and transportation trucks.

As a result, a better packaging leads to less vehicle use since more space is used in store and storing gets easier. This efficiency improvement affects environment directly. Green production includes some factors such as clean production, product design by accounting for environment, re-production, and pure production. One of the key factors in doubling Japanese companies’ productivity compared to western companies is “pure production” which decreases production methods, leadership duration, and materials and labor costs and simultaneously improves production quantity and quality as well as the competitiveness. The success of green production comes from three factors:

- Minimization of the activities which has no value added for company
- Design and use of efficient work systems
- Human resource management

The variables of green production include (Duber-Smith, 2005):

- Application of environmentally-compatible raw materials
- Elimination of the raw materials which has destructive effect on environment
- Accuracy in the field of the environmentally-compatible criteria
- Accuracy in design through environmentally-compatible methods
- Optimization of processes to reduce wastes
- Application of clean technologies in order to conserve energy and water and reduce pollutants
- Recycling of raw material during production stage
- Application of comprehensive quality management principles

2.3. External logistic:

There is just a little difference between external logistic activities and internal logistic. External logistic deals with made product which has higher added value and has more controllable variables. Nonetheless, most of the decisions related to exchange are different for internal and external logistic. External logistic includes all physical distribution activities and involves the gathering, storing, and distribution of the made products among buyers. Most of the decisions in external logistic require considering market, customer, product, and company resources. Two factors of accordance with company’s current goals and satisfaction of superior chief management goals should be considered when designing distribution networks. Reduction of operational points in supply chain is one of the new tactics in distribution network design. Using this tactic, logistic managers will be able to execute their operations more efficiently and using less stock of product, while retaining service provision to customers at the same level. The result is conservation and elimination of extra energy use and numerous places which exist in traditional distribution network. Such acts accord with the preservation of environment. The product stock-related decisions in external logistic are: amount of product stock, location of
stores, concentration or dispersion of distribution centers, service provision policy for different products, management of rejected products, and stock re-preparation policy (Sheu et al., 2005).

Marketing: Level of service provision to customers and distribution channels have a direct effect on supply chain. Today, most of the producers are connected to the computers of retailers and exchange information directly. This results in more accurate prediction of sales and programming for product movement in supply chain. Such information exchange in supply chain leads to movement of products towards the shops which need them, faster specification of customers, and acceleration of transportation when demand exists. Informational systems have a direct influence on environment and prevent extra stock of products in stores and inefficient transportation through better prediction and coordination.

Provision of after-sale service: Retention of a broad after-sale service proving network is an important part of product in durable industrial goods. Among various activities, supply chain managers emphasize the transportation of returned goods, management of spare parts supply, retention of supply network to provide customers with fast and reliable service. During recent years, management of returned goods has assumed importance because of the increasing emphasis on transportation of dangerous and recyclable materials.

3. Obstacles, advantages, and results of green supply chain management:

Some of the advantages of green supply chain are as follows:

- Increase efficiency, improvement of productivity, creation of new markets, cost reduction, pollutant reduction, improvement of organization’s social prestige, increase of organization’s social responsibility and commitment (Rao, 2002)
- Optimization of energy consumption, reduction of residual materials, cost reduction, preservation of natural resources, improvement of life quality, creation and preservation of a better environment for future generations (Arif et al., 2009)

The obstacles to achieving green supply chain management are as follows (Arif et al., 2009; Farahani et al., 2009; Polonsky & Rosenberger, 2001; Rao, 2002; Zhu & Sarkis, 2006):

- Lack of an active and voluntary policy of organization and suppliers as to conforming to the environmental standards and social responsibilities.
- Inability of suppliers (from the viewpoint of technical knowledge and technology) for gaining the standard 14000.
- Inability to create tangible competitive advantage originated from green supply chain implementation.
- Difficulty of organizing and coordinating units when implementing green supply chain.
- Lack of sufficient incentives provided by government to gain green supply chain management.
- The high cost of green supply chain implementation.
- Lack of sufficient legal levers for execution of environmental rules
- Lack of appropriate information technology infrastructures to facilitate green supply chain implementation
- Shortage of knowledge and education on environmental problems
Lack of the support by organization’s chief and middle managers
Absence at global markets
lack of strategic environmental program and goals in organization
Excess required cost for implementation of green supply chain

The advantages and results of green supply chain management implementation are classified in five groups of positive economic results, environmental results, negative economic results, and improvement of production performance and satisfaction of beneficiaries (Bowen et al., 2002; Carter & Rogers, 2008; Zhu & Sarkis, 2004; Zhu, Sarkis, & Geng, 2005; Zhu, Sarkis, & Lai, 2007):

Environmental results: reduction of air, water, and soil pollutants, reduction of solid and liquid wastes, reduction in use of the materials which are poisonous, destructive and dangerous for environment, reduction in level of destructive environmental events, improvement of organization’s environmental prestige.

