Criteria definition and approaches in green supplier selection – a case study for raw material and packaging of food industry

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This paper formulates an integrated framework for deciding about the green supplier selection criteria in food supply chain and also proposes different methods that account for single and multiple sourcing of supplier selection. Green supplier selection relies on green criteria, so determination of suitable set of criteria will affect decision-maker results directly. In this research, an operational model including combination of general and environmental criteria is introduced for green supplier selection criteria in raw material and packaging of food industry. This model reviewed a literature on general and environmental criteria that help us to know and make a set of common green criteria. Afterward, weighting criteria and collecting of sub-criteria are done by an expert team using the Analytic Hierarchy Process and Delphi method. The expert team tried to propose important and practical sub-criteria which are well fitted to food industry. Finally, in the section of supplier selection, two kinds of qualitative and quantitative data are discussed when single and multiple sourcing are required, respectively. Fuzzy Grey Relational Analysis is proposed to ranking suppliers in presence of qualitative and imprecise data. Also linear programming is used to present a model which can select the best suppliers and allocate the orders among them optimally.

Keywords: green supplier selection; food industry; raw material; packaging supplier

1. Introduction

Enterprises realize that a large amount of direct and indirect profits can be obtained from effective and efficient supply chain management practices. Supplier selection has great impact on integration of the supply chain relationship. Effective and accurate supplier selection decisions are significant components for productions and logistics management in many firms to enhance their organizational performance.

The issue of supply chain (management of networks, decision-makings, scheduling, etc.) is the area of science that has been strongly developing since the 80s of the last century (Bocewicz, Wójcik, & Banaszak, 2012; Sitek & Wikarek, 2014). A definition of a supply chain can be proposed as: the global network of players involved in executing the production and distribution of a predefined good from raw materials through to delivery to satisfy a consumer demand (Chen, Simon, Reich-Weiser, & Woo, 2013). The aim of supply chain management is to increase sale, reduce costs, and take full advantage of business (Sitek & Wikarek, 2014). Green supply chain is similar while
managers simultaneously consider environmental impacts and work to reduce those impacts over time. Namely according to Sirvastava (2007), Green Supply Chain Management (GSCM) can be defined as “integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing process, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.” GSCM is to eliminate or minimize waste in the form of energy, emission, hazardous, chemical, and solid waste (Olugu, Wong, & Shaharoun, 2011).

Deciding whether to make or buy a new product or service is the first decision that must be made in managing supply chain. It determines where and how the supply chain will be managed (Schoenfeldt, 2008). If you decide to buy, so next step of SCM implementation includes the purchase, movement, and storage of raw materials (Harland, 1996).

Having seen the significance of collaborative supply chain and centralized purchasing in environmental management performance, it is now obvious that deciding which suppliers to collaborate with and how to select suppliers is a very crucial decision for the organization performance.

Fundamentally, supplier selection is divided into two kinds as single sourcing and multiple sourcing. In single sourcing, one supplier can satisfy all the buyer’s requirements, but in multiple sourcing, company needs to select a collection of selected suppliers and their allocations (Wikipedia contributors, 2014).

Decision-making on supplier selection is based on criteria, so definition and selection of criteria have an important role in your selection. Supplier selection is a critical managerial decision-making problem, which requires considering various qualitative and quantitative criteria (Toloo, 2014). In conventional supply chain, general criteria are used; general selection criteria ordinarily intend to cover issues such as quality, capacity in terms of finance, services, and equipment, quantity, responsiveness, and others. In GSCM, environmental criteria are joined to general; environmental supplier selection criteria arise from an organization inclination to respond to any existing trends in environmental issues related to business management and processes. A good combination of conventional and environmental criteria will show the exact image of green supplier selection.

Building accepted definitions and characteristics of these criteria before their implementation in decision models is necessary for the acceptance of the methodologies, and, most importantly, for the decisions that derive from this methodologies. Despite the large amount of literature to supplier selection, there is narrow literature on green supplier selection and especially criteria definition, most of which are qualitative. Also, the methods for identifying, defining, grouping, and filtering criteria would greatly enhance the research, development, and application of models and their criteria. These areas are important and necessary directions (Govindan, Rajendran, Sarkis, & Murugesan, in press). The selected criteria are systematically integrated from supplier selection papers (general criteria) and green supplier selection (environmental criteria).

Given this complexity, this study presents a compound approach, first capable to integrate Delphi and AHP for criteria selection and then, according to supplier’s data and company’s requirements, defines two different kinds of GSS: (1) single sourcing with qualitative supplier’s data using FUZZY GRA to rank suppliers and select just one green supplier and (2) multiple sourcing with quantitative supplier’s data using linear programming to select and allocate green suppliers of raw ingredients and packaging material food industries.
Generally, this study is organized as follows. Sections 2 and 3 explain greening food industry and reviews pertinent literature on green supplier selection of food industry. Next, Section 4 introduces the applied model and related methods. Section 5 describes the applicability of the proposed approach by food industry experts. Conclusions are finally drawn in Section 6, along with recommendations for future research.

