Strategic Outsourcing: An International Journal

Decision support system framework for performance based evaluation and ranking system of carry and forward agents

Karthik B, Rakesh D Raut, Sachin S Kamble, Manoj Govind Kharat, Sheetal Jaisingh Kamble,

Decision support system framework for performance based evaluation and ranking system of carry and forward agents

Karthik B., Rakesh D. Raut, Sachin S. Kamble, Manoj Govind Kharat and Sheetal Jaisingh Kamble
Department of Operations Management, National Institute of Industrial Engineering (NITIE), Mumbai, India

Received 19 February 2015
Revised 19 March 2015
Accepted 7 April 2015

Abstract

Purpose – The purpose of this paper is to present a research model that explore strategic outsourcing practices for sustainable competitive advantages. In this paper, a decision support system (DSS) for sustainable performance measurement of carry and forward agents (CFAs) is proposed.

Design/methodology/approach – The importance of seven criteria as a means of selecting the best CFA for warehouses under the aspect of sustainable environment is analyzed. The criteria are compared and ranked using analytic hierarchy process (AHP) with the combined assistance of literature review and expert opinions. This study makes use of unstructured interviews of Regional Distribution Manager and senior strategic leaders of the firms.

Findings – This paper discusses how strategic outsourcing can help firm to achieve desired business outcomes. The selection of best CFA gives a direction to the company to move toward excellence and provides the key areas to work upon to achieve competitive advantage. The main contribution of this paper includes modeling the performance evaluation problem within the context of a sustainable supply chain based on triple bottom line (TBL) concept.

Research limitations/implications – The identified selection criteria are bound with Indian transportation and logistics industry. Further, it is suggested to conduct a real-life application of this study to other companies from different countries, to obtain criteria based on globally acceptable norms. The results may yield the network-specific evaluation criteria and their evaluations.

Practical implications – The developed excel-based tool could be used to record the inspection data, compare the CFAs and determine the best CFAs on the basis of selected criteria. With the help of this tool, CFAs know their position and ranking among all the CFAs and the focus areas they need to work upon to perform well. The training module could be used to keep the CFA staff on the right track which is very essential in a typical manufacturing industry warehouse. The improved performance of CFAs will in turn help to improve the manufacturing process, thus maximizing the gains along with environmental benefits.

Originality/value – This paper provides a priority of sustainable issues for evaluating the performance of the best CFA. The paper presents a strategic outsourcing model, which suggest both theoretical and managerial implications showing how to implement successful outsourcing practices in the global market by analyzing the performance of outsourcing partners, i.e. CFAs.

Keywords Sustainability, AHP, Corporate social responsibility, Supplier or partner selection, Performance management and benchmarking, Carry and forward agent (CFA), Pharmaceutical manufacturing

Paper type Research paper

Strategic Outsourcing: An International Journal
Vol. 8 No. 1, 2015
pp. 23-52

1753-8297
DOI 10.1108/SO-02-2015-0008

Introduction

Owing to the globalization of markets, the diversification of customer needs and the complexity of product components, the efficiency of supply chain management (SCM) has become an important factor in an enterprise's competitiveness. Carry and forward agents (CFAs) represent an important dimension or a function of logistics outsourcing which deals specifically with the transportation. Although it is a traditional logistics service, combined transportation highlights its importance among other logistics services because of its impact on the overall logistics cost and service quality. Consequently, CFAs maintain their positions as important intermediaries within the logistics channels.

Most of the work related to multi-criteria decision making (MCDM) in the manufacturing and services industry focused on common issues such as service quality or lead time but did not give enough importance to sustainability. Sustainable distribution is a pertinent and timely issue in any industry. Recently, there has been a paradigm shift with regard to improving the social and environmental (sustainability) performances of organizations from the manufacturing or the service industry (Hart and Milstein, 2003; Govindan *et al.*, 2015). Recent trends in global production has increased supply chain complexity and reinforced the notion that logistics strategies and practices are essential elements of business strategy (Kannan and Choon Tan, 2003; Perona and Miragliotta, 2004). Nowadays, most of the organizations are reducing their horizontal supply chain and increasing the vertical supply chain. Today's business environment emphasizes supplier relationship development for sustainable enterprise management (Krause and Ellram, 1997). The objective of the supplier selection and evaluation process is to reduce risk and maximize overall value to the purchaser. In fact, supplier selection has been shown to be a multiple criteria decision-making process, and if other real-world considerations are taken into account, may turn out to be an even more complicated problem (Kumar *et al.*, 2006; Jolai *et al.*, 2011). An adequate and appropriate performance measurement/evaluation is an important issue for service industries due to the fact that inadequate performance evaluation/measurement can negatively affect the overall performance, productivity and profit of a service industry system. For an effective evaluation, the decision-maker may require a large amount of data to be analyzed with multiple factors to be considered (Ayağ and Özdemir, 2006; Dagdeviren *et al.*, 2009). Dickson (1966) conducted a study on supplier selection problem and considered 23 criteria such as price, quality, delivery, etc. Due to the increased globalization of trade and higher level of competition, firms are now considering every factor to minimize the costs and to maximize profit. To cope with the increased competition, different companies design strategies in their supplier selection process which considers the sustainability and environmental responsibility requirements. Sustainability plays a vital, basic role in supplier selection and performance evaluation according to many researchers. This is particularly critical for the pharmaceutical manufacturing industry.

Sustainable supply chain in pharmaceutical manufacturing industry has been constantly a global challenge. A good CFA performance makes a significant difference to an organization's future to reduce risks and improve the quality of its products. Thus, the CFAs as important intermediaries play an important role for the facilitation of transportation services in an effective and efficient manner. There have been a lot of factors in today's pharmaceutical manufacturing industry in which that influence CFAs to search for a competitive advantage by focusing on key performance indicators (KPIs).

Therefore, motivating the CFAs to perform well is a key to the manufacturing industry and represents a major opportunity for companies to reduce risks. The traditional approach to determine the best CFA performer selection was mainly based on the rapport they had for many years. However, as companies have learnt that rapport as a single criterion for CFA performance evaluation is insufficient, they have turned into more comprehensive MCDM techniques. A basic supply chain process for pharmaceutical manufacturing industry is shown in Figure 1.

The supply chain consists of stock movement from manufacturing plant to hub and then to a primary warehouse which is a centralized location. From the primary warehouse, it moves to CFAs of four regions at north, west, south and east regions. The stock is finally delivered to stockists in each region from the respective CFAs.

Recently, the criteria for CFA evaluation have become increasingly complex as environmental, commercial, audit and customer satisfaction concerns have been added to the traditional factors of stock management, regulatory and statutory compliance. These evaluation criteria involve trade-offs and are a key issue in the CFA assessment process, as it measures the performance of CFAs. In addition, the importance of each criterion varies from one CFA to the other and is complicated further by the fact that some criteria are quantitative, while others are qualitative. Thus, a systematic method is required that can adjust for the decision-maker's attitude toward the importance of each criterion and incorporates both qualitative and quantitative factors. The overall objective of the CFA evaluation process is to reward them and motivate the not so well performers. In this study, the selection of the CFAs is evaluated through analytic hierarchy process (AHP) analysis. The selection criteria were obtained through literature review and unstructured interviews. Thus, a methodology was developed in Indian context and was applied in real-time to a pharmaceutical manufacturing company, India, which showed excellent results.

The remainder of paper is as follows. A review of existing literature is given in Section 2. Section 3 provides the materials and methods used. Results are discussed in Section 4, and Section 5 presents conclusions and directions for further study.

Literature review

Logistics outsourcing is a widely studied topic in the literature due to its impact on business performance industry and overall logistics efficiency. The number of papers concerning sustainability and green SCM has been increasing. Sustainable SCM is an

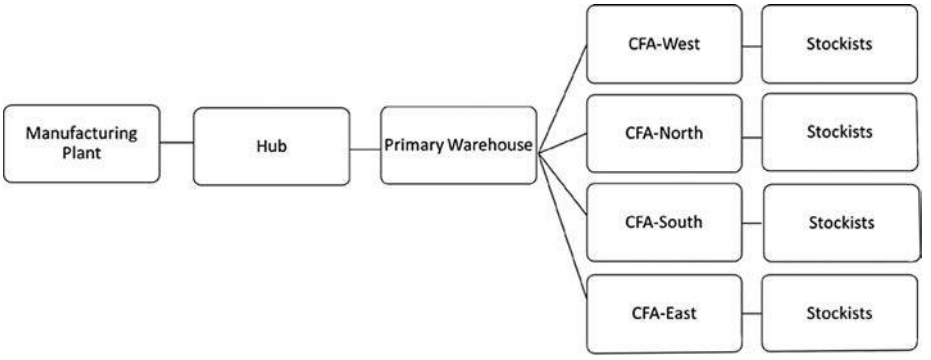

Figure 1. Supply chain – pharmaceutical manufacturing company

organizational aim to have minimal negative impact on the global or local environment, society and economy – a business that strives to meet the triple bottom line. In sustainable SCM, competitiveness would be maintained through meeting supply and demand needs with associated economic criteria, while social and environmental attributes need to be fulfilled by the supply chain members to remain within the chain (Büyüközkan and Çifçi, 2011). Sharma and Vredenburg (1998) referred environmental performance to the environmental effects that the corporation's activities have on the natural environment. Firms carefully consider the benefits and risks and optimize the outsourcing effects to sustain their long-term competitive advantages (Busi and McIvor, 2008). The outsourcing activity provides a number of diverse benefits which include lower cost, more investment on core competencies, flexibility, reduction assets and complementary capabilities (Hansen *et al.*, 2008).

Zhu *et al.* (2007) studied the Chinese automotive industry through a set of performance measures, which included traditional economic (e.g. cost and investment) and environmental measures (energy use, air emissions, water and solid waste). Tsoulfas and Pappis (2006) have identified and integrated environmental principles for the design and operation of supply chains. Baskaran *et al.* (2011) studied the supplier selection problem with corporate social responsibility (CSR) issues. In this study, criteria such as discrimination, abuse of human rights, child labor, long working hours, unfair competition and pollution were taken under consideration. Xu *et al.* (2013) analyzed the importance of seven criteria as a means of selecting the best supplier under CSR environment. The criteria considered for the study were human rights issues, underage labor, female gender labor, long working hours, pollution, safeguarding mechanisms and organizational. Bai and Sarkis (2010a, 2010b) and Akamp and Müller (2013) demonstrated an analytical evaluation of green suppliers using "rough set theory". In developed countries, the triple bottom line is considered as the major criterion in supplier selection process, but in developing countries, it is uncommon. As a result, developing countries fail as a supplier for developed countries legal responsibilities (Xu *et al.*, 2013). Haq and Kannan (2006) proposed a structured model for evaluating vendor selection using the AHP and fuzzy AHP. They examined the structure of the decision hierarchy, whether it can represent vendor selection decisions in reality or it covers all key factors affecting vendor selection choices.

De Boer and van der Wegen (2003) and Bruno *et al.* (2012) found that the lack of widely accepted cross industry performance measurement systems makes it more difficult to measure the performance of entire supply chains and their members (as already pointed out by Lee and Billington (1992). Therefore, it is important that the performance measurement criteria should be designed in such a way that they can be easily understandable by all supply chain members and offer less opportunity for manipulation (Gunasekaran *et al.*, 2004; Bruno *et al.*, 2012; Genovese *et al.*, 2013). Tuzkaya *et al.* (2009) applied a hybrid fuzzy multi-criteria decision approach for evaluating suppliers' environmental performance. Hsu and Hu (2009) incorporated hazardous substance management (HSM) into supplier selection in green SCM and proposed a HSM-based supplier selection model by using the AHP technique. Kang *et al.* (2009) presented a model and case illustrations that explore strategic outsourcing practices for sustainable competitive advantages in the Chinese context. They showed that how a clear and disciplined strategic outsourcing can help to achieve desired business outcomes by outsourcing low-risk and high-profit leveraging items.

Awasthi *et al.* (2010) presented a fuzzy technique for order preference by similarity to ideal solution (TOPSIS) approach for evaluating environmental performance of suppliers. Bai and Sarkis (2010a, 2010b) integrated sustainability into supplier selection with grey systems and rough set methodologies. Buyukozkan and Çifçi (2011) proposed a novel fuzzy multi-criteria decision framework for sustainable supplier selection with incomplete information.

Jiang *et al.* (2012) developed a method for the environmental evaluation of a manufacturing process plan, where actual values for various environmental measures for the different operations in the plan were used to form an impact matrix. Scores for each process, each environmental measure and for the entire plan were obtained by applying weights obtained from the AHP. Kim *et al.* (2014) developed a decision-guidance framework to improve sustainability in manufacturing processes with the help of life-cycle analysis (LCA). The proposed framework included sustainability performance analysis, interpretation and decision support and guidance designed in terms of functionality, usability, flexibility/reusability and interoperability.

Increasingly, more authors are addressing supplier selection issues in the light of environmental aspects. Studies so far focus on application of existing sustainability supply chain models for the management of service supply chains (Sengupta *et al.*, 2006; Baltacioglu *et al.*, 2007; Ellram *et al.*, 2007). Boonitt and Pongpanarat (2011), Arlbjørn *et al.* (2011) and Cho *et al.* (2012) applied the Q-sort technique to the scale development process to address the reliability and validity problems caused by subjectivity of the SCM in service. They developed a meaningful scale to measure service SCM processes. Baltacioglu *et al.* (2007) developed a new framework for the service supply chain, which was built on the existing knowledge derived from the SCOR and Ellram *et al.*'s (2004) models, with an application in the health-care industry. Seuring (2013) brought to the notice that there are no papers that exclusively focus on social issues, and integration of all three dimensions of sustainability is only presented by Clift (2004) and Foran *et al.* (2005). Seuring and Müller (2008) emphasized the need for increasing co-operation along the supply chain if sustainability goals are to be reached (Gold *et al.*, 2010). Hence, this should be reflected in related goals. A closer look is therefore taken on each dimension and on which related goals are put forward to achieve sustainability (Seuring, 2013).

The main contribution of this paper includes modeling the performance evaluation problem within the context of a sustainable supply chain based on triple bottom line (TBL) concept. The concept of TBL was developed by Elkington (1997) who stressed the distinction of the economic and social dimensions of sustainability, which have been absorbed by the environmental dimension of sustainability. The integration of all the three dimensions/criteria (economic, social and environmental) plays a central role, but is not often addressed so far in the literature (Seuring and Müller, 2008). Performance evaluation/measurement is a MCDM problem, where multiple sustainable attributes/criteria should be considered in decision-making, containing subjectivity, uncertainty and ambiguity in the assessment process. There are various studies that addressed this issue by incorporating fuzzy numbers into TOPSIS models in the literature (Ertugrul and Karakasoglu, 2009; Secme *et al.*, 2009; Chamodrakas *et al.*, 2011; Ebrahimnejad *et al.*, 2010). The approach is suitable to the problem under consideration reasons:

- TOPSIS logic is rational and understandable.
- The computation processes are straightforward.

- The concept permits the pursuit of best alternatives for each criterion depicted in a simple mathematical form.
- The importance weights are incorporated into the comparison procedures.
- In contrast to other methods like AHP or ELimination and choice expressing reality (ELECTRE), it is less computationally demanding (Hwang and Yoon, 1981; Wang and Yang, 2007; Önüt *et al.*, 2009; Jolai *et al.*, 2011).

Vijayvagy (2012) conducted a research study on the manufacturing industry for global supplier selection with fuzzy AHP approach. Noorul Haq and Kannan (2006) used an integrated approach, i.e. AHP and TOPSIS in supplier selection process; seven major criteria with 18 sub-criteria were analyzed, and an interview was conducted on 50 purchasing managers to justify the quality supplier. Kannan *et al.* (2008) adopted the combined MCDM techniques of AHP and interpretive structural modeling (ISM) for supplier's selection with green concept. Borade *et al.* (2013) dealt with vendor managed inventory analysis with the assistance of AHP. Dey and Cheffi (2013) proposed an analytical framework for measuring the environmental performance of manufacturing supply chains. The proposed framework was then applied to three selected manufacturing organizations in the UK. Their green supply chain (GSC) performance was measured and benchmarked by using the AHP. The AHP-based framework offers an effective way to measure and benchmark organizations' GSC performance. Moghimi and Anvari (2014) used fuzzy MCDM approach and analysis to evaluate Iranian cement companies. The aim was to develop a fuzzy model to evaluate financial performance. Genovese *et al.* (2013) used a case study-based research methodology to investigate the real-life perspective of the issues encountered while evaluating the supplier performance in a sustainable supply chain. An in-depth study of one of the biggest fast-moving consumer goods companies in the UK was discussed. Sarkis (2003) introduced an analytic network process-based approach. However, the main drawback for present techniques is that they are too internally focused, as they measure the performance of individual organizations and do not assess the sustainable performance of the supply network.

Chan and Chung (2004) developed a multi-criterion genetic optimization for solving distribution network problems in SCM. They combined AHPs with genetic algorithms to capture the capability of multi-criterion decision making. The proposed algorithm allows decision-makers to give weightings for criteria using a pairwise comparison approach and determination of the optimization solutions. A faceted approach to manufacturing process classifications has been proposed by Kumaraguru *et al.* (2014). They developed a visual interface to navigate the process classification scheme.

The criteria and sub-criteria for evaluating sustainability are presented in Table I below.

After overviewing the studies (detailed in Table I), it is found that many researchers concentrated only on the quantity, quality, price and/or on-time delivery for supplier selection. Most of the studies focused on manufacturing industry, but sustainability criteria are still not often discussed in the supplier selection process and performance measurement issues. Hence, this research paper proposes a framework for sustainability performance measurement of CFA across the upstream and downstream supply chain. For this, the framework makes use of AHP. The sustainability performance of the CFA is measured and benchmarked. Therefore, this work develops

Serial no.	Criteria	Sub-criteria	Author(s)
1	Quality	Quality systems	Yang and Wu (2007), Hsu and Hu (2009)
		Process capability	Yang and Wu (2007)
		Quality systems	Yang and Wu (2007), Kuo *et al.* (2010), Lee *et al.* (2009), Tseng (2011), Buyukozkan and Cifci (2011), Hsu and Hu (2009), Grisi *et al.* (2010), Buyukozkan and Cifci (2011), Chiou *et al.* (2008)
		Reject rate	Kuo *et al.* (2010), Cao (2011)
		Management	Kuo *et al.* (2010), Lee *et al.* (2009), Yeh and Chuang (2011)
		Commitment to quality	Kuo *et al.* (2010)
		Process improvement	Kuo *et al.* (2010)
		Warranties and claim policies	Kuo *et al.* (2010)
		Capability of handling abnormal quality	Lee *et al.* (2009)
2	Price	Purchasing price	Yang and Wu (2007), Grisi *et al.* (2010), Buyukozkan and Cifci (2011)
		Price performance value	Chiou *et al.* (2008), Kuo *et al.* (2010), Cao (2011)
		Compliance with sectoral price behavior	Kuo *et al.* (2010)
		Transportation cost	Kuo *et al.* (2010), Yeh and Chuang (2011)
		Production cost	Yeh and Chuang (2011)
3	Capability of supplier/delivery	Supplying capability	Yang and Wu (2007), Chiou *et al.* (2008), Kuo *et al.* (2010), Grisi *et al.* (2010), Tseng (2011)
		Level of technique	Yang and Wu (2007), Grisi *et al.* (2010), Cao (2011)
		Capability of product development	Yang and Wu (2007), Lee *et al.* (2009), Kuo *et al.* (2010)
		Order fulfill rate	Kuo *et al.* (2010)
		Lead time	Kuo *et al.* (2010), Cao (2011)
		Capability of R&D	Lee *et al.* (2009)
		Technology level	Lee *et al.* (2009)
		Flexibility of the supplier	Tseng (2011), Buyukozkan and Cifci (2011)
		Supplier stock management	Hsu and Hu (2009), Kuo *et al.* (2010), Grisi *et al.* (2010)

(*continued*)

Table I. Criteria and sub-criteria of sustainability

Serial no.	Criteria	Sub-criteria	Author(s)
4	Service	Rate of processing order form	Yang and Wu (2007)
		Rate of delivery in time	Yang and Wu (2007), Yeh and Chuang (2011), Cao (2011)
		Degree of information	Humphreys *et al.* (2003a, 2003b), Yang and Wu (2007), Hsu and Hu (2009)
		Modernized service quality	Chiou *et al.* (2008), Tseng (2011), Buyukozkan and Cifci (2011), Cao (2011)
5	Environment protection	Environment certification	Handfield *et al.* (2002), Humphreys *et al.* (2003a, 2003b), Chiou *et al.* (2008), Awasthi *et al.* (2010), Bai and Sarkis (2010a,b), Yeh and Chuang (2011), Buyukozkan and Cifci (2011), Chiou *et al.* (2011), Cao (2011)
		Validity of clean technique	Humphreys *et al.* (2003a, 2003b), Yang and Wu (2007), Cao (2011)
		Environment efficiency	Humphreys *et al.* (2003a, 2003b), Yang and Wu (2007), Grisi *et al.* (2010)
		EUP	Kuo *et al.* (2010)
		ODC	Handfield *et al.* (2002), Kuo *et al.* (2010), Cao (2011)
		RoHS	Kuo *et al.* (2010), Tseng (2011)
		Capability of preventing pollution	Lee *et al.* (2009)
		Continuous monitoring and regulatory compliance	Chiou *et al.* (2008), Lee *et al.* (2009)
		Internal control process	Lee *et al.* (2009)
		Environmental management systems	Tseng (2011)
		Environmental protection policies	Humphreys *et al.* (2003a, 2003b), Awasthi *et al.* (2010), Yeh and Chuang (2011)
		Environmental protection plans	Humphreys *et al.* (2003a, 2003b), Yeh and Chuang (2011), Cao (2011)

Table I. (*continued*)

Serial no.	Criteria	Sub-criteria	Author(s)
6	Management system	Management systems	Yang and Wu (2007), Chiou *et al.* (2008)
		Management ideas	Yang and Wu (2007)
		Researching and developing	Yang and Wu (2007)
		Relationship to the supplier	Tseng (2011)
		Reverse logistics system	Humphreys *et al.* (2003a, 2003b), Chiou *et al.* (2008), Yeh and Chuang (2011), Buyukozkan and Cifci (2011)
		Management commitment	Awasthi *et al.* (2010)
		Management support	Humphreys *et al.* (2003a, 2003b)
		Production facilities and capacity	Grisi *et al.* (2010), Buyukozkan and Cifci (2011)
7	Corporate social responsibility (CSR)	The interests and rights of employee	Kuo *et al.* (2010), Buyukozkan and Cifci (2011)
		The rights of stakeholder	Kuo *et al.* (2010)
		Information disclosure	Chiou *et al.* (2008), Kuo *et al.* (2010)
		Respect for the policy	Chiou *et al.* (2008), Kuo *et al.* (2010)
8	Environmental	Use of environment friendly technology	Humphreys *et al.* (2003a, 2003b), Awasthi *et al.* (2010)
9	Performance	Use of environment friendly materials	Humphreys *et al.* (2003a, 2003b), Chiou *et al.* (2008), Awasthi *et al.* (2010)
		Partnership with green organizations	Humphreys *et al.* (2003a, 2003b), Awasthi *et al.* (2010)
		Training supplier employees on environmental issues	Bai and Sarkis (2010a, 2010b)
		Supplier environmental evaluation and feedback	Bai and Sarkis (2010a, 2010b)
		Auditing suppliers	Bai and Sarkis (2010a, 2010b)

Table I.

a sustainable MCDM approach based on the seven criteria to establish a performance evaluation/measurement model for CFA, which was successfully applied in a pharmaceutical manufacturing industry.

Methodology

Identification of the evaluation criteria

The evaluation criteria have to be most prevalent and important in the selection process. To explore the selection criteria, a thorough literature review and unstructured

interviews with experts were carried out. The discussions assisted in developing a relevant set of evaluation criteria. Thus, in the current study, criteria have been considered and adopted from the literature survey and expert's opinions.

Analytic hierarchy process

The AHP, originally developed by Thomas Saaty in 1971 (Saaty, 1980; Saaty and Vargas, 2000), is a process designed for solving complex problems involving multiple criteria. The AHP is a powerful and flexible decision-making process to help managers set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered.

Saaty's (1977 and 1980) AHP is a popular means to determine the weights which is one of the classical problems in multi-criteria decision analysis. The AHP decomposes the decision process as a hierarchical structure and deals with quantifiable and intangible criteria by using the pairwise comparison matrices, as shown in Figure 2.

The AHP divides the decision problem into the following steps (Chamodrakas *et al.*, 2010; Raut *et al.*, 2011):

- Define an objective of problem and determine its goal.
- Structure the hierarchy from the top (objectives from a decision-makers' viewpoint) through intermediate levels (criteria on which subsequent levels depend) to the lowest level, which typically contains a list of alternatives.
- Use a pairwise comparison approach. Saaty (2000) developed the fundamental scale for pairwise comparisons (Table II). The pairwise comparison matrix A, in which the element a_{ij} of the matrix is the relative importance of the i^{th} factor with respect to the j^{th} factor, could be calculated as:

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \dots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \quad (1)$$

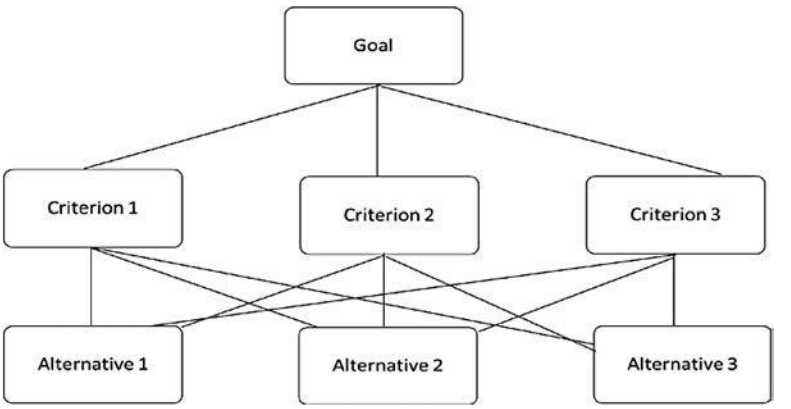

Figure 2.
Analytic hierarchy process – block diagram

Numerical rate	Judgment
1	Factors *i* and *j* are equal important
3	Factor *i* is weak important
5	Factor *i* is strong important
7	Factor *i* is demonstrated important
9	Factor *i* is absolute important
2, 4, 6, 8	Intermediate values between the two adjacent judgment
Reciprocal	If the important rate of factors *i* to *j* is Rxy, then the important rate of factors *j* to *i* is Ryx = 1/Rxy

Source: Saaty (1980)

Table II.
Scale for pairwise comparisons

- There are $n(n-1)$/judgments required developing the set of matrices in Step 3. Reciprocals are automatically assigned to each pairwise comparison, where n is the matrix size.
- Hierarchical synthesis is now utilized to weigh the eigenvector according to weights of criteria. The sum is for all weighted eigenvector corresponding to those in the next lower hierarchy level.
- Having made all pairwise comparisons, consistency is identified by using the eigenvalue λmax, to calculate the consistency index. Saaty (1990) proposed that the largest eigenvalue, λmax, will be:

$$\lambda\max = \sum_{j=1}^{n} a_{ij}\frac{W_j}{W_i} \tag{2}$$

where λmax is the principal or largest eigenvalue of positive real values in a judgment matrix, W_j is the weight of j^{th} factor and W_i is the weight of i^{th} factor:

- Consistency test, each pairwise comparison contains numerous decision elements for the consistency index (CI), which measures the entire consistency judgment for each comparison matrix and the hierarchy structure. Saaty (1990) utilized the CI and consistency ration (CR) to assess the consistency of the comparison matrix. The CI and CR are defined as:

$$\text{CI} = \frac{\lambda\max - n}{n-1} \tag{3}$$

where n is the matrix size:

$$\text{CR} = \frac{\text{CI}}{\text{RI}} \tag{4}$$

where the judgment consistency can be checked by taking the CR of CI with the appropriate value (Table III). The CR is acceptable if it does not exceed 0.10. If the CR is > 0.10, then the judgment matrix is inconsistent. To acquire a consistent matrix, judgments should be reviewed and improved.

Problem description

A global pharmaceutical company has 32 CFAs spread over various states of India. The annual turnover of the company is more than 200 crore. These CFAs are divided into four different regions with each region headed and supervised by a Regional Distribution Manager (RDM). Every RDM has five to nine CFAs under his control. The problem the firm faced was that some of the CFAs were performing well whereas others were not up to the global business expectations. Hence, the top management of the company decided to motivate the CFAs based on the performance assessment. According to this move, the company rewarded the top performing CFAs monthly. Now, the priority was to quantify the CFAs performance situated across different regions.

This paper provides a priority of sustainable issues for evaluating the performance of the best CFA. Unstructured interviews were conducted with managers at the pharmaceutical manufacturing industry in the four regions of India. From the responses obtained, a pairwise comparison of those entire set of criteria over another has been made. By this pairwise comparison, an approach has been made on the data with an AHP technique. The results obtained from this analysis were used to prioritize the sustainable issues for measuring the best CFA. Table IV shows the main criteria and the sub-criteria with their supporting literatures. Furthermore, the paper represents every criterion with additional references.

Proposed hybrid method for CFA selection and evaluation

We used AHP method to find efficient and inefficient CFAs sensitively, as shown in Figure 3. In the first step, initial data collection (KPIs) and analysis is done.

There are six main steps in the proposed hybrid method such as follows:

(1) initial data collection (KPIs) and analysis;

(2) formulation of pairwise comparison matrices for KPIs and Sub-KPIs;

(3) choosing three decision-makers and make them fill the KPI pairwise comparison matrices;

(4) determination of criteria and sub-criteria weights;

(5) design of data collection template for RDMs to inspect CFA warehouses; and

(6) modeling of ranking system that captures inspection data and generates reports.

Results

The weights of criteria were found by finding the geometric means of the responses and calculating the contribution of each geometric means to their overall sum, as shown in the Table V.

From the results tabulated in Table V, it is found that the criteria of environmental and safety obtained maximum weight receiving first rank, and is most important, followed by statutory and regulatory compliance, stock management, commercial operations, cold chain maintenance and good warehousing practices, while audit performance obtained least weightage. From the point of view of sustainability, it is

Table III. Average random consistency

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table IV. Proposed selection criteria for CFA

Serial no.	Criteria	Sub-criteria	Owner
1	Statutory and regulatory compliance (SRC)	Valid drug license (VDL)	Author-proposed criteria
		Valid FSSAI license with validity (VFL)	Author-proposed criteria
		Valid PCB license for breakage and expiries (VPL)	Author-proposed criteria
		Valid shops license (VSEL)	Author-proposed criteria
		Valid electrical inspectorate approval for DG sets (VEIA)	Author-proposed criteria
		Verification of AWD (authorized wholesale dealer) licenses (VADL)	Author-proposed criteria
		Payment of PF and ESI (PPE)	Author-proposed criteria
		Ensuring number of child labor (ENCL)	Author-proposed criteria
2	Stock management (SM)	Monthly/weekly blind count of stocks (MWBCS)	Author-proposed criteria
		Invoice accuracy (INA)	Author-proposed criteria
		Unloading and entering stocks in JDE same day (UESJ)	Author-proposed criteria
		Dispatching of invoiced goods to AWD within 24 hours (DIGA)	Author-proposed criteria
		Accurate treatment of quarantine/expired/near expiry/damage stocks (ATS)	Author-proposed Criteria
3	Audit performance (AP)	Number of observations in KPMG audit (NOKA)	Author-proposed criteria
		Number of observations in EHS audit (NOEA)	Author-proposed criteria
		Number of observations in CQD audit (NOCA)	Author-proposed criteria
		Number of observations in PWC audit (NOPA)	Author-proposed criteria
		Number of observations in L1 audit (NOL1A)	Author-proposed criteria
4	Commercial operations (CO)	Invoicing of orders on same day (IOSD)	Author-proposed criteria
		Effective tracking of deliveries (ETDS)	Author-proposed criteria
		Accuracy in issuing credit notes (AICN)	Author-proposed criteria
		Issues Saleable credit notes within two working days of receipt of approval from CQD (ISCN)	Author-proposed criteria
		Issues unsaleable credit notes within 30 days from the date of receipt of stocks at CFA (IUNCN)	Author-proposed criteria
		Timely banking of checks (TABC)	Author-proposed criteria
		Timely action on check bounce instances (TACB)	Author-proposed criteria
		Confirming that checks in a fire proof safe (CCFPS)	Author-proposed criteria

(*continued*)

Table IV.

Serial no.	Criteria	Sub-criteria	Owner
		Immediate updation of check control register (IUCCR)	Author-proposed criteria
		Dealer query handling by CFA and maintenance of customer complaints register–reply within 24 hours (DQHC)	Author-proposed criteria
		Monthly stockist visit by CFA/Manager (MSV)	Author-proposed criteria
		Timely communication to HO on queries (TCHQ)	Author-proposed criteria
		Cost, quality innovation (CQI)	Author-proposed criteria
5	Cold chain maintenance (CCM)	Packing and dispatching cold chain products as per SOP (PADCCP)	Author-proposed criteria
		Cold chain products receipt/dispatch tracing (CCPRDT)	Author-proposed criteria
		Data loggers readings verification (DLRV)	Author-proposed criteria
		Temperature mapping of cold and cool rooms (TMCCR)	Author-proposed criteria
		Availability of hooter for WIC (AHWIC)	Author-proposed criteria
		CAPA	Author-proposed criteria
		Maintenance of cold chain records (MCCR)	Author-proposed criteria
		Cost, quality and innovation (CQI)	Author-proposed criteria
6	Good warehousing practices (GWP)	Pest control treatment (PCT)	Author-proposed criteria
		General overall housekeeping (GOHK)	Author-proposed criteria
		No cracks on walls (NCW)	Author-proposed criteria
		Stocks not stored on the floor (NSSF)	Author-proposed criteria
		Valid AMC for AC's, DG sets, WICs (VAMC)	Author-proposed criteria
		Regular training on SOP's (RTOS)	Author-proposed criteria
7	Environment and safety (ES)	Checking of fire extinguishers for date of refilling (CFE)	Author-proposed criteria
		First-aid box containing emergency medicines (FABCEM)	Author-proposed criteria
		Display of required licenses (DRLELO)	Author-proposed criteria
		Number of accidents during a month (NAM)	Author-proposed criteria
		Electrical safety–verification by a A1 electrical contractor (ESV)	Author-proposed criteria

Notes: CQD = Care quality commission; EHS = Environmental, health and safety; AMC = Annual maintenance contracts; AC = Air Conditioners; DG = Diesel generating; WIC = Walk in; SOP = Standard operating procedure

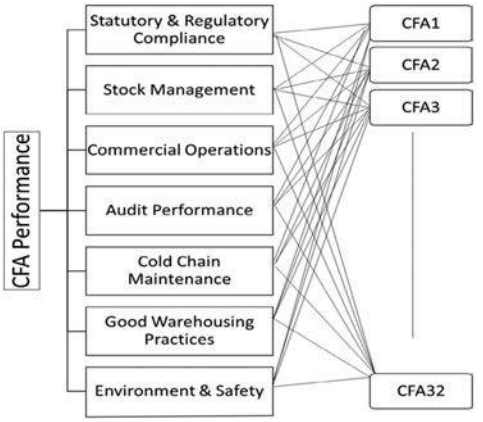

Figure 3.
Criteria for CFA performance

Criteria	SRC	SM	CO	AP	CCM	GWP	ES	Geometric mean	Weights (%)
SRC	1	5	3	3	5	9	3	3.471416	33
SM	1/5	1	3	5	5	1	1/7	1.115025	11
CO	1/3	1/3	1	5	1/7	3	1/9	0.595174	6
AP	1/3	1/5	1/5	1	5	1/3	1/9	0.424137	4
CCM	1/5	1/5	7	1/5	1	3	1/9	0.566252	5
GWP	1/9	1	1/3	3	1/3	1	1/9	0.456246	4
ES	1/3	7	9	9	9	9	1	3.961408	37
							SUM	10.58966	100

Table V.
Pairwise comparison matrix for KPIs

very important to follow the environmental and safety standards and compliance with the statutory and regulatory frameworks. Similarly, pairwise comparison matrices for all the sub-criteria are formulated and filled by the decision-makers (Tables VI-XII).

The ranking and weightage of sub-criteria of statutory and regulatory compliance is presented in Table VI above. The ranking shows that the sub-criteria of payment of provident fund and employees' state insurance, not employing child labor, and valid and proper license receive highest ranks. The sub-criteria of valid electrical inspectorate approval for DG sets (VEIA) are least preferred.

Statutory and regulatory compliance	VDL	VFL	VPL	VSEL	VEIA	VADL	PPE	ENCL	Geometric mean	Weights (%)
VDL	1	3	1.00	3.00	3.00	7.00	0.11	0.11	1.111724	10
VFL	0.33	1	3.00	3.00	3.00	3.00	0.11	0.11	0.871686	8
VPL	1	0.33	1	9.00	7.00	1.00	0.11	0.11	0.844728	8
VSEL	0.333	0.33	0.11	1	3.00	0.33	0.33	0.33	0.438691	4
VEIA	0.333	0.33	0.14	0.33	1	0.33	0.33	0.33	0.343971	3
VADL	0.142	0.33	1	3	3	1	1.00	1.00	0.899504	8
PPE	9	9	9	3	3	1	1	7.00	3.826119	36
ENCL	9	9	9	3	3	1	0.1428	1	2.352253	22
								SUM	10.68868	100

Table VI.
Pairwise comparison matrix for statutory and regulatory compliance

Similarly, for the stock management criteria, ATS (accurate treatment of quarantine/expired/near expiry/damage stocks) and monthly/weekly blind count of stocks (MWBCS) receive highest weightage and ranks among the sub-criteria, as shown in Table VII above. The proper maintenance of stocks plays an important role in increasing efficiency and reducing the cost. Among the four sub-criteria of stock management, unloading and entering stocks in JDE (UESJ) same day and invoice accuracy (INA) are the sub-criteria with lowest weightage and rank, which do not affect the overall performance to major extent.

The pairwise comparison for sub-criteria of audit performance is presented in Table VIII above. The results indicated that, the number of observations in CQD audit (NOCA) is of highest priority followed by the number of observations in EHS audit (NOEA), while the number of observations in l1 audit (NOL1A) is found to be less contributing with least weightage. The results support the importance of statutory and regulatory compliance.

The ranking and weightage of sub-criteria of commercial operations is presented in Table IX above. The sub-criteria of timely action on check bounce instances (TACB) and invoicing of orders on same day (IOSD) are the highest preferred sub-criteria, while cost, quality innovation (CQI) sub-criteria received less priority. The results are accepted, as they may help to reduce the unnecessary delay and will help to improve the relationship and efficiency.

The ranking and weightage of sub-criteria of cold chain maintenance is presented in Table X above. The ranking shows that the sub-criteria of maintenance of cold chain records (MCCR) and data loggers readings verification (DLRV) are important with the highest percentage of weights. The maintenance of record will help to increase the efficiency. Temperature mapping of cold and cool rooms (TMCCR) sub-criteria is found to be less contributing with 5 per cent of weightage.

The pairwise comparison forsub-criteria of good warehousing practice is presented in Table XI above. The results indicated that valid AMC for AC's, DG sets and WICs

Table VII. Pairwise comparison matrix for stock management

Stock management	MWBCS	INA	UESJ	DIGA	ATS	Geometric mean	Weights (%)
MWBCS	1	7	7.00	1.00	0.14	1.475773162	18
INA	0.14285	1	1.00	0.20	0.11	0.316473893	4
UESJ	0.14285	1	1	0.20	0.14	0.33278733	4
DIGA	1	5	5	1	0.14	1.289936684	15
ATS	7	9	7	7	1	4.987780419	59
					SUM	8.402751487	100

Table VIII. Pairwise comparison matrix for audit performance

Audit performance	NOKA	NOEA	NOCA	NOPA	NOL1A	Geometric mean	Weights (%)
NOKA	1	5.00	0.11	0.14	5.00	0.831227479	13
NOEA	0.2	1	3.00	5.00	5.00	1.718771928	26
NOCA	9	0.33	1	7.00	7.00	2.713085417	42
NOPA	7	0.2	0.142	1	5.00	1	15
NOL1A	0.2	0.2	0.142	0.2	1	0.257987337	4
					SUM	6.52107216	100

Table IX. Pairwise comparison matrix for commercial operations

Commercial operations	IOSD	ETDS	AICN	ISCN	IUNCN	TABC	TACB	CCFPS	IUCCR	DQHC	MSV	TCHQ	CQI	GM	Weights (%)
IOSD	1	3	1	1	5	3	0.2	5	3	7	9	5	9	2.69	15
ETDS	0.3	1	0.1	0.1	0	0.1	0.2	0.2	0.2	3	3	1	1	0.4	2
AICN	1	9	1	7	1	1	0.3	5	5	9	5	5	9	2.91	16
ISCN	1	7	0.1	1	1	1	0.2	0.3	0.2	5	5	5	5	1.18	6
IUNCN	0.2	7	1	1	1	0.3	0.1	1	0.3	5	5	5	5	1.22	7
TABC	0.3	9	1	1	3	1	1	0.2	1	7	5	5	5	1.76	10
TACB	5	5	3	5	7	1	1	7	1	5	5	5	5	3.49	19
CCFPS	0.2	5	0.2	3	1	5	0.1	1	1	5	5	5	5	1.54	8
IUCCR	0.3	5	0.2	5	3	1	1	1	1	5	5	5	5	1.86	10
DQHC	0.1	0.3	0.1	0.2	0	0.1	0.2	0.2	0.2	1	5	1	5	0.4	2
MSV	0.1	0.3	0.2	0.2	0	0.2	0.2	0.2	0.2	0.2	1	0	1	0.25	1
TCHQ	0.2	1	0.2	0.2	0	0.2	0.2	0.2	0.2	1	5	1	5	0.48	3
CQI	0.1	1	0.1	0.2	0	0.2	0.2	0.2	0.2	0.2	1	0	1	0.26	1
														18.4	100

(VAMC) with 41 per cent weightage is of the highest priority followed by regular training on SOP's (RTOS). Good maintenance of warehouse plays a significant role in increasing the efficiency. The sub-criteria of the number cracks on walls and general overall housekeeping are the criteria with the lowest rank and weightage and thus less significant.

Table X. Pairwise comparison matrix for cold chain maintenance

Cold chain maintenance	PADCCP	CCPRDT	DLRV	TMCCR	AHWBC	CAPA	MCCR	Geometric mean	Weights (%)
PADCCP	1	9.00	1.00	5.00	5.00	0.20	0.14	1.304503	17
CCPRDT	0.111	1	1.00	3.00	3.00	3.00	1.00	1.169931	15
DLRV	1	1	1	7.00	3.00	1.00	3.00	1.807377	23
TMCCR	0.2	0.33	0.14	1	0.33	3.00	0.20	0.408701	5
AHWBC	0.2	0.33	0.33	3	1	5.00	0.20	0.679183	9
CAPA	5	0.33	1	0.33	0.2	1	1.00	0.7306	9
MCCR	7	1	0.33	5	5	1	1	1.787614	23
								7.887909	100

Table XI. Pairwise comparison matrix for good warehousing practices

Good warehousing practices	PCT	GOHK	NCW	NSSF	VAMC	RTOS	Geometric mean	Weights (%)
PCT	1	7.00	5.00	0.33	1.00	0.11	1.044201	13
GOHK	0.142857	1	1.00	0.33	1.00	0.20	0.4604	6
NCW	0.2	1	1	0.33	0.20	0.20	0.372387	5
NSSF	3	3	3	1	0.33	0.20	1.102924	14
VAMC	1	1	5	3	1	1.00	1.570418	20
RTOS	9	5	5	5	1	1	3.224968	41
					SUM		7.775297	100

Table XII. Pairwise comparison matrix for environment and safety

Environment and safety	CFE	FABCEM	DRLELO	NAM	ESV	Geometric mean	Weights (%)
CFE	1	7.00	7.00	1.00	1.00	2.177906424	33
FABCEM	0.1428571	1	0.33	0.20	1.00	0.39424132	6
DRLELO	0.1428571	3	1	0.20	0.20	0.443421392	7
NAM	1	5	5	1	5.00	2.626527804	40
ESV	1	1	5	0.2	1	1	15
					SUM	6.642096941	100

Table XIII. Average weights for KPIs

Sr. no.	Criteria	Average percentage weights (%)
1	Statutory and regulatory compliance	32
2	Stock management	11
3	Commercial operations	11
4	Audit performance	6
5	Cold chain maintenance	11
6	Good warehousing practices	6
7	Environment and safety	23

Sr. no.	(%)
Statutory and regulatory compliance	
Valid drug license with two competent persons (VDL)	21
Valid FSSAI license with validity (VFL)	12
Valid PCB license for breakage and expiries (VPL)	12
Valid shops and establishment license (VSEL)	6
Valid electrical inspectorate approval for DG sets (VEIA)	4
Verification of AWD licenses on regular basis will bill any AWD without DL (VADL)	11
Payment of PF and ESI as per regulations to be implemented as per Act (PPE)	20
Ensuring number of child labor employed at the CFA (ENCL)	15
Stock management	
Monthly/weekly blind count of stocks and reporting of variances (MWBCS)	33
Invoice accuracy (quantity packed vs. ordered and batches packed vs. invoiced) (INA)	23
Unloading and entering the stocks in JDE same day (UESJ)	10
Dispatching of invoiced goods to AWD within 24 hours (for orders recd before 3 p.m.) expects past three days (DIGA)	11
Accurate treatment of quarantine/expired/near expiry/damage stocks (physical and document) (ATS)	24
Commercial operations	
Invoicing of orders on same day expect month end (ensuring signed and sealed orders) (IOSD)	12
Effective tracking of deliveries to stockist (vaccines and other stocks) (ETDS)	5
Accuracy in issuing credit notes (quantity received, instances) (AICN)	16
Issues saleable credit notes within two working days of receipt of approval from CQD (ISCN)	7
Issues unsaleable credit notes within 30 days from the date of receipt of stocks at CFA and incineration as per the SOP guidelines (IUNCN)	8
Timely and accurate banking of check (TABC)	12
Timely action on check bounce instances (TACB)	16
Confirming that checks in a fire proof safe (CCFPS)	6
Immediate updation of check control register (IUCCR)	7
Dealer query handling by CFA and maintenance of customer complaints register–reply within 24 hours (DQHC)	2
Monthly stockist visit by CFA/Manager (MSV)	2
Timely communication to HO on queries (TCHQ)	2
Cost, quality innovation (CQI)	5
Audit performance	
Number of observations in KPMG audit (major–attributable to CFA performance) (NOKA)	25
Number of observations in EHS audit (major–attributable to CFA performance) (NOEA)	24
Number of observations in CQD audit (major–attributable to CFA performance) (NOCA)	33
Number of observations in PWC audit (major–attributable to CFA performance) (NOPA)	10
Number of observations in L1 audit (major–attributable to CFA Performance) (NOL1A)	9

(*continued*)

Table XIV. Average weights for sub-criteria

The pairwise comparison of environment and safety sub-criteria was carried out, and the results are presented in Table XII above. Checking of fire extinguishers for date of refilling (CFE) and the number of accidents during a month (NAM) are the highest ranked sub-criteria. The results indicate that compliance with environmental and safety

	(%)
Cold chain maintenance	
Packing and dispatching cold chain products as per the SOP, i.e. CFA to CFA and CFA to stockist (PADCCP)	30
Cold chain products receipt/dispatch tracing, i.e. CFA to CFA and CFA to Stockiest (CCPRDT)	18
Data loggers readings verification on daily basis (DLRV)	12
Temperature mapping of cold and cool rooms as per the schedule (TMCCR)	7
Availability of hooter for WIC and bottle coolers and checking of Hooters on weekly basis (AHWBC)	9
Corrective and preventive action on temperature excursions (CAPA)	12
Maintenance of cold chain records, cold chain product receipt details and training to the concern CFA staff (MCCR)	12
Good warehousing practices	
Pest control treatment as per the schedule (PCT)	28
General overall housekeeping on daily basis (GOHK)	14
Number of cracks on walls and number pot holes on floor (NCW)	7
None of the stocks are stored on the floor and height not exceeding six feet; distance from wall one feet (NSSF)	9
Valid AMC for ACs, DG sets, WICs, bottle coolers, deep freezers, fire extinguishers, trolleys, lifts, pest control, etc. (VAMC)	21
Regular training on SOPs (every two days – Saturday of the month) (RTOS)	22
Environment and safety	
Checking of fire extinguishers for date of refilling and pressure testing and recording thereof (CFE)	36
First-aid box containing emergency medicines–checking on monthly basis for replacement/ expiries and recording thereof (FABCEM)	10
Display of required licenses, emergency telephone numbers, layout chart and organizational chart is exhibited (DRLELO)	7
Number of accidents during a month (NAM)	26
Electrical safety–verification by a A1 electrical contractor once in six months (ESV)	21

Table XIV.

standard will help improve productivity and reduce the risk of accidents and hazards. First-aid box containing emergency medicines (FABCEM) and display of required licenses (DRLELO) are the least ranked sub-criteria with the lowest weights, as they are found to be less significant in the overall performance evaluation.

Similarly, the same pairwise comparison matrices are filled by other two respondents, and the averages of the percentage weights are evaluated which are tabulated below in Table XIII. The criteria of statutory and regulatory compliance are the most important and highly weighted criteria.

Table XIV below shows the average weights of the sub-criteria.

Design of inspection data template

The inspection data recording template required for the RDMs of four regions was designed in such a way that whenever an RDM visits a CFA, they has to give a rating (on a scale of one to five) to each of the criterion. The sample template for the east region is shown below in Figures 4-8.

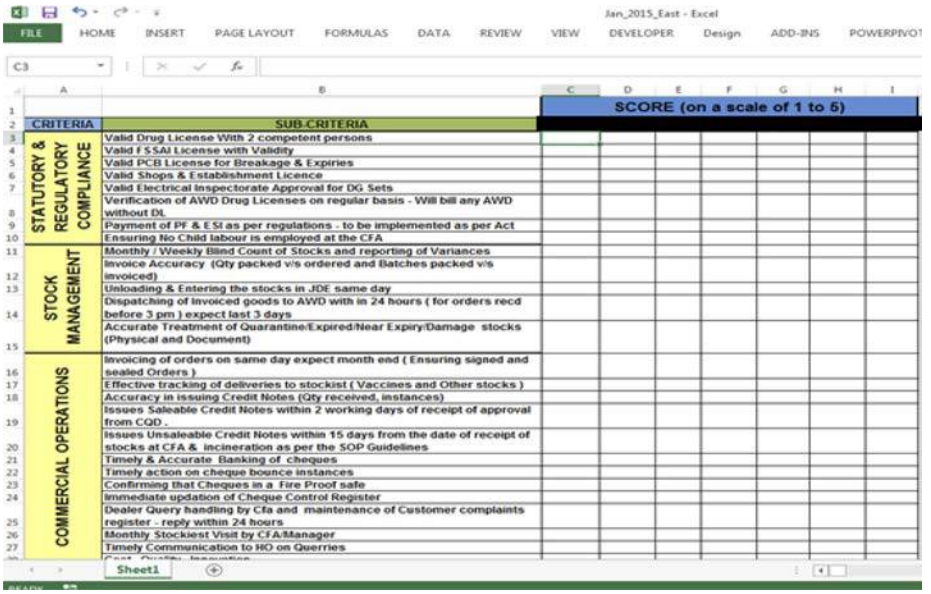

Figure 4.
Inspection template – east region

Similar templates were designed for the other three west regions. The templates vary only in terms of CFA locations.

Modeling of ranking system

The Ranking System is an excel based dashboard that allows the user to input the Inspection Data gathered across all the 32 CFA warehouses of the company in India for evaluation and ranking of the CFAs. The tool uses AHP for evaluating the scores based on inspection data.

The tool can generate monthly and yearly performance reports. Each report is generated in a new excel workbook which contains four sheets. Three sheets contain nationwide ranking, region-wide ranking and Criteria-based ranking. The fourth sheet consists of a tabulation containing the scores allocated to each of the criteria as well as the region wise ranks.

Discussion and conclusion

As evident from the results of our analysis in Table XIII, it is clear that statutory and regulatory compliance is of the highest importance with 32 per cent weightage, as it covers the most important regulatory aspects of the study. It is then followed by environment and safety with 23 per cent weightage which takes care of various safety control measures required to be followed.

With the help of the developed tool, the company can monitor the performance of CFAs on a national, regional and criteria level; motivate the not so well performing CFAs by rewarding the top performers; determine which CFAs could be removed if required; and determine the priorities of KPIs and sub-KPIs for CFAs along with weights:

Rank	CFA Location	Score
1	*Indore*	375
2	*Agra*	371
3	*Hosur*	357
4	*Nagpur*	348
5	*Jodhpur*	344
6	*Madurai*	341
7	*Ahmedabad*	340
8	*Jabalpur*	336
9	*Mumbai*	324
10	*Chennai*	324
11	*Cuttack*	323
12	*Guwahati*	322
13	*Dehradun*	320
14	*Patna*	316
15	*Kolkata*	315
16	*Jammu*	312
17	*Ranchi*	311
18	*Parwanoo*	306
19	*Goa*	305
20	*Agartala*	305
21	*Bangalore*	302
22	*Bhiwandi*	302
23	*Lucknow*	299

Figure 5.
Output report – national ranking

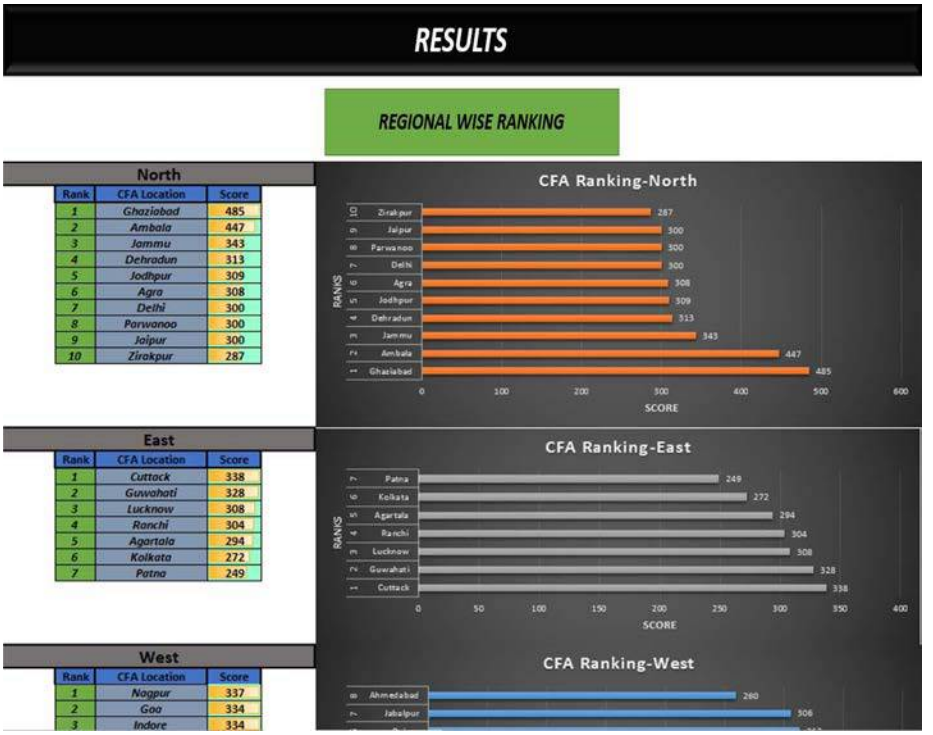

Figure 6.
Report – regional ranking

- *Monitor the performance of CFAs on a national, regional and criteria level*: The firm is able to continuously monitor and manage the performance of CFAs at both national and regional levels. Also, it is able to identify the criteria wise top performers. The trend that the CFAs performance follows can be established. Based on the performance levels of CFAs, certain strategies to improve business profitability can be formulated and hence implemented.
- *Motivate the not so well performing CFAs by rewarding the top performers*: The performance-based reward system serves as one of the motivational strategies for the CFAs. With this, the low-level performers try to improve their performance and reach to the top positions to grab the rewards.
- *Determine which CFAs could be removed if required*: There may be situations with the firm where there is need to stop the operations of certain warehouses for cost cutting or due to continuous low performance which is non-value adding to the organization. The tool is of immense help during those particular situations for making decisions on selecting which warehouses to be removed.
- *Determine the priorities of KPIs and sub-KPIs for CFAs along with weights*: The tool also gives the priority wise list of KPIs and sub-KPIs with corresponding weights. It helps the RDMs to assess the warehouses with the KPIs by giving a certain level of importance to each of them.

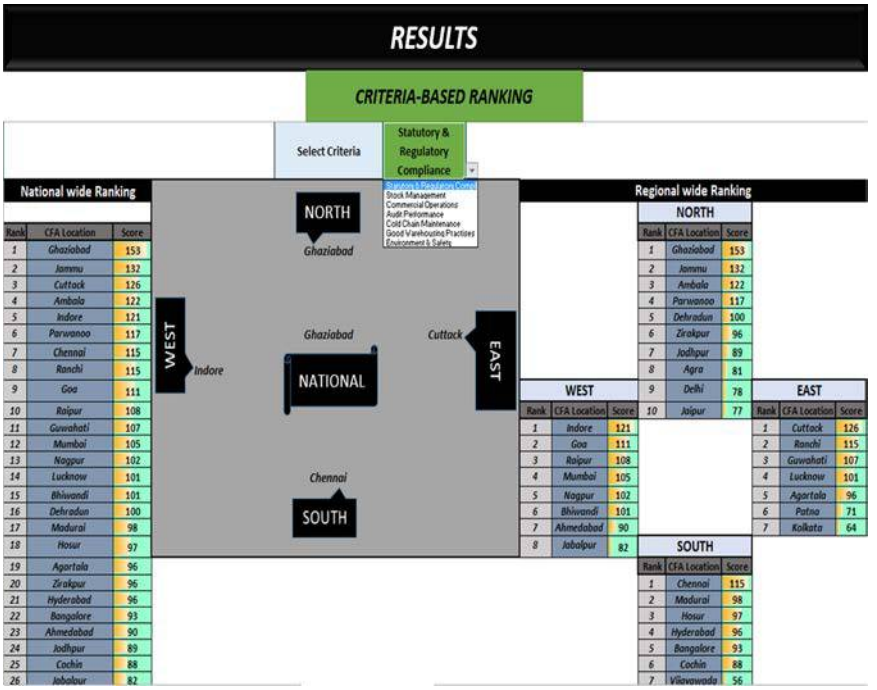

Figure 7.
Report – criteria-wise ranking

The developed excel based tool could be used to record the inspection data, compare the CFAs and determine the best CFAs on the basis of selected criteria. With the help of this tool, CFAs know their position and ranking among all the CFAs and the focus areas they need to work upon to perform well. The training module could be used to keep the CFA staff on the right track which is very essential in a typical manufacturing industry warehouse. The improved performance of CFAs will in turn help to improve the manufacturing process, thus maximizing the gains along with environmental benefits.

The study has its limitations though. The identified selection criteria are bound with Indian transportation and logistics industry. Further, it is suggested to conduct a real-life application of this study to other companies from different countries, to obtain criteria based on globally acceptable norms. The results may yield the network-specific evaluation criteria and their evaluations.

In terms of future scope, future studies can apply the proposed method to other areas of decision making or the computation of weights of other objects. More work can be done to show why the criteria are important and other is not. The methodology may be extended to other logistics service providers to contribute the literature for horizontal cooperation in logistics. Further, future studies may consider an MCDM method under uncertainty, prompting the need for the method to handle imprecise judgments from decision-makers.

REGIONAL WISE SCORES									
		CRITERIA SCORE							
RANK	LOCATION	Statutory & Regulatory Compliance	Stock Management	Commercial Operations	Audit Performance	Cold Chain Maintenance	Good Warehousing Practises	Environment & Safety	TOTAL SCORE
1	Agra	117	41	22	24	48	26	95	371
2	Jodhpur	134	33	38	11	29	18	81	344
3	Dehradun	119	35	25	16	32	21	72	320
4	Jammu	92	38	40	21	30	18	73	312
5	Parwanoo	100	32	26	19	33	15	81	306
6	Ghaziabad	94	34	25	13	27	19	77	290
7	Jaipur	85	28	36	18	37	13	62	278
8	Ambala	76	32	38	22	39	14	55	278
9	Zirakpur	81	27	42	18	37	20	41	265
10	Delhi	74	21	36	19	38	22	45	255
1	Cuttack	86	40	36	29	30	15	87	323
2	Guwahati	94	47	37	13	46	18	66	322
3	Patna	82	38	38	23	29	14	91	316
4	Kolkata	93	37	29	20	30	26	81	315
5	Ranchi	95	46	37	12	34	12	75	311
6	Agartala	96	29	33	20	40	19	68	305
7	Lucknow	107	26	32	15	44	28	46	299
1	Indore	124	37	42	14	32	24	103	375
2	Nagpur	117	27	32	25	42	15	90	348
3	Ahmedabad	81	37	38	12	38	30	103	340
4	Jabalpur	104	29	29	22	24	21	108	336
5	Mumbai	111	32	31	20	36	9	85	324
6	Goa	122	34	37	13	29	20	49	305
7	Bhiwandi	117	36	27	12	37	14	58	302
8	Raipur	76	26	37	18	26	19	96	298
1	Hosur	130	49	31	16	31	15	86	357
2	Madurai	138	21	42	15	46	14	66	341

Figure 8.
Report – criteria-wise ranking

References

Akamp, M. and Müller, M. (2013), "Supplier management in developing countries", *Journal of Cleaner Production*, Vol. 56 No. 1, pp. 54-62.

Arlbjørn, J.S., Freytag, P.V. and de Haas, H. (2011), "Service supply chain management: a survey of lean application in the municipal sector", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 3, pp. 277-295.

Awasthi, A., Chauhan, S.S. and Goyal, S.K. (2010), "A fuzzy multi-criteria approach for evaluating environmental performance of suppliers", *International Journal of Production Economics*, Vol. 126 No. 2, pp. 370-378.

Ayağ, Z. and Özdemir, R.G. (2006), "A fuzzy AHP approach to evaluating machine tool alternatives", *Journal of Intelligent Manufacturing*, Vol. 17 No. 2, pp. 179-190.

Bai, C. and Sarkis, J. (2010a), "Green supplier development: analytical evaluation using rough set theory", *Journal of Cleaner Production*, Vol. 18 No. 12, pp. 1200-1210.

Bai, C. and Sarkis, J. (2010b), "Integrating sustainability into supplier selection with grey system and rough set methodologies", *International Journal of Production Economics*, Vol. 124 No. 1, pp. 252-264.

Baltacioglu, T., Ada, E., Kaplan, M.D., Yurt, O. and Cem Kaplan, Y. (2007), "A new framework for service supply chains", *The Service Industries Journal*, Vol. 27 No. 2, pp. 105-124.

Baskaran, V., Nachiappan, S. and Rahman, S. (2011), "Supplier assessment based on corporate social responsibility criteria in Indian automotive and textile industry sectors", *International Journal of Sustainable Engineering*, Vol. 4 No. 4, pp. 359-369.

Boonitt, S. and Pongpanarat, C. (2011), "Measuring service supply chain management processes: the application of the Q-sort technique", *International Journal of Innovation, Management and Technology*, Vol. 2 No. 3, pp. 217-221.

Borade, A.B., Kannan, G. and Bansod, S.V. (2013), "Analytical hierarchy process-based framework for VMI adoption", *International Journal of Production Research*, Vol. 51 No. 4, pp. 963-978.

Bruno, G., Esposito, E., Genovese, A. and Passaro, R. (2012), "AHP-based approaches for supplier evaluation: problems and perspectives", *Journal of Purchasing and Supply Management*, Vol. 18 No. 3, pp. 159-172.

Busi, M. and McIvor, R. (2008), "Setting the outsourcing research agenda: the top-10 most urgent outsourcing areas", *Strategic Outsourcing: An International Journal*, Vol. 1 No. 3, pp. 185-197.

Büyüközkan, G. and Çifçi, G. (2011), "A novel fuzzy multi-criteria decision framework for sustainable supplier selection with incomplete information", *Computers in Industry*, Vol. 62 No. 2, pp. 164-174.

Cao, H. (2011), "The study of the suppliers evaluating and choosing strategies based on the green supply chain management", Business Management and Electronic Information (BMEI), 2011 International Conference, IEEE, Vol. 3, pp. 788-791.

Chamodrakas, I., Batis, D. and Martakos, D. (2010), "Supplier selection in electronic marketplaces using satisficing and fuzzy AHP", *Expert Systems with Applications*, Vol. 37 No. 1, pp. 490-498.

Chamodrakas, I., Leftheriotis, I. and Martakos, D. (2011), "In-depth analysis and simulation study of an innovative fuzzy approach for ranking alternatives in multiple attribute decision making problems based on TOPSIS", *Applied Soft Computing*, Vol. 11 No. 1, pp. 900-907.

Chan, F.T.S. and Chung, S.H. (2004), "Multi-criteria genetic optimization for distribution network problems", *The International Journal of Advanced Manufacturing Technology*, Vol. 24 Nos 7/8, pp. 517-532.

Chiou, C.Y., Hsu, C.W. and Hwang, W.Y. (2008), "Comparative investigation on green supplier selection of the American, Japanese and Taiwanese electronics industry in China", Industrial Engineering and Engineering Management, 2008: IEEE International Conference, IEEE, pp. 1909-1914.

Chiou, T.Y., Chan, H.K., Lettice, F. and Chung, S.H. (2011), "The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 47 No. 6, pp. 822-836.

Cho, D.W., Lee, Y.H., Ahn, S.H. and Hwang, M.K. (2012), "A framework for measuring the performance of service supply chain management", *Computers and Industrial Engineering*, Vol. 62 No. 3, pp. 801-818.

Clift, R. (2004), "Metrics for supply chain sustainability", *Technological Choices for Sustainability*, Springer, Berlin Heidelberg, pp. 239-253.

Dağdeviren, M., Yavuz, S. and Kılınç, N. (2009), "Weapon selection using the AHP and TOPSIS methods under fuzzy environment", *Expert Systems with Applications*, Vol. 36 No. 4, pp. 8143-8151.

De Boer, L. and Van der Wegen, L.L.M. (2003), "Practice and promise of formal supplier selection: a study of four empirical cases", *Journal of Purchasing and Supply Management*, Vol. 9 No. 3, pp. 109-118.

Dey, P.K. and Cheffi, W. (2013), "Green supply chain performance measurement using the analytic hierarchy process: a comparative analysis of manufacturing organisations", *Production Planning and Control*, Vol. 24 Nos 8/9, pp. 702-720.

Dickson, G.W. (1966), "An analysis of vendor selection systems and decisions", *Journal of Purchasing*, Vol. 2 No. 1, pp. 5-17.

Ebrahimnejad, S., Mousavi, S.M. and Seyrafianpour, H. (2010), "Risk identification and assessment for build–operate–transfer projects: a fuzzy multi attribute decision making model", *Expert Systems with Applications*, Vol. 37 No. 1, pp. 575-586.

Elkington, J. (1997), *Cannibals with Forks: The Triple Bottom Line of 21st Century*, New Society Publishers, Vancouver.

Ellram, L.M., Tate, W.L. and Billington, C. (2004), "Understanding and managing the services supply chain", *Journal of Supply Chain Management*, Vol. 40 No. 3, pp. 17-32.

Ellram, L.M., Tate, W.L. and Billington, C. (2007), "Services supply management: the next frontier for improved organizational performance", *California Management Review*, Vol. 49 No. 4, p. 44.

Ertuğrul, İ. and Karakaşoğlu, N. (2009), "Performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods", *Expert Systems with Applications*, Vol. 36 No. 1, pp. 702-715.

Foran, B., Lenzen, M., Dey, C. and Bilek, M. (2005), "Integrating sustainable chain management with triple bottom line accounting", *Ecological Economics*, Vol. 52 No. 2, pp. 143-157.

Genovese, A., Lenny Koh, S., Bruno, G. and Esposito, E. (2013), "Greener supplier selection: state of the art and some empirical evidence", *International Journal of Production Research*, Vol. 51 No. 10, pp. 2868-2886.

Gold, S., Seuring, S. and Beske, P. (2010), "The constructs of sustainable supply chain management – a content analysis based on published case studies", *Progress in Industrial Ecology, An International Journal*, Vol. 7 No. 2, pp. 114-137.

Govindan, K., Azevedo, S.G., Carvalho, H. and Cruz-Machado, V. (2015), "Lean, green and resilient practices influence on supply chain performance: interpretive structural modeling approach", *International Journal of Environmental Science and Technology*, Vol. 12 No. 1, pp. 15-34.

Grisi, R.M., Guerra, L. and Naviglio, G. (2010), "Supplier performance evaluation for green supply chain management", *Business Performance Measurement and Management*, Springer, Berlin Heidelberg, pp. 149-163.

Gunasekaran, A., Patel, C. and McGaughey, R.E. (2004), "A framework for supply chain performance measurement", *International Journal of Production Economics*, Vol. 87 No. 3, pp. 333-347.

Handfield, R., Walton, S.V., Sroufe, R. and Melnyk, S.A. (2002), "Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process", *European Journal of Operational Research*, Vol. 141 No. 1, pp. 70-87.

Hansen, M., Schaumburg-Muller, H. and Pottenger, E. (2008), "Towards a developing country firm perspective on outsourcing", *Strategic Outsourcing: An International Journal*, Vol. 1 No. 3, pp. 210-229.

Haq, A.N. and Kannan, G. (2006), "Fuzzy analytical hierarchy process for evaluating and selecting a vendor in a supply chain model", *The International Journal of Advanced Manufacturing Technology*, Vol. 29 Nos 7/8, pp. 826-835.

Hart, S.L. and Milstein, M.B. (2003), "Creating sustainable value", *The Academy of Management Executive*, Vol. 17 No. 2, pp. 56-67.

Hsu, C.W. and Hu, A.H. (2009), "Applying hazardous substance management to supplier selection using analytic network process", *Journal of Cleaner Production*, Vol. 17 No. 2, pp. 255-264.

Humphreys, P.K., Wong, Y.K. and Chan, F.T.S. (2003a), "Integrating environmental criteria into the supplier selection process", *Journal of Materials Processing Technology*, Vol. 138 No. 1, pp. 349-356.

Humphreys, P., McIvor, R. and Chan, F. (2003b), "Using case-based reasoning to evaluate supplier environmental management performance", *Expert Systems with Applications*, Vol. 25 No. 2, pp. 141-153.

Hwang, C.L. and Yoon, K. (1981), *Multiple Attribute Decision Making: Methods and Applications, A State of the Art Survey*, Sprinnger-Verlag, New York, NY.

Jiang, Z., Zhang, H. and Sutherland, J.W. (2012), "Development of an environmental performance assessment method for manufacturing process plans", *The International Journal of Advanced Manufacturing Technology*, Vol. 58 Nos 5/8, pp. 783-790.

Jolai, F., Yazdian, S.A., Shahanaghi, K. and Khojasteh, M.A. (2011), "Integrating fuzzy TOPSIS and multi-period goal programming for purchasing multiple products from multiple suppliers", *Journal of Purchasing and Supply Management*, Vol. 17 No. 1, pp. 42-53.

Kang, M., Wu, X. and Hong, P. (2009), "Strategic outsourcing practices of multi-national corporations (MNCs) in China", *Strategic Outsourcing: An International Journal*, Vol. 2 No. 3, pp. 240-256.

Kannan, G., Haq, A.N., Sasikumar, P. and Arunachalam, S. (2008), "Analysis and selection of green suppliers using interpretative structural modelling and analytic hierarchy process", *International Journal of Management and Decision Making*, Vol. 9 No. 2, pp. 163-182.

Kannan, V.R. and Choon Tan, K. (2003), "Attitudes of US and European managers to supplier selection and assessment and implications for business performance", *Benchmarking: An International Journal*, Vol. 10 No. 5, pp. 472-489.

Kim, D.B., Shin, S.J., Shao, G. and Brodsky, A. (2014), "A decision-guidance framework for sustainability performance analysis of manufacturing processes", *The International Journal of Advanced Manufacturing Technology*, pp. 1-17.

Krause, D.R. and Ellram, L.M. (1997), "Critical elements of supplier development the buying-firm perspective", *European Journal of Purchasing and Supply Management*, Vol. 3 No. 1, pp. 21-31.

Kumar, M., Vrat, P. and Shankar, R. (2006), "A fuzzy programming approach for vendor selection problem in a supply chain", *International Journal of Production Economics*, Vol. 101 No. 2, pp. 273-285.

Kumaraguru, S., Rachuri, S. and Lechevalier, D. (2014), "Faceted classification of manufacturing processes for sustainability performance evaluation", *The International Journal of Advanced Manufacturing Technology*, Vol. 75 Nos 9/12, pp. 1309-1320.

Kuo, R.J., Wang, Y.C. and Tien, F.C. (2010), "Integration of artificial neural network and MADA methods for green supplier selection", *Journal of Cleaner Production*, Vol. 18 No. 12, pp. 1161-1170.

Lee, A.H., Kang, H.Y., Hsu, C.F. and Hung, H.C. (2009), "A green supplier selection model for high-tech industry", *Expert Systems with Applications*, Vol. 36 No. 4, pp. 7917-7927.

Lee, H.L. and Billington, C. (1992), "Managing supply chain inventory: pitfalls and opportunities", *Sloan Management Review*, Vol. 33 No. 3.

Moghimi, R. and Anvari, A. (2014), "An integrated fuzzy MCDM approach and analysis to evaluate the financial performance of Iranian cement companies", *The International Journal of Advanced Manufacturing Technology*, Vol. 71 Nos 1/4, pp. 685-698.

Noorul Haq, A. and Kannan, G. (2006), "Design of an integrated supplier selection and multi-echelon distribution inventory model in a built-to-order supply chain environment", *International Journal of Production Research*, Vol. 44 No. 10, pp. 1963-1985.

Önüt, S., Kara, S.S. and Işik, E. (2009), "Long term supplier selection using a combined fuzzy MCDM approach: a case study for a telecommunication company", *Expert Systems with Applications*, Vol. 36 No. 2, pp. 3887-3895.

Perona, M. and Miragliotta, G. (2004), "Complexity management and supply chain performance assessment: a field study and a conceptual framework", *International Journal of Production Economics*, Vol. 90 No. 1, pp. 103-115.

Raut, R.D., Bhasin, H.V., Kamble, S.S. and Banerjee, S. (2011), "An integrated fuzzy-AHP-LP (FAHLP) approach for supplier selection and purchasing decisions", *International Journal of Services and Operations Management*, Vol. 10 No. 4, pp. 400-425.

Saaty, T.L. (1977), "A scaling method for priorities in hierarchical structures", *Journal of Mathematical Psychology*, Vol. 15 No. 3, pp. 234-281.

Saaty, T.L. (1980), *The Analytic Hierarchy Process*, McGraw-Hill, New York, NY.

Saaty, T.L. (1990), "How to make a decision: the analytic hierarchy process", *European Journal of Operational Research*, Vol. 48 No. 1, pp. 9-26.

Saaty, T.L. (2000), *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*, Rws Publications, Pittsburgh, PA, Vol. 6.

Saaty, T.L. and Vargas, L.G. (2000), *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process*, Kluwer Academic Publishers, Boston, Vol. 1, p. 46.

Sarkis, J. (2003), "A strategic decision framework for green supply chain management", *Journal of Cleaner Production*, Vol. 11 No. 4, pp. 397-409.

Seçme, N.Y., Bayrakdaroğlu, A. and Kahraman, C. (2009), "Fuzzy performance evaluation in Turkish banking sector using analytic hierarchy process and TOPSIS", *Expert Systems with Applications*, Vol. 36 No. 9, pp. 11699-11709.

Sengupta, K., Heiser, D.R. and Cook, L.S. (2006), "Manufacturing and service supply chain performance: a comparative analysis", *Journal of Supply Chain Management*, Vol. 42 No. 4, pp. 4-15.

Seuring, S. (2013), "A review of modeling approaches for sustainable supply chain management", *Decision Support Systems*, Vol. 54 No. 4, pp. 1513-1520.

Seuring, S. and Müller, M. (2008), "From a literature review to a conceptual framework for sustainable supply chain management", *Journal of cleaner production*, Vol. 16 No. 15, pp. 1699-1710.

Sharma, S. and Vredenburg, H. (1998), "Proactive corporate environmental strategy and the development of competitively valuable organizational capabilities", *Strategic Management Journal*, Vol. 19 No. 8, pp. 729-753.

Tseng, M.L. (2011), "Green supply chain management with linguistic preferences and incomplete information", *Applied Soft Computing*, Vol. 11 No. 8, pp. 4894-4903.

Tsoulfas, G.T. and Pappis, C.P. (2006), "Environmental principles applicable to supply chains design and operation", *Journal of Cleaner Production*, Vol. 14 No. 18, pp. 1593-1602.

Tuzkaya, G., Ozgen, A., Ozgen, D. and Tuzkaya, U.R. (2009), "Environmental performance evaluation of suppliers: a hybrid fuzzy multi-criteria decision approach", *International Journal of Environmental Science and Technology*, Vol. 6 No. 3, pp. 477-490.

Vijayvagy, L. (2012), "Decision framework for supplier selection through multi criteria evaluation models in supply chain", *International Journal of Management and Innovation*, Vol. 4 No. 2.

Wang, J.J. and Yang, D.L. (2007), "Using a hybrid multi-criteria decision aid method for information systems outsourcing", *Computers and Operations Research*, Vol. 34 No. 12, pp. 3691-3700.

Xu, L., Kumar, D.T., Shankar, K.M., Kannan, D. and Chen, G. (2013), "Analyzing criteria and sub-criteria for the corporate social responsibility-based supplier selection process using AHP", *The International Journal of Advanced Manufacturing Technology*, Vol. 68 Nos 1/4, pp. 907-916.

Yang, Y. and Wu, L. (2007), "Grey entropy method for green supplier selection", International Conference on WiCom, IEEE, 21-25 September, pp. 4682-4685.

Yeh, W.C. and Chuang, M.C. (2011), "Using multi-objective genetic algorithm for partner selection in green supply chain problems", *Expert Systems with Applications*, Vol. 38 No. 4, pp. 4244-4253.

Zhu, Q., Sarkis, J. and Lai, K.H. (2007), "Green supply chain management: pressures, practices and performance within the Chinese automobile industry", *Journal of Cleaner Production*, Vol. 15 No. 11, pp. 1041-1052.

Further reading

Yuzhong, Y. and Liyun, W. (2007), "Grey entropy method for green supplier selection", International Conference on Wireless Communications, Networking and Mobile Computing, WiCom 2007, IEEE, pp. 4682-4685.

Corresponding author

Manoj Govind Kharat can be contacted at: manojgkharat@gmail.com

This article has been cited by:

1. PanigrahiSwayam Sampurna, Swayam Sampurna Panigrahi, BahinipatiBikram, Bikram Bahinipati, JainVipul, Vipul Jain. Sustainable supply chain management. *Management of Environmental Quality: An International Journal*, ahead of print. [Abstract] [Full Text] [PDF]
2. Zulfiquar N. Ansari, Ravi Kant. 2017. Exploring the Framework Development Status for Sustainability in Supply Chain Management: A Systematic Literature Synthesis and Future Research Directions. *Business Strategy and the Environment* **26**:7, 873-892. [Crossref]
3. QaiserFahham Hasan, Fahham Hasan Qaiser, AhmedKarim, Karim Ahmed, SykoraMartin, Martin Sykora, ChoudharyAlok, Alok Choudhary, SimpsonMike, Mike Simpson. 2017. Decision support systems for sustainable logistics: a review and bibliometric analysis. *Industrial Management & Data Systems* **117**:7, 1376-1388. [Abstract] [Full Text] [PDF]
4. Zulfiquar N. Ansari, Ravi Kant. 2017. A state-of-art literature review reflecting 15 years of focus on sustainable supply chain management. *Journal of Cleaner Production* **142**, 2524-2543. [Crossref]