Positive economic results: increase of market share, creation of competitive advantage for organization, costs reduction caused by reduction in energy, water, and raw materials consumption, costs reduction resulted from the reduction of wastes rate, reduction of environmental penalties, and costs reduction originated from residual management.

Improvement of production performance: quality improvement, reduction in level of spares stock, increase of production capacity, increase of efficiency, and improvement of effectiveness.

Satisfaction of beneficiaries: customers’ satisfaction, satisfaction of shareholders, satisfaction of employees, satisfaction of the general public.

Negative economic results: increase of investment cost, increase of operational cost (research and development, design, etc.), increase of education cost, increase of the product’s cost price.

Although the concepts of sustainable supply chain management and green supply chain management are used alternatively, they are, in fact, different from each other. Sustainable supply chain management includes the economic dimensions and environmental and social sustainability. Therefore, the concept of sustainable supply chain management is broader than green supply chain management and, indeed, green supply chain management is just a part of sustainable supply chain management (Farahani et al., 2009).


AHP technique is used to assess the performance of various suppliers (Handfield et al., 2002). Humphreys et al. specified the environmental criteria which affect the purchase policy of factories and then divided them to two groups of quantitative and qualitative environmental criteria. Then, they created a knowledge-based decision supporting system which is used to select suppliers considering environmental criteria (Humphreys et al., 2003). In 2003, they also designed another similar system using multivariate analysis (Humphreys et al., 2003). Chen, in
2005, divided the supplier selection into two stages. In first stage, the environmental performance is considered as the minimum of obligations while the criteria such as quality, delivery due, and general parameters of performance are used in second stage. Only the suppliers who have an ISO 14000 certificate are assessed in second stage (Chen, 2005).

A fuzzy hierarchical system is introduced in order to facilitate the process of supplier selection using environmental criteria (Humphreys et al., 2006). Lu et al., in 2007, propounded a multi-criteria decision making process in order to help green supply chain managers with evaluation of suppliers’ performance using FAHP method (Lu et al., 2007). Kannan et al. employed structural modeling and AHP method to analyze and select suppliers (Kannan et al., 2008). Furthermore, AHP and genetic algorithm are used for evaluation of suppliers in green supply chain (Yan, 2009). Dynamic fuzzy programming is also used for evaluation of suppliers (Tsai and Hung, 2009). In (Lee et al., 2009), a developed fuzzy AHP method is applied to evaluate suppliers.

However, in many studies, only environmental factors have been considered for evaluation of green supply chain suppliers (Lee et al., 2009). In addition to environmental parameters, general parameters of supply chain have also been considered for evaluation of green supply chain suppliers and totally, 22 parameters have been used. Analysis of major variables is one of the multivariate analysis techniques and is mainly used in order to decrease dimension. The parameters used for evaluation of suppliers can be taken as random variables which have a special value for any supplier. Petroni and Braglia employed PCA technique for selection of supply chain suppliers (Petroni & Braglia, 2000). Furthermore, multi-dimensional scaling, as one the multivariate analysis techniques, is applied for selection and control of supply chain suppliers (Lasch and Janker, 2005). A fuzzy PCA is used for selection of material suppliers in construction projects (Lam et al., 2010).

**Problem Description**

Greening of supply chain is the process of considering criteria or environmental consideration throughout supply chain. Green supply chain management integrates supply chain management with environmental obligations during all the stages of product design, raw materials selection and supply, production and manufacture, distribution and transportation processes, delivery to customer and finally recycling management and re-use in order to maximizing the efficiency of energy and resources consumption along with improvement of entire supply chain performance (Sarkis, 2006). When investigating the environmental effects of supply chain activities, the effects of products on environment is analyzed using a holistic approach (involving analysis of product life time from beginning to end). In this approach, all of the ecologic (the science of habit and life style of creatures and their interactions with environment) effects of any activity during various stages of product life time such as concept of product, design, raw materials preparation, manufacture and production, assembly, maintenance, packaging, transportation, and re-use of product are measured and considered for product design (Farahani et al., 2009).

(Srivastava, 2007) defines green supply chain as the consideration of environmental issues in supply chain management including product design, selection of and search for resources of materials, manufacture and production process, delivery of final product to customer and management of product after consumption and duration of its useful life.
The present study aims to specify and prioritize the effective factors in green supply chain in Saipa Alborz Corporation in Iran using Topsis technique. Therefore, the main study question is: According to Topsis model, which one of the effective factors in green supply chain is of great importance for supplier selection in Saipa Alborz Corporation?

**Methodology**

This study is an applied research from the viewpoint of goal, and a survey research from the viewpoint of research method. The statistical population of this study involves 250 managers and employees of Saipa Alborz Company. Cochran’s sample size determination formula was used to calculate the sample size as described below. The values of q, p, and e have been taken to be 0.5, 0.5, and 0.095 respectively. Therefore:

\[
Z_{a/2} = 1.96 \\
N = 250 \\
p = 0.5 \\
q = 0.5 \\
e = 0.095
\]

\[
n = \frac{N(Z_{a/2})^2 \times p \times q}{e^2(N-1) + (Z_{a/2})^2 \times p \times q}
\]

\[
n = \frac{160(1.96)^2 \times (0.5 \times 0.5)}{(0.095)^2 \times (160 - 1) + (1.96)^2 \times (0.5 \times 0.5)} = 71.19 \approx 72
\]

In this study, questionnaire was used as data collection tool. The validity of questionnaire was face validity type since the measurement tool key was distributed among experts and university professors, asking them for review and comment on questionnaire. After gathering the comments and revising some of the questions, the validity of questionnaire was found to be high. To investigate the reliability of questionnaires, the questionnaires were distributed among 72 people of statistical population for two time with a time gap of four weeks and the correlation of the results from two these two stages was found to be 0.93 using Pearson’s correlation coefficient. Using this questionnaire, the decision making matrix was used to execute Topsis technique and to select supplier.

Topsis model was suggested by Huang and Yun in 1981. This model is one of the best multivariate decision making models and is widely used. Through this method, m alternatives are evaluated by n parameters. This technique is based on this concept that the selected option should have the minimum distance from positive ideal solution (the best possible situation) and the maximum distance from the negative ideal solution (the worst possible situation). The assumption is the properness of any parameter is uniformly increasing or decreasing (Zhu et al., 2005). The TOPSIS process is carried out as in the following stages:
Stage 1: Create an evaluation matrix consisting of m alternatives and n criteria

Stage 2: Calculate the weighted normalized decision matrix

Stage 3: Determine the worst alternative and the best alternative

Stage 4: Calculate the L2-distance between the target alternative \( z \) and the worst condition and the distance between the alternative \( z \) and the best condition

Stage 5: Calculate the similarity to the worst condition

Results and Findings

We present the result according to the five stages of Topsis technique.

First stage: quantification of decision matrix and making it dimensionless:

Bipolar distance matrix was used to convert qualitative parameters to quantitative ones as described in Table 1.

Table 1: Bipolar distance matrix

<table>
<thead>
<tr>
<th>Negative</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Very low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Decision making matrix is a quantitative technique used to rank the multi-dimensional options of an option set. Execution of Topsis technique requires the decision making matrix originated from pair wise comparisons. This matrix is shown in Table 2.

Table 2: Decision making matrix

<table>
<thead>
<tr>
<th>Effective factors</th>
<th>Green internal logistic</th>
<th>Green production</th>
<th>Green supplier</th>
<th>Green external logistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier No. 1</td>
<td>6.7</td>
<td>7.2</td>
<td>3.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Supplier No. 2</td>
<td>7.5</td>
<td>8.1</td>
<td>4.8</td>
<td>5.9</td>
</tr>
<tr>
<td>Supplier No. 3</td>
<td>9.1</td>
<td>5.3</td>
<td>6</td>
<td>3.7</td>
</tr>
<tr>
<td>Supplier No. 4</td>
<td>6.2</td>
<td>6.7</td>
<td>5.4</td>
<td>5.5</td>
</tr>
<tr>
<td>Supplier No. 5</td>
<td>7.2</td>
<td>4.9</td>
<td>7.3</td>
<td>5.8</td>
</tr>
<tr>
<td>Supplier No. 6</td>
<td>6.4</td>
<td>5.2</td>
<td>4.9</td>
<td>8.1</td>
</tr>
<tr>
<td>Supplier No. 7</td>
<td>4.9</td>
<td>3.8</td>
<td>5.1</td>
<td>7.4</td>
</tr>
<tr>
<td>Supplier No. 8</td>
<td>4.9</td>
<td>5.3</td>
<td>6.8</td>
<td>5.4</td>
</tr>
</tbody>
</table>
Parameters should be made dimensionless to make them comparable. In Topsis model, vector dimensionless method is used for this purpose. Doing this, the values of different parameters will have no dimension and can be added up.

Second stage: acquisition of weighted dimensionless matrix (v): the dimensionless matrix of N is multiplied by the weights matrix \((W_{non})\). The weight of each parameter was calculated using Shannon entropy. Shannon entropy is the average unpredictability in a random variable, which is equivalent to its information content. Results are shown in Tables 3 and 4.

\[
W_j = \frac{d_j}{\sum_{j=1}^{m} d_j}, \quad \forall j, \quad d_j = 1 - E_j, \quad \forall j
\]

**Table 3: Level of confidence**

<table>
<thead>
<tr>
<th>Effective factors</th>
<th>Green supply chain parameters</th>
<th>Green internal logistic</th>
<th>Green production</th>
<th>Green supplier</th>
<th>Green external logistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum</td>
<td>52.9</td>
<td>46.5</td>
<td>43.7</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>Ej</td>
<td>0.90177</td>
<td>0.84079</td>
<td>0.87179</td>
<td>0.8483</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4: Weight of criteria**

<table>
<thead>
<tr>
<th>Effective factors</th>
<th>Green supply chain parameters</th>
<th>Green internal logistic</th>
<th>Green production</th>
<th>Green supplier</th>
<th>Green external logistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D_j = 1 - E_j)</td>
<td>0.09823</td>
<td>0.15921</td>
<td>0.12821</td>
<td>0.1517</td>
<td></td>
</tr>
<tr>
<td>(W_j)</td>
<td>0.182804</td>
<td>0.296287</td>
<td>0.238598</td>
<td>0.282311</td>
<td></td>
</tr>
</tbody>
</table>

The results of weighted dimensionless matrix are shown in Table 5.
Table 5: Dimensionless matrix

<table>
<thead>
<tr>
<th>Effective factors</th>
<th>Green internal logistic</th>
<th>Green production</th>
<th>Green supplier</th>
<th>Green external logistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier No. 1</td>
<td>0.064266</td>
<td>0.126584</td>
<td>0.051378</td>
<td>0.06933</td>
</tr>
<tr>
<td>Supplier No. 2</td>
<td>0.07194</td>
<td>0.142407</td>
<td>0.072533</td>
<td>0.099767</td>
</tr>
<tr>
<td>Supplier No. 3</td>
<td>0.087287</td>
<td>0.09318</td>
<td>0.090667</td>
<td>0.062566</td>
</tr>
<tr>
<td>Supplier No. 4</td>
<td>0.05947</td>
<td>0.117793</td>
<td>0.0816</td>
<td>0.093003</td>
</tr>
<tr>
<td>Supplier No. 5</td>
<td>0.069062</td>
<td>0.086147</td>
<td>0.110311</td>
<td>0.098076</td>
</tr>
<tr>
<td>Supplier No. 6</td>
<td>0.061389</td>
<td>0.091422</td>
<td>0.074044</td>
<td>0.136969</td>
</tr>
<tr>
<td>Supplier No. 7</td>
<td>0.047001</td>
<td>0.066808</td>
<td>0.077067</td>
<td>0.125132</td>
</tr>
<tr>
<td>Supplier No. 8</td>
<td>0.047001</td>
<td>0.09318</td>
<td>0.102756</td>
<td>0.091312</td>
</tr>
</tbody>
</table>

Third stage: Determination of negative and positive ideal solutions as described below. TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. \((V^-_j)\): the worst alternative and \((V^+_j)\): best alternative. The results are shown in Table 6.

\[
V^+_j = \{(Max V^+_i \mid j \in J), (Min V^-_i \mid j \in J) \mid i = 1, \ldots, m\} \\
= \{V^+_1, V^+_2, \ldots, V^+_n\} \\
V^-_j = \{(Min V^-_i \mid j \in J), (Max V^+_i \mid j \in J) \mid i = 1, \ldots, m\} \\
= \{V^-_1, V^-_2, \ldots, V^-_n\}
\]

Table 6: Determination of negative and positive ideal solutions

<table>
<thead>
<tr>
<th>Effective factors</th>
<th>Green supply chain parameters</th>
<th>Green internal logistic</th>
<th>Green production</th>
<th>Green supplier</th>
<th>Green external logistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V^+_j)</td>
<td></td>
<td>0.087287</td>
<td>0.142407</td>
<td>0.110311</td>
<td>0.136969</td>
</tr>
<tr>
<td>(V^-_j)</td>
<td></td>
<td>0.047001</td>
<td>0.066808</td>
<td>0.051378</td>
<td>0.062566</td>
</tr>
</tbody>
</table>

Fourth stage: normalizing scores for each criterion and calculating the geometric distance between each alternative and the negative and positive ideal solutions:
Fifth stage: calculation of the parameter of similarity or relative closeness to the ideal (*CL*):

\[ CL_i^* = \frac{d_i^-}{d_i^- + d_i^+}, \quad 0 \leq CL_i^* \leq 1, i = 1,2,...,n \]

\( CL_i = 1 \) if and only if the alternative solution has the worst condition

\( CL_i = 0 \) if and only if the alternative solution has the best condition.

The results of fourth and fifth stages are illustrated in table 7 and 8

**Table 7:** The results obtained for the distance of each factor from negative and positive ideal and calculation of relative closeness

<table>
<thead>
<tr>
<th>Effective factors</th>
<th>( d_i^+ )</th>
<th>( d_i^- )</th>
<th>( CL_i^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier No. 1</td>
<td>0.09396</td>
<td>0.062586</td>
<td>0.399792</td>
</tr>
<tr>
<td>Supplier No. 2</td>
<td>0.055196</td>
<td>0.09038</td>
<td>0.620843</td>
</tr>
<tr>
<td>Supplier No. 3</td>
<td>0.091351</td>
<td>0.062145</td>
<td>0.404866</td>
</tr>
<tr>
<td>Supplier No. 4</td>
<td>0.064318</td>
<td>0.067785</td>
<td>0.51312</td>
</tr>
<tr>
<td>Supplier No. 5</td>
<td>0.070781</td>
<td>0.074799</td>
<td>0.513801</td>
</tr>
<tr>
<td>Supplier No. 6</td>
<td>0.067716</td>
<td>0.08284</td>
<td>0.550225</td>
</tr>
<tr>
<td>Supplier No. 7</td>
<td>0.092647</td>
<td>0.067634</td>
<td>0.421973</td>
</tr>
<tr>
<td>Supplier No.8</td>
<td>0.078663</td>
<td>0.06451</td>
<td>0.450573</td>
</tr>
</tbody>
</table>

In Table 7, suppliers in a range of best to worst in terms of compliance with the standards in green production, green logistic etc. are classified. It can be seen that supplier NO.2 has less distance from standards in this area and its measures are closer to green supply chain.
Table 8: Prioritization of factors

<table>
<thead>
<tr>
<th>Effective factors</th>
<th>(CL^*_i)</th>
<th>Priority factors rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier No.2</td>
<td>0.620843</td>
<td>1</td>
</tr>
<tr>
<td>Supplier No.6</td>
<td>0.550225</td>
<td>2</td>
</tr>
<tr>
<td>Supplier No.5</td>
<td>0.513801</td>
<td>3</td>
</tr>
<tr>
<td>Supplier No.4</td>
<td>0.51312</td>
<td>4</td>
</tr>
<tr>
<td>Supplier No.8</td>
<td>0.450573</td>
<td>5</td>
</tr>
<tr>
<td>Supplier No.7</td>
<td>0.421973</td>
<td>6</td>
</tr>
<tr>
<td>Supplier No.3</td>
<td>0.404866</td>
<td>7</td>
</tr>
<tr>
<td>Supplier No.1</td>
<td>0.399792</td>
<td>8</td>
</tr>
</tbody>
</table>

Conclusion

Nowadays, the sustainable development of any country is only guaranteed by preservation and optimum exploitation of the limited and non-replaceable resources of that country and government have taken different actions to tackle this issue such as exertion of green rules and principles like use of the environmentally-compatible raw materials in industrial and manufacturing units, reduction in use of petroleum and fossil energy resources, recycling of papers, and reuse of wastes in all public sector and private sector companies and organizations. Acceleration of governmental regulations for obtaining environmental standards and the increasing demand of consumers to supply green products to supply chain which includes all of the activities related to goods flow from raw material stage to goods delivery to final consumer along with the information flow throughout the chain, resulted in advent of the new concept of “green supply chain management” or GSCM which embraces all stages of the product life time cycle from design to recycling. Adopting an investment strategy to improve environmental performance of supply chain has a lot of advantages such as conservation of energy resources, reduction of pollutants, elimination or reduction of wastes, creation of value for customers and finally, promotion of companies’ productivity.

Therefore, considering the importance of green supply chain for preservation of environment, this paper prioritized the suppliers of Saipa Alborz Company using Topsis technique to select the best candidate from the viewpoint of green supply chain criteria. To achieve this, questionnaire were prepared in order to use the experts’ views on selected criteria and pair wise comparisons and then distributed among the experts of Siapa Alborz Company. The results showed that the supplier no. 2 has the first priority, thus selected as the best supplier. Among main criteria, green production criteria are of great importance for decision makers. Hence, the factory’s spare parts are suggested to be purchased from the supplier no. 2.
References