2. Greening food industry

When compared to other industries, food and agricultural products have some unique characteristics related to public health. Food supply chains can be distinguished into “fresh agricultural products” (e.g. vegetables or fruits) and “processed food products” (e.g. convenience food or soft drinks) (Apaiaha, Linnemanna, & van der Kooi, 2006) which here we focused on it. Resulting product-related issues include but are not limited to “shelf life constraints, variable quantity and quality due to biological variations, seasonality, random factors connected with weather and pests and other biological hazards” (van der Vorst, van Dijk, & Beulens, 2001).

Efforts have consequently been intensified to enable tracking and tracing of materials and ingredients in food supply chains, for example, food safety and traceability standards by the European Union (EU) requiring every ingredient to be traceable (EU, 2002). In supply chain management, to build strategic and strong relationships, food industries should select best suppliers by applying appropriate method and selection criteria.

Food companies are closely monitored by their customers who want to be confident that the food being purchased is safe. In this regard, they are usually asked to pass an independent audit to check whether good manufacturing practice, good hygiene practice, and HACCP (Hazard Analysis and Critical Control Points) principles are fully implemented and strictly followed in each step of the process (Losito, Visciano, Genualdo, & Cardone, 2011). Quality and safety of food ingredients and packaging are paramount to company success, so choosing a good supplier is a critical business decision. Generally, companies in food industry try to develop their supplier assessment form according to HACCP, ISO 9000, and other related regulation and special requirements.

Something that has become apparent is that in the near future, the design and operation of agricultural supply chains will be subject to more stringent regulations and closer monitoring, in particular, those for products destined for human consumption (Bosona & Gebresenbet, 2013). This implies that the traditional supply chain practices may be subject to revision and change. One of the aspects that may be the subject of considerable scrutiny is the supplier selection along the supply chains of food products (Gendron & Audet, 2012).

Beside the conventional factors like quality, safety, and hygienic factors, it should be noted that the food industry is one of the world’s largest industrial sectors, and hence has large environmental impacts (Grunert, Hieke, & Wills, 2014). Greenhouse gas (GHG) emission, which has increased remarkably due to tremendous input and energy use, has resulted in global warming, perhaps the most serious problem that humankind faces today (Ilbery & Maye, 2005). With growing worldwide awareness of environmental protection, green food production has become an important issue for almost every producer and will determine the sustainability of producers in the long term. It is the responsibility of the food industry to develop and implement green supplier selection in the first step of green supply chain establishment.
3. Literature review

A food producer needs to buy raw ingredients and packaging material, so suppliers in food industries are divided in two groups. A number of literature reviews have been completed to summarize supplier selection criteria adopted and decision models published (Aissaoui, Haouari, & Hassini, 2007; Chai, Liu, & Ngai, 2013; Govindan et al., in press). Unfortunately, there are few studies which are focused on food supplier selection and none of them suggested environmental criteria. Some information about their criteria and techniques are summarized in Table 1.

In the field of package printing industry, Vachon and Klassen (2006) studied a comparative green supplier selection problem and determined green supplies in Canadian and United States Package Printing Industry. They purposed Green projects partnership as environmental criteria to select green supplier. Also Kumar, Hong, and Haggerty (2011) and Magdalena (2012) studied a global supplier selection process for packaging. Kumar et al. (2011) noted risk of disruption, volume and product flexibility, and innovation as specific criteria for packaging suppliers. This paper attempts to construct a practical model for purchase manager and decision-maker in green supplier selection of food industry. In the latest research of Banaeian, Nielsen, Mobli, and Omid (2014) on GSS in food industry, they used method of Data Envelopment Analysis (DEA) to rank and compare green suppliers, different criteria of price, and carbon footprint as inputs, and delivery and quality as outputs of models.

4. Material and method

4.1. General model (guideline)

Figure 1 shows the structured model. In this paper, we discussed widely about green supplier selection criteria and formed a selection model step by step:

Phase I

- Reviewing general & green supplier selection criteria
- Selection of relevant criteria for green supplier selection

Phase II

- Determining the weights of relevant criteria using AHP
- Determining branches for each relevant criterion and selecting the most effective branch based on Delphi group opinion in raw material and package suppliers

Phase III

- Identifying company requirements and supplier characteristics
- Decision-making for selection of best green supplier in case of single sourcing
- Modeling for selection and allocation of best green suppliers in case of multiple sourcing
| Authors/Year | Technique | Criteria/Sub-criteria |
|-------------|-----------|----------------------|
| Cebi and Bayraktar (2003) | AHP+LGP | Logistic Lead time, Supply lots, Flexibility, Delivery condition  
Technologic Capacity, Involvement, Improvement efforts, problem solving  
Business Reputation, Financial strength, Management  
Relationship Communication, Past experience, Sales representation |
| Shen, Liu, and Tzeng (2012) | DEMATEL+ANP | Cost Unit cost, operating cost, warranty cost  
Delivery Delivery performance, delivery speed, fill rate  
Quality Product quality, steadiness of quality  
Service Follow-up, process flexibility, professionalism, supply chain responsiveness  
Technology Ability to solve technical problems, machinery, outlook for the future  
Company image Attitude, relationship closeness, reputation and financial position |
| Prusak, Stefanow, Niewczas, and Sikora (2013) | AHP | Finance Price, Price difference, Time limit for payment  
Assortment Possible changes, Diversity  
Logistic Buffer stock, Flexibility, Promptness of supply  
Service Innovativeness, contact, Acceptable procedure, Customer service, On-line platform  
Quality The use of SPC (Statistical process control), ISO standards, Technical support, Reaction on problem |
| Liao, Fu, Chen, and Chih (2012) | Fuzzy MSGP | Financial Stability Product quality  
Reputation in industry  
R&D capability  
Service quality |
| Shen, Olfat, Govindan, Khodaverdi, and Diabat (2013) | DEA | Inputs  
Synthetic cost, Geographical position  
Outputs  
Quantitative Product qualification ratio, Market occupancy ratio, Order changing received ratio, Deliver punctual Ratio, R&D success rate, R&D return rate, Total assets turnover ratio, Profit increasing ratio  
Qualitative Quality system, enterprise reputation, compatibility, upstream firm’s management, traceability system, information level |
4.2. Analytical hierarchy process

AHP is a structured technique for organizing and analyzing complex decisions based on paired comparisons of both projects and criteria (Saaty, 1990). This method compares weights in pairs and is more straightforward and easier to use for the decision-makers. The strength of the AHP method lies in its ability to construct complex, multi-person, multi-attribute, and multi-period problem hierarchically. Thus, it has been discussed in a wide variety of decision situations in fields such as business planning, resource allocation, priority setting, and selection among alternatives.

First, under the designed hierarchy model, pairwise comparisons are classically carried out by asking the decision-maker how valuable a criterion (C1) is when compared to another criterion (C2) with respect to overall goal. The verbal judgments of the decision-maker are then transformed into numerical values using the scale presented in Table 2, then a pairwise comparison matrix is constructed.

The pairwise comparison of criteria can be summarized in an \((n \times n)\) evaluation matrix \(A=(a_{ij})\) for \(n\) criteria, where every element \((i, j = 1,2,\ldots,n)\) is the quotient of weights of the criteria. This pairwise comparison can be shown by a square and reciprocal matrix, (see Equation (1)).
A = (a_{ij}) = \begin{pmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{pmatrix}; \quad (1)

a_{ij} = \begin{cases} 1 & i = j \\ a_{ij}, a_{ij}^{-1} & i \neq j \end{cases}; \quad (2)

In order to measure the subjective evaluation of the decision-maker, (Saaty, 1990) proposes a consistency index (CI). CIs are calculated for each pairwise comparison matrix and to check consistency using a random index (RI). If the calculated ratio is significantly small (10% or less), the priorities will be accepted otherwise, the DM is asked to revise the pairwise comparisons.

4.3. Delphi method

Delphi is a method of popular survey technique that brings consensus of opinions among a set of experts or panelists (informed individuals) by maintaining the unanimity among them (Prusty et al., 2010). In this paper, Delphi method is used for describing sub-criteria based on food industry necessity and selects the most important sub-criteria. Each Delphi panelist was asked to answer two main questions:

First round – According to criteria collection, describe sub-criteria which are important for your supplier selection.

Second round – Score each sub-criteria between 1 (not important) and 9 (very important).

Finally, Delphi score is proposed by Listone and Turoff (2002) as illustrated in Equation (2):

\[
\text{Delphi Score} = \frac{\text{Lowest Score} + \text{Highest Score} + (4 \times \text{Average Score})}{6} \quad (3)
\]

4.4. Qualitative and single source green supplier selection

In decision-making process of supplier selection, the decision-makers try to gather as much information as possible through surveys, investigations, sampling, etc. To reach the aspired decision, sometimes obtaining all the quantitative information is impossible; therefore, decisions are often made in uncertain process, i.e. without complete or quantitative information. In these situations, decision-makers try to apply qualitative models.
Fuzzy theory and sets, first introduced by Zadeh (1965), have been recognized as a powerful tool for modeling systems with imprecise input data, such as the decision-maker opinions. Linguistics terms are used to express the variables by means of fuzzy sets and membership function. Triangular fuzzy number (TFN) has been the most popular form to present fuzzy numbers which represented with three points; \( A = (l, m, u) \). A model based on subjective preferences of a decision-maker is not always accurate as it demands a great deal of knowledge, expertise, and experience (Li, Yamaguchi, & Nagai, 2008). This is where “fuzzy” approaches are used in MCDM problems. Incorporating fuzzy sets in decision-making models can produce more realistic outcomes as they aim to transform uncertain human knowledge into a mathematical formula (Zadeh, 1965).

Numerous MCDM techniques have been proposed (Chai et al., 2013) to tackle the problem of supplier selection in order to rank them in the presence of qualitative data. Grey Relational Analysis (GRA), originally proposed by Dong (1982), is applied to imprecise information in the form of interval values and also aims to show the degree of similarity or difference of development trends between an alternative and the reference (ideal) alternative (Kuo & Liang, 2011). Grey system theory has shown to be able to handle both incomplete information and ambiguities (Hu, Zhang, Hu, & Jiang, 2010).

Therefore, combination of Fuzzy logic and GRA is a good choice for single sourcing when quantitative and precise data are not available; so Fuzzy GRA would allow for effective qualitative assessment.

4.5. Quantitative and multiple source Green Supplier Selection

The incorporation of environmental criteria into supplier selection practices is gaining increasing importance. By increasing GSS studies and development of its concept, the applications of GSS in companies are growing quickly. Therefore in future, measuring of many quantitative criteria is possible. Future GSS researches can consider other important environmental criteria (like Carbon Footprint, GHG emissions, Life Cycle Assessment of products, etc.) which currently have been focused on. These kinds of environmental subjects will provide more practical results in GSS, provided that suppliers trace its environmental footprint accurately.

The purchaser only needs to make one decision, which supplier is the best. However, in multiple sourcing, purchasers need to decide which are the best suppliers and how much order should be placed on each selected supplier. It is based on firm’s condition and depends on manager’s decision directly. Linear programming is the easiest way which helps managers to select multiple source suppliers and their allocations, otherwise by changing constraints, managers are able to select single source. Linear programming (LP; also called linear optimization) is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships. This method was proposed by Ghodsypour and O’Brien (1998) for the first time to indicate best suppliers and their allocations in multiple sourcing models.

5. Results

5.1. Criteria collection (Phase I)

One of the most significant business decisions faced by purchasing managers in a supply chain is the selection of appropriate suppliers while trying to satisfy multiple criteria based on price, quality, customer service, and delivery (Arikan, in press). Hence, supplier selection by its nature involves the need to trade-off multiple criteria, as well as
the presence of both quantitative and qualitative data. A popular area of research in the field of supply chain was establishing the criteria for supplier selection and evaluation since the 1960s. If we look into the history of popular criterion identified in the literature, we can conclude three primary categories of emphasis: in the late 1970s and early 1980s, cost was the main focus; then in the early 1990s, cycle time and customer responsiveness were considered, and, finally, in the late 1990s, the focus shifted to flexibility. Now, environmental factors are a key issue which gives rise to the new paradigm of focusing on green supply chains (Haung & Keskar, 2007).

5.1.1. General criteria

Traditionally, companies only focus on their internal environmental measures of waste reduction, pollution control, and hazardous material control to comply with existing regulations and address their social responsibilities. These days, companies have started to realize that they have to do something more than these internal controls, so they are responsible for environmental concerns about supplier selection, product distribution, etc. (Chen et al., 2013).

Many previous studies on supplier selection and evaluation defined numerous evaluation criteria and selection models for supplier selection. In consideration of the criteria for supplier selection, the pathfinder work by Dickson (1966) has been one of the most cited studies.

Weber, Current, and Benton (1991) re-examined Dickson’s work by reviewing published articles between 1966 and 1990. Twenty-three distinct criteria are identified in various supplier selection problems in Dickson (1966) and Weber et al. (1991). Among the 23 criteria identified for vendor selection, the product quality was ranked as most important, it was followed by on-time delivery, performance history of supplier and warranties, and claimed policies, and so on.

In a later work, Cheraghi, Dadashzadeh, and Subramanian (2004) continued to extend these key players initial work to obtain the current perspective of supplier selection by analyzing articles published between 1990 and 2001. Cheraghi et al. (2004) provided an update of Dickson’s seminal work with 13 more criteria. Also, Thiruchelvam and Tookey (2011) reviewed supplier selection studies and comprise the selection criteria between two periods of 1966–2001 and 2001–2010.

Previous studies indicate that quality, price, and delivery are general (traditional) key criteria that consistently appear for vendor selection (Wu, Zhang, Wu, & Olson, 2010).

Chang, Chang, and Wu (2011) used DEMATEL to find influential factors in selecting SCM suppliers and found that “technology ability”, “stable delivery of goods”, “lead-time”, and “production capability” criteria are more influential than other evaluation criteria. They also suggested extending the scope of this study and exploring the addition of a green supply chain in future studies.

Table 3 shows summary results of review paper on most important general criteria on supplier selection. Often each of these important criteria contains several sub-criteria which are described completely in past literature.

5.1.2. Environmental criteria

The past few years have led researchers to investigate the environmental concepts in management and supply chains. We comprehensively collected the literature associated with the descriptors “Green/Environmental supplier selection,” “vendor selection,” and
from academic databases including Science Direct, Emerald, Springer-Link Journals, IEEE Xplore, Academic Search Premier, and World Scientific Net. After a methodological decision analysis of all collected articles, we reviewed 59 international journal articles published to 2014. This review of literature provides the basis for identification and definition of green supplier selection criteria.

As you can see in Figure 2, most of empirical studies on green supplier selection are concentrated on electronic (42%) and automotive industries (19%).

So for exact studies on other industries, specialized consultant is necessary to choose suitable criteria. Unfortunately, agriculture and food industry is neglected from the vision of researchers. Regarding to high environmental impacts on agriculture and food industry (Pluimers, Kroeze, Bakker, Calla, & Hordijk, 2000), it is necessary to pay attention more on this field.

Based on reviewing papers, widespread set of criteria were purposed. Unfortunately, lack of consistent studies about basic green criteria caused widespread number of green criteria in each study. Jabbour and Jabbour (2009) concluded there is no standard for criteria or for use on the part of analyzed companies. Nonetheless, evolving criteria have

Table 3. Most important general criteria on conventional supplier selection.

| Authors                  | The most important criteria as a result of review papers                                                                 |
|--------------------------|------------------------------------------------------------------------------------------------------------------------|
| Dickson (1966)           | Quality, delivery, performance history                                                                                |
| Weber et al. (1991)      | Price, delivery, facilities and capacity, geographic location, technology capability                                      |
| Cheraghi et al. (2004)   | Quality, delivery, price, repair service, technical capability                                                        |
| Ho et al. (2010)         | Quality, delivery, price/cost, manufacturing capability, service, management, technology                                |
| Thiruchelvam and Tookey (2011) | Quality, delivery, price                                                                                           |

Figure 2. GSS position among different industries.
emerged due to competitive market as number of suppliers has increased over the years. Therefore, inception of new criteria is essential to narrow and qualify not only deserving but exceptional suppliers. Also under the current rapid GSCM transformation edge, reliability and flexibility of each supplier are considered as key contributing factors (Chang et al., 2011).

Govindan et al. (in press) reviewed 33 papers on green supplier and introduced relevant selection methods and criteria. The most popular approach in green supplier selection was AHP followed by ANP, DEA, also EMS was the most popular environmental criteria (Table 4).

In two comprehensive review paper (Govindan et al., in press; Nielsen, Banaeian, Golinska, Mobli, & Omid, 2014), researcher collected environmental criteria on supplier selection literature (Table 4). The most important green criteria derived from 57 review articles are: environmental management system (EMS) (20 frequencies), green image (8 frequencies), environmental competences (7 frequencies), design for environment (5 frequencies), environmental improvement costs (5 frequencies), and environmental performance (5 frequencies).

5.2. Criteria selection (Phase II)

According to Figure 1, Phase II investigate calculate the weights of criteria collected in previous section using expert team, also sub-criteria which are more important and influential in edible oil production are introduced.

5.2.1. Expert team

Due to many factors to be considered, purchasing managers might choose an easier path of evaluating based on certain important criteria and ignoring the rest. A larger number of attributes also contribute to the complications of being assigned with consistent and meaningful weights. The selection decision also becomes more difficult as the number of business rules that must be considered increases.

The Expert team is applied first to weighting criteria, second to define related sub-criteria and third for determination of most effective sub-criteria. Handfield, Walton, Sroufe, and Melnyk (2002) developed an expert team of environmental experts and noted that for better results in future studies, group should include purchasing managers who may not be directly familiar with environmental metrics. A good combination of experts will help to ensure that the tool is practical from an actual user’s standpoint (Handfield et al., 2002). In order to obtain a rational framework, the model was developed through an expert team (10 people) described in Table 5. However, experts had a variety of titles, but were responsible for materials management and waste reduction activities within food processing organizations.

5.2.2. Weighting criteria

Weight of each criterion can be concluded from the paired comparison between the criteria using the AHP method, which represents the importance of criteria, is determined by means of a nine-point Likert scale.

The AHP method is often combined with Fuzzy Linear Programming in the decision-making process (Cebi & Bayraktar, 2003; Tektas & Aytekin, in press, etc.); the difference is that in relevant studies, AHP is used for estimating criteria situation in
each supplier, but here, we used it for weighting criteria and tried to use quantified data for each supplier.

A questionnaire, which is based on the format proposed by Humphreys, Wong, and Chan (2003), ought to be carried out to determine the number of criteria. According to verbal judgement (Table 1), pairwise comparison of criteria are done by expert team. Finally using AHP method, criteria weights in raw material and package are calculated and shown in Table 6.

5.2.3. Sub-criteria description

The most relevant criteria are selected from reviewed papers (Cheraghi et al., 2004; Dickson, 1966; Ho et al., 2010; Thiruchelvam & Tookey, 2011; Weber et al., 1991) on supplier selection criteria (quality, price, and finally service and delivery). Main green criteria is selected based on reviewing green supplier selection papers (EMS), as (Govindan et al., in press) determined EMS as the most popular criteria on green supplier selection.

Since the lack of sufficient information about green supplier selection in food industries, expert team (Delphi group) determines sub-criteria based on the nature of industry. They also emphasized that in a practical model, measures should be relatively easy to assess, as commodity strategy development teams often do not have access to all the requisite information. Finally, each criterion is described by several sub-criteria as mentioned follow (Table 7). For example in criteria A, Capital and financial power of supplier company (A1) proposed raw material price (A2) and Transportation cost to the geographical location (A3) were the most important sub-criteria from the financial point of view.

Quality for food package material depends on durability, shelf life, interaction with content, density, etc., but based on expert opinion, the highest difference between package suppliers is providing precision and intact items to reduce leakage and waste rate. Also preserving nutritive and qualitative characters (Shelf life) is determined as quality factor for raw ingredients.

5.2.4. Conclusive criteria selection

Determining sub-criteria will help the Delphi group to decide more precision. The group was asked to score each sub-criteria for raw material and packaging supplier separately (It can be seen in Table 8). Delphi results of financial criteria shows that, capital and financial power of supplier in selection of raw ingredients and proposed price in

| Table 4. Frequency of most important environmental criteria on conventional supplier selection. |
|----------------------------------------|--------|----------------------------------------|
| Duration                              | 1996–2011 | 1996–2014 |
| Number of reviewed paper              | 33      | 57         |
| Criterion                             |         |            |
| Environmental Management System       | 11      | 20         |
| Green Image                           | 4       | 8          |
| Environmental Competences             | 3       | 6          |
| Design for environment                | 3       | 5          |
| Environmental Improvement Costs       | 2       | 5          |
| Environmental Performance             | 3       | 5          |
selection of packaging material were the most important sub-criteria in financial aspect. On-time delivery (lead time) and quality are most important in service and qualitative criteria in both raw ingredients and packaging materials. Mean Delphi score shows that there are some differences between raw ingredients and packaging materials from the aspect of EMS criteria. Environmental prerequisite and environmental friendly material are the most important for the raw ingredients and packaging materials, respectively. The greenest concerning subject in choosing packaging material is easily recycling capability; but in the food ingredient, training special courses for staff training are the most important criteria. For suppliers claiming to be green, the most tangible activity is awarding at least one environmental certificate or labels (like ISO14000, eco-friendly label and carbon footprint label, etc.), so we consider this term as first provision for green supplier selection.

5.3. Supplier selection (Phase III)

After identification of criteria and their weight (the main goal of this paper), decision-makers have to decide about supplier selection methodology. According to Sections 4.3 and 4.4, methods are different and should select based on company requirements and data characteristics.

5.3.1. Ranking and supplier selection by Fuzzy GRA

Fuzzy GRA works as follows. Assume that \( m \) potential suppliers are determined, \( n \) selected criteria (here based on the previous section, four selected sub-criteria in Table 8), and \( k \) decision-makers (here based on Table 5, 10 decision-makers). According to Table 9, the appropriate linguistic ratings can determine for suppliers with respect to criteria \( (x_{ij}) \) as TFN. It means that each decision-maker has to rank importance degree of \( n \) criteria in \( m \) suppliers (Overall \( n \times m \times k \) linguistic variables) for raw material and packaging supplier separately.

| Expert occupation | Experience         | Total expert |
|-------------------|--------------------|--------------|
| Active member of Food Industry Association (president) | Professional and academic | 4 |
| Purchase manager in food industry | Professional and academic | 4 |
| Environmental technician | Professional and academic | 2 |

| Table 5. Summary of Delphi group. |

| Expert occupation                | Experience           | Total expert |
|----------------------------------|----------------------|--------------|
| Active member of Food Industry Association (president) | Professional and academic | 4 |
| Purchase manager in food industry | Professional and academic | 4 |
| Environmental technician        | Professional and academic | 2 |

| Table 6. Criteria weight in raw material and package. |

|                    | Raw material | Package |
|--------------------|--------------|---------|
| Financial \((w_1)\) | 0.04         | 0.09    |
| Service \((w_2)\)   | 0.21         | 0.12    |
| Quantitative \((w_3)\) | 0.65     | 0.51    |
| EMS \((w_4)\)       | 0.10         | 0.28    |
In the initial step of the selected multi-criteria supplier selection methods, aggregated ratings of suppliers (decision matrix) are constructed. The aggregated fuzzy rating $\tilde{x}_{ij}$ of alternative $A_i$ under criterion $C_j$ is:

$$\tilde{x}_{ij} = \frac{1}{k} \left[ \tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \cdots + \tilde{x}_{ij}^k \right]$$ (4)

### Table 7. Sub-criteria description based on expert team opinion.

| Criteria | Sub-criteria |
|----------|--------------|
| A- Financial | A1- Capital and financial power of supplier company  
A2- Proposed raw material price  
A3- Transportation cost to the geographical location (Availability) |
| B- Delivery & service | B1- Communication System (willing to trade, attitudes, acceptance of procedures and flexibility)  
B2- On time delivery (lead time)  
B3- After sales service (policy, quality assurance, and damage ratings)  
B4- Production capacity |
| C- Qualitative | C1- Quality (the supplier ability to access the quality characteristics)  
C2- Operational control (reporting, quality control, inventory control, research and development)  
C3- Expert labor, technical capabilities and facilities  
C4- Business experience and Position among competitors |
| D- Environmental management system | D1- Environmental prerequisite (environmental staff training)  
D2- Environmental planning (program to reduce environmental impacts, green research and development)  
D3- Environmental friendly material (low waste: easily recycling and reuse capability)  
D4- Environmental friendly technology (emission of pollutant: CO$_2$ equivalent, VOC, BOD and COD content and etc.) |

### Table 8. Mean Delphi score of experts.

| Criteria | Sub-criteria | Raw ingredients | Packaging material |
|----------|--------------|----------------|-------------------|
| A        | A1           | 24.5           | 21.5              |
|          | A2           | 22.5           | 23.5              |
|          | A3           | 21             | 20.5              |
| B        | B1           | 19.8           | 18.8              |
|          | B2           | 27.2           | 26.6              |
|          | B3           | 19.5           | 21.5              |
|          | B4           | 20.5           | 22.7              |
| C        | C1           | 30.9           | 18.9              |
|          | C2           | 11.3           | 11.2              |
|          | C3           | 14.6           | 16.4              |
|          | C4           | 15.4           | 17.3              |
| D        | D1           | 6.11           | 9                 |
|          | D2           | 5.5            | 7.3               |
|          | D3           | 4.4            | 12.3              |
|          | D4           | 5.8            | 8.3               |
The aggregated decision matrix can then be constructed as follows:

\[
\vec{X} = \begin{bmatrix}
A_1 & \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\
A_2 & \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
A_m & \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn}
\end{bmatrix};
\]  

(5)

Decision matrix (\(\vec{X}\)) is converted into the normalized decision matrix \(\vec{R}\). Given

\[
\tilde{r}_{ij} = \left( l_{ij}/u_j^+, m_{ij}/u_j^+, u_{ij}/u_j^+ \right), i = 1, \ldots, m; \ j = 1, \ldots, n
\]  

(6)

where \(u_j^+ = \max_i \{u_{ij}\} \quad \forall i = 1, \ldots, m\)  

(7)

The reference series can be determined from (Gumus et al., 2013):

\[
\vec{R}_0 = [\tilde{r}_{01}, \tilde{r}_{02}, \tilde{r}_{03}, \tilde{r}_{04}] \text{ where } \tilde{r}_{0j} = \max_j(\tilde{r}_{ij}) \ j = 1, \ldots, 4
\]  

(8)

The distance matrix is then established. The distance \(\delta_{ij}\) between the reference value and each comparison value is computed from Equation (7) of TFNs. The distance between \(A\) and \(B\) is defined as follows (Krohling & Campanharo, 2011; Zhang & Liu, 2011):

\[
d(A, B) = \sqrt{\frac{1}{3} \left[ (l_1 - l_2)^2 + (m_1 + m_2)^2 + (u_1 - u_2)^2 \right]}
\]  

(9)

The grey relational coefficient \(\xi_{ij}\) is defined as (Gumus et al., 2013):

\[
\xi_{ij} = \frac{\delta_{\min} + \rho \delta_{\max}}{\delta_{ij} + \rho \delta_{\max}}, \ \delta_{\min} = \max(\delta_{ij}), \ \delta_{\max} = \min(\delta_{ij}) \text{ and } \rho \ \text{resolving coefficient } \rho
\]  

\(\in [0, 1]\)

(10)

Defuzzification formula (Definition 4) is applied to \(\tilde{\nu}_j\); then the grey relational grade \(\gamma_i\) is estimated by the relation (Gumus et al., 2013):

\[
\gamma_i = \sum_{j=1}^{n} w_j \xi_{ij}, \ \ i = 1, \ldots, m
\]  

(11)

Table 9. Linguistic variables for supplier ratings.

| Number | Linguistic variables (degree of importance) | TFNs |
|--------|---------------------------------------------|------|
| 1      | Very Poor (VP)                             | (0, 1, 2) |
| 2      | Poor (P)                                   | (1, 2, 3) |
| 3      | Medium Poor (MP)                           | (2, 3.5, 5) |
| 4      | Fair (F)                                   | (4, 5, 6) |
| 5      | Medium Good (MG)                           | (5, 6.5, 8) |
| 6      | Good (G)                                   | (7, 8, 9) |
| 7      | Very Good (VG)                             | (8, 9, 10) |
where \( w_j \) is the weight of the \( j \)th criterion, \( \sum_{j=1}^{n} w_j = 1 \) which are presented in Table 5. The alternatives can now be ranked in accordance with the value of grey relational grade. The bigger the value, the better would be the alternatives.

5.3.2. Supplier selection and allocation by programming

An environmental objective function was added to the proposed model by Ghodsypour and O’brien (2001). Thus, our model is a multi-objective model considering four objectives of financial, quantity, service, and EMS issues for green supplier selection in food industry. The presented model can select the best suppliers and allocate the orders among them optimally too. Consequently, one objective function and five constraints are considered to calculate Total Purchase Value (TPV). The elements of model and constraints are presented below:

All suppliers have limited capacities and minimum order quantity (13, 9).
Total order quantity must be equal the amount of demand (14).
Summation of supplier’s capacity must be above the amount of demand (15).
Since managerial matter, also there is a limitation on number of selected suppliers (16).

The parameters of the proposed model are defined as follows:

\[
\text{Max TPV} = \sum_{i=1}^{n} \left[ Y_i Z_i \left( w_1 F_i^p + w_2 S_i + w_3 Q_i^p + w_4 E_i^p \right) \right] * X_i
\]

(12)

\[
ST : X_i \leq C_i Y_i ; i = 1, 2, \ldots, n
\]

(13)

\[
\sum_{i=1}^{n} X_i = D
\]

(14)

\[
\sum_{i=1}^{n} C_i \geq D
\]

(15)

\[
n_{\min} \leq \sum_{i=1}^{n} Y_i \leq n_{\max}
\]

(16)

\[
X_i \geq Q_{i,\min} Y_i ; i = 1, 2, \ldots, n
\]

(17)

Base on criteria selection process, the model includes four objective functions to optimize the four criteria for green supplier selection: financial, service, qualitative, and EMS of suppliers are expressed as follows:

\[
F_i^p : \begin{cases} 
\text{for raw ingredients} = \frac{F_i}{\text{Max} F_i}; & F_i : \text{Capital of supplier} \\
\text{for packaging materials} = \frac{\text{Min} F_i}{F_i}; & F_i : \text{Proposed price by supplier } i 
\end{cases}
\]

(18)

\[
E_i^p : \begin{cases} 
\text{for raw ingredients} = \frac{\text{Number of trained staff}}{\text{Number of total staff}}; & E_i^p \text{ : Number of trained staff} \\
\text{for packaging material} = \frac{\text{Amount of collected package from consumer}}{\text{Total amount of production}}
\end{cases}
\]

(19)
\[ Q_i = \frac{Q_i}{Q_{\max}}; Q_i = \text{Shelf life of items provided by supplier } i \]

for packaging material = percent of intact items delivered by supplier \( i \)

\[ S_i = \frac{S_i}{S_{\max}}; S_i = \text{Lead time (day) items provided by the supplier } i \]

\( n \): Number of suppliers

\( D \): The amount of demand for the period

\( X_i \): Order quantity for the supplier \( i \)

\( Q_{i \min} \): Minimum order quantity of the \( i \)th supplier

\( C_i \): The capacity of the supplier \( i \)

\( Y_i \): 1 if the supplier is selected; 0 otherwise

\( Z_i \): 1 if the supplier award environmental certificate; 0 otherwise

\( W_{1,2,3,4} \): Represent the weight of each criterion using the AHP method as described completely in previous section which is different for raw ingredients and packaging materials.

6. Conclusion

GSS literature reviewed in this paper showed that most of papers are focused on automotive, electronics, and manufacturing industries. The principal benefit of this paper is to provide an extended GSS guideline (from the definition of criteria to GSS) to help decision-makers in various industries often neglected in previous GSS studies.

Food and agricultural products have some unique characteristics related to public health, which has not been properly investigated in GSS literature. Green purchase is an inclusive concept and people may attach different meanings to it, especially among multifarious number of environmental management actions in food industry. So in this study, an expert team tried to define easy understanding criteria and sub-criteria and also select easy access ones in a food company.

As the main goal, this study tried to show the single platform in order to choice criteria and sub-criteria in GSS and calculate the weights of criteria, applied in an edible oil company. In addition, an example of different ways to GSS (single and multiple sourcing) is also briefly illustrated.

In this paper, general and environmental criteria are systematically selected: general and green supplier selection criteria are reviewed comprehensively, and relevant criteria for green supplier selection are selected. In order to obtain a rational framework, the model was developed through an expert team (including Active members of Food Industry Association, purchase managers and environmental technicians) to find most suitable criteria and their weights. The weights of relevant criteria using AHP are determined, also branches for each relevant criterion and selecting the most effective branch based on Delphi group opinion in raw material and package suppliers are calculated.

In the section of supplier selection, two kinds of qualitative and quantitative data are discussed when single and multiple sourcing are required, respectively. Fuzzy GRA is proposed to ranking suppliers in presence of qualitative and imprecise data. Also programming is used to present a model which can select the best suppliers and allocate the orders among them optimally.

There are certain limitations for this study that can provide opportunities for further research in this area. While it is believed that the presented model provides operational value in criteria selection, there are also further points in supplier selection that can be
included. Application of single and multiple sourcing of GSS (phase III) will be study in future papers. Additional research is required to identify and define more clearly specific criteria in different products and industries.

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References
Aissaoui, N., Haouari, M., & Hassini, E. (2007). Supplier selection and order lot sizing modeling: A review. Computers & Operations Research, 34, 3516–3540.
Apaiaha, R. K., Linnemanna, A. R., & van der Kooi, H. J. (2006). Exergy analysis: A tool to study the sustainability of food supply chains. Food Research International, 39(1), 1–11.
Arikan, F. (in press). An interactive solution approach for multiple objective supplier selection problem with fuzzy parameters. Journal of Intelligent Manufacturing. doi:10.1007/s10845-013-0782-6
Banaeian, N., Nielsen, I. E., Mobli, H., & Omid, M. (2014). Green supplier selection in edible oil production by a hybrid model using Delphi method and Green Data Envelopment Analysis (GDEA). Management and Production Engineering Review, 5, 3–8.
Bocewiez, G., Wