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Developing sustainable SCM evaluation model using fuzzy AHP in publishing industry

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Abstract

In the new economic context the long term success of any organization is built not only on profits and profitability but also on its contribution to the future of people and the future of the planet. Being supply chains a key cornerstone in any organization the consideration of sustainability at the supply chain level is recognized as an emerging area that needs to be studied in a systematic way. In this paper we proposed a fuzzy AHP approach for evaluating of SCM sustainability in publishing industry. For this work, we define a hierarchical framework regarding with Ageron et al model and criteria and sub criteria based on viewpoints of practical and academic experts. Results show that criteria relating with company and supplier selection factors are most important criteria.

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Keyword: Sustainable SCM; Fuzzy AHP; Multi criteria decision making (MCDM); Publishing industry

1. Introduction

Supply chain management (SCM) is a business term that has emerged in the last few decades and has been gaining in popularity ever since. The typical definition of the term supply chain management [1] is as follows: The supply chain comprises all those activities associated with the transformation and flow of goods and services, including their attendant information flows, from the sources of materials to end users. Management refers to integration of all these activities, both internal and external to the firm.

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Nowadays, consideration is given to the convergence of green/environmental and sustainable SCM. Sustainable SCM is the management of material, information and capital flows, as well as cooperation among companies along the supply chain, while taking into account goals from all three dimensions of sustainable development – economic, environmental and social – derived from customer and stakeholder requirements [2]. In doing so, the focus on environmental management and operations is moved from local optimization of environmental factors to consideration of the entire supply chain during the production, consumption, customer service and post-disposal disposition of products [3].

Sustainable development is defined as ‘‘a development that meets the needs of the present with outcome promising the ability of future generation to meet their own needs’’ [4]. It relies on the economic, environmental and social dimensions. Ho et al. [5] observe that green concerns are increasingly used as supplier selection criteria. Taking this perspective, in this paper we study the sustainability of upstream SCM considering the fact that supply management (strategic alliances, supplier section and its criteria) plays a major role in supply chain management. The main objective of our research is to investigate whether ‘‘sustainable sourcing’’ can positively impact company image and enhance the drive for business sustainability [6, 7]. One of the most useful and efficient tools for decision making process is fuzzy analytical hierarchy process (fuzzy AHP). The fuzzy AHP is easier to understand and can effectively handle both qualitative and quantitative data in the multi-attribute decision making problems. We apply fuzzy AHP for appraisal sustainable SCM.

The organization of the paper is as follows: Section 2 reviews some selected literature on Sustainable Supply Chain Management (SSCM) and the importance of supply management sustain- ability. A theoretical framework for Sustainable Supply Management (SSM) is proposed in Section 3. Fuzzy AHP and its methodology are reviewed in sections 4 and 5 respectively. Section 6 discusses the research objectives and methodology employed. The results of the empirical data analysis are presented in Section 5. Section 6 includes a summary of findings, conclusions and future research directions.

2. SSCM research: reviews and classification

Several excellent reviews have been written over the years that examine various aspects of SSCM-related research. For instance, many of the existing reviews explore the SSCM literature for implications of environmental concerns on firm’s individual functions involving activities such as product design, production planning, or inventory management. On the contrary, we examine the existing studies from a value-chain perspective, and discuss environmental concerns in managerial decisions across functions. Moreover, most of the existing reviews cover literature that is, in some cases, over a decade old. Our review focuses on more recent research in this fast changing and growing field [8].

Early research efforts in SSCM were largely devoted to understanding the technical and operational considerations inherent in collecting, testing, sorting, and remanufacturing of returned products. Research in this domain can broadly be classified under the following headings: (i) Production planning, scheduling and control; (ii) Inventory management; and (iii) Reverse logistics. While research in these areas continues, given the availability of excellent reviews covering this domain, we will abstract from these issues in our review, and encourage the readers to consult the papers mentioned below.

In an early review of the literature, Greenberg [9] surveys the use of mathematical programming models for controlling environmental quality, focussing on air, water, and land. Fleischmann et al. [10] focus on quantitative models of reverse logistics, and subdivide the literature in three areas: distribution planning, inventory control, and production planning. Gungor and Gupta [11] focus on ‘environmentally conscious manufacturing and product recovery’, described as integrating environmental thinking into new product development including design, material selection, manufacturing processes, product delivery to the consumers, and end-of-life management of the product.

3. A model for sustainable supply management (SSM)

In this section, we define a conceptual model for Sustainable Supply Management (SSM) based on the Ageron et al model [7]. This model consists of 7 ‘‘building blocks’’ that will influence SSM: (1) reasons for sustainable SSM, (2) criteria employed for SSM, (3)greening supply chains, (4) characteristics of suppliers, (5) managerial approaches for SSM, (6)barriers for SSM and (7) benefits and motivation for SSM. The detail of the model is discussed here after (Fig. 1).

3.1. Reasons for SSM

As discussed earlier, the concern of government institutions, and both profit and not-for-profit organizations about global warming and depletion of natural, non-renewable resources and increasing industrial activities from developed and emerging economies have forced various stakeholders to focus on sustain- able business development. In recent years, corporate, social and environmental responsibility seems to have become part of strategic goals and objectives of both manufacturing and service organizations and contributes to the bottom line of the organizations in a positive way. There are other factors that also influence companies to pursue sustainable supply chain management, in particular, as pertains to the upstream side of the supply chain. These factors can be classified as either external or internal. The external factors include regulatory requirements, the nature of the business, competitor, and stakeholder actions (such as NGOs) and internal factors include top management vision, customer demand and suppliers’ sustainable initiatives [7].

3.2. Performance criteria employed for SSM

Suppliers play a major role in SSCM; therefore using the ‘‘right’’ criteria for their selection takes on great importance. These criteria should include objectives such as price, quality, reliability (dependability), service rate, delivery performance, flexibility, size of suppliers’ firm, supplier certifications, associated services, length of relationships, location, environmental aspects, economic dependency, application of IT/IS and social responsibility. We have selected criteria pertaining to three sustainable perspectives including corporate, social and environmental objectives [12].

3.3. Greening supply chain

“Green” supply chain management has been defined as “integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life [13]. Greening supply chains is a broad strategy to manage materials flow along value chains through different phases like sourcing, production and distribution so that the environment can be protected thanks to safeguarding natural resources, and reducing global warming and carbon footprint. Other environmental issues include waste reduction, packaging materials reduction, ISO 14001 adherence, lean management, eco-design, production facilities, clean programs, reducing carbon footprints, product life cycle costing or assessment, reducing transportation costs, reverse logistics and remanufacturing. Since our focus is on supply management, we asked suppliers about different environmental issues strategies, techniques and tools.

3.4. Characteristics of suppliers

Supplier characteristics in terms of geographical location, company size, vision with well articulated strategic plans, and global or domestic operations can influence their commitment and support for sustainable supply management (SSM). For example, small to medium sized companies can experience challenges in terms of skills and capital when attempting to support sustainable supply. Strategic thinking and visioning are critical if companies intend to integrate their commitment for corporate, social and environmental sustainability into their over- all functioning. Strategic partnerships incorporate long-term collaborative business relationships leading to sustainable supply and chain management. Supplier location can define the general culture and government regulations affecting social and environ- mental sustainability and therefore, the commitment for sustain-able business development.

3.5. Managerial approaches for SSM

Management takes on many different forms based on the decision making processes of suppliers or partnering firms. It can be active, reactive, pro-active, collaborative or individual. An active management approach involves being continually alert and keeping up with developments in sustainability strategies and techniques.

3.6. Barriers for SSM

Resistance to change always exists in organizations. Sources for resistance are multiple, potentially including top management, financial issues, location, system capacity, culture, type of business, supply network configuration, costs, performance objectives, human resources, and knowledge management. Some of the major barriers from the supply side can include: financial costs, green investments, ROI, product price, top management commitment, organizational culture of suppliers' firms, production capacity, human resources, supply chain configuration, location and size of suppliers, etc.

3.7. Benefits and motivation for SSM

Understanding perceived benefits of and motivation for sustainability in supply management is essential for organizational competitiveness in terms of price, quality, dependability, flexibility and responsiveness. Benefits from sustainable supply management include customer satisfaction, quality, and innovation, trust, managing supply risk, fill rate, optimal inventory, flexibility, lead time and cost control. These benefits must be considered when determining whether sustainable supply management initiatives such as ISO 14001, greening logistics, greening production, recycling, remanufacturing, design for sustainable products and processes, reducing carbon footprints, and life cycle assessment and costing merit investment or not.

4. Fuzzy Analytic Hierarchy Process

Analysis Hierarchical Process (AHP) is a multi-criteria decision making tool first proposed by Saaty [14]. Since it was introduced, AHP have been one of the most useful multi-criteria decision making tools available to decision makers and researchers. Although AHP is sophisticated in recording knowledge, the conventional AHP is unable to veritably reflect the way human thinks [15]. Although it uses a precise yardstick to compare the opinions of decision makers, the conventional AHP becomes confusing. AHP is criticized for using lopsided judgmental scales and its inability to properly consider the inherent uncertainty and carelessness of pair comparisons [16].

To overcome these deficiencies, FAHP is developed to resolve the expanded hierarchical issues. Decision makers found out that distanced judgment is more persuasive than rigid judgments. That's because the individual often cannot explicitly express his preferences regarding the fuzzy nature of comparison process [15].

Since the relative importance specified by the AHP decision makers is oral, it is vague and imprecise. Decision makers often prefer to employ oral presentation rather than numerical value. Because due to the nature of pair-wise comparisons, they can not explicitly express their opinions about priorities. In such conditions the best solution is to make decisions on the basis of multiple conditions and goals to achieve a relatively desirable level of achievement. These issues have caused the nature of decision making to be full of complexities and ambiguities in the most minor to most major cases. Consequently, most decisions are made in a fuzzy environment. Therefore, considering that the fuzzy logic method is proposed for decision making in uncertain and ambiguous situations, using this method can reduce ambiguities and increase the effectiveness of decisions made [17].

5. FAHP methodology

In this study, we utilize Extent Analysis (EA) method, as originally proposed by Chang [18]. In this method, for each pair rows of pair-wise comparisons matrix, the amount of S*k* which is a triangular number, is calculated as follows [17]:

$$S_k = \sum_{j=1}^{n} m_{g_i}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} m_{g_i}^{j} \right]^{-1} \tag{1}$$

K represents the number of rows and *i* and *j*, respectively, indicate alternatives and indicators. In EA method after amounts of S_k calculation must their large degree compared with each other is calculated. *A* large degree on the M1 with M_2 is indicated as ($M_1 \geq M_2$) which is calculated as follows:

$$V(M_1 \geq M_2) = \sup\left[\min\left(\mu_{m_1}(x), \mu_{m_2}(y)\right)\right] \tag{2}$$

$$\begin{cases} 1 & m_2 \geq m_1 \\ 0 & l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \tag{3}$$

We also have:

The large degree on the M with $M_1, M_2, \ldots, M_k$ is calculated as follows

$$V(M \geq M_1, M_2, ..., M_k) = V\left[(M \geq M_1) and (M \geq M_2) and ... (M \geq M_k)\right] = \min V(M \geq M_i)$$

$$i = 1, 2, ..., k$$

Suppose that d (A*i*) = min V (Si ≥Sk), k=1, 2, 3,…, $n, k \neq i$. Then the following weight vector is obtained.

$$A_i (i = 1, 2, ..., n) \tag{4}$$

That $A_i (i = 1, 2, ..., n)$ are n elements. For normalization, the normalized weight vectors as follows which W is a non-fuzzy number:

$$W = (d(A_1), d(A_2, ..., d(A_n)))^T \tag{5}$$

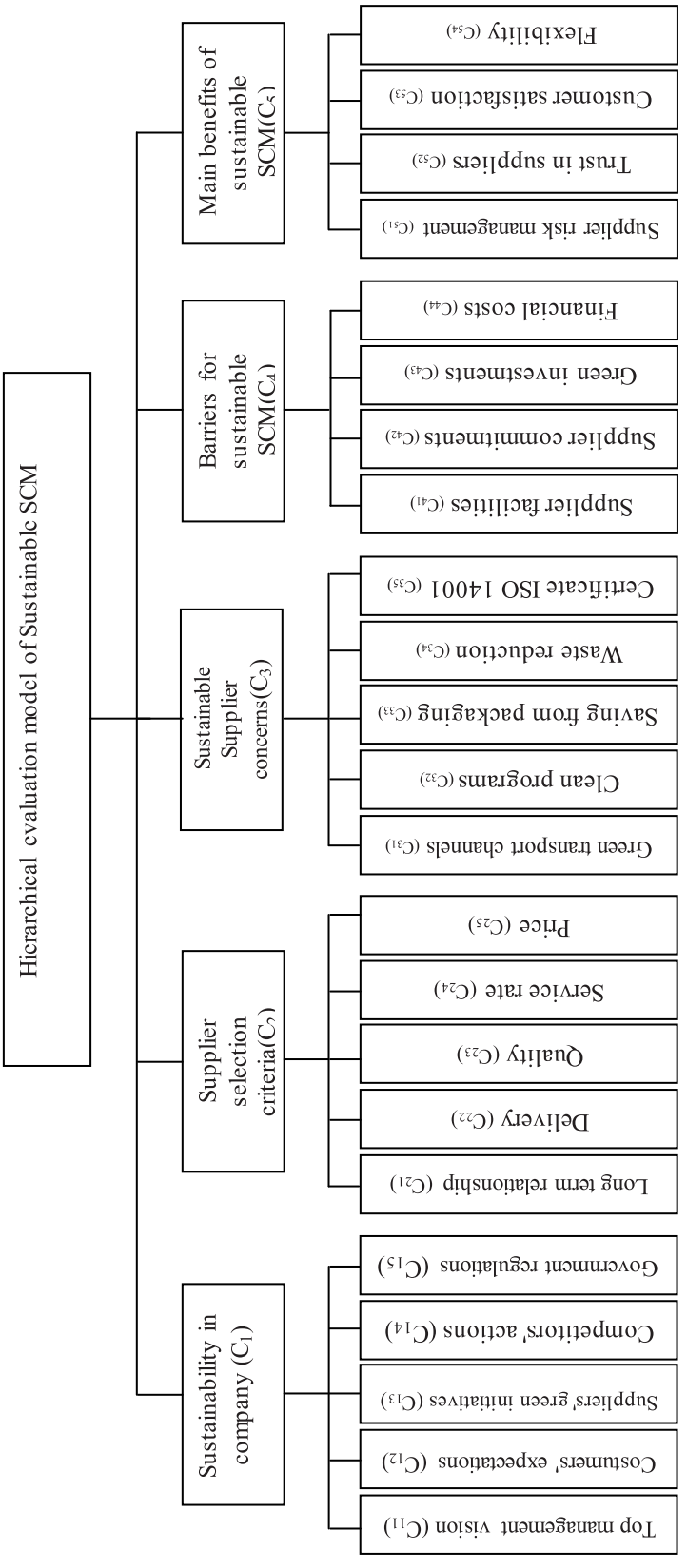

Fig 1. Hierarchical structure of proposed model

As you see in Fig. 1, the model has five main criteria and each criteria has four or five sub criteria for evaluating of sustainable SCM in Sooreh Mehr Company. First of all, the MCDM questionnaire is designed based on pair-wise comparison concept by using Saaty scale from 1/9 to 9. Saaty spectrum is shown in Table 1.

Table 1. Saaty's 9 point scale

Fuzzy number	1	3	5	7	9
Definition	Equally important	Moderately more important	Strongly more important	Very strongly more important	Extremely important

Decision makers from different views may define different weight vectors. This usually not only makes vague evaluation but also provides several problems during the decision process [19]. For this reason, we offer a group decision based on pair-wise comparisons.

Fuzzy AHP method has been selected to reduce uncertainty and ambiguity in decision making and to obtain subjective judgments of experts [17]. To fill the tables by experts, from 9-point spectrum of Saaty has been used. For this work, 10 experts from Sooreh Mehr Publication and 5 experts in academic are were selected. To gather opinions of experts, special survey forms was provided and sent for them. Then ranking experts merged from the following formula and comprehensive pair-wise comparisons matrix was developed.

$$\left(\tilde{x}_{ij}\right)=\left(a_{ij},b_{ij},c_{ij}\right),\ l_{ij}=\min\left\{a_{jk}\right\},m_{ij}=\frac{1}{k}\sum_{k=1}^{k}b_{ijk},u_{ij}=\max\left\{d_{ijk}\right\}$$

Questionnaires are distributed among mentioned experts and after they are filled, fuzzy AHP calculations with respect to section 5 are performed. For avoiding prolixity, just final results of calculations are presented. The overall ranking of criteria and sub criteria are shown in table 2.

As you see, the most important criteria in sustainable SCM are sustainability in company (C1), supplier selection criteria (C2), main benefits of sustainable SCM (C5), barriers for sustainable SCM (C4) and sustainable Supplier concerns (C3) respectively. Although, the most important sub criteria are top management vision (C11), government regulations (C15) and flexibility (C54) and weakest sub criteria are clean programs (C32), waste reduction (C34) and certificate ISO 14001 (C35).

Table 2 – Final result of study

Criteria	Final weight	Ranking	Sub criteria	Local weight	Overall weight	anking

Sustainability in company (C_1)	0.33	1	C_{11}	0.28	0.092	1
			C_{12}	0.19	0.063	6
			C_{13}	0.13	0.043	11
			C_{14}	0.15	0.049	10
			C_{15}	0.25	0.082	2
Supplier selection criteria (C_2)	0.24	2	C_{21}	0.17	0.041	12
			C_{22}	0.15	0.036	14
			C_{23}	0.27	0.065	5
			C_{24}	0.11	0.026	
			C_{25}	0.30	0.072	4
Sustainable Supplier concerns (C_3)	0.06	5	C_{31}	0.20	0.012	19
			C_{32}	0.19	0.011	20
			C_{33}	0.29	0.017	17
			C_{34}	0.18	0.0108	21
			C_{35}	0.14	0.008	22
Barriers for sustainable SCM (C_4)	0.14	4	C_{41}	0.20	0.028	16
			C_{42}	0.41	0.057	7
			C_{43}	0.12	0.0168	18
			C_{44}	0.27	0.038	13
Main benefits of sustainable SCM (C_5)	0.20	3	C_{51}	0.25	0.05	9
			C_{52}	0.18	0.036	14
			C_{53}	0.28	0.056	8
			C_{54}	0.39	0.078	3

7. Conclusion

Today, sustainability is receiving an increasing level of attention at both the local and global levels, which

eventually leads to questions on how to integrate sustainability with business operations and strategy. Sustainable supply chain management (SSCM) could be a good means to extend the responsibility of business organizations from being reactive in reducing pollution and waste and other sustainable related efforts, to proactively assuming full responsibility for their products from acquisition of raw materials to the final disposal of the products from a sustainability perspective. This paper examines effective factors of sustainable supply chain management by using fuzzy AHP approach in publishing industry. For doing this study, Ageron et al model [7] is used. Firstly, mentioned model is considered by experts from Sooreh Mehr Publication and academic experts and some changes and modifications are performed. Then pair-wise comparison matrix and fuzzy questionnaire are designed and distributed among experts. Results show that sustainability in company (C1) and sustainable Supplier concerns (C3) are most important and weakest criteria in sustainable SCM respectively. It seems that environment problem and challenges have least attention in publishing industry. Meanwhile, regarding with result, weakness of supply chains and lack of strategic vision in supply chain management in publishing industry can be another challenge. Combination between other mathematical approaches with sustainable SCM or other MCDM methods such as ANP, TOPSIS and ElECTERE are proposed for future studies.

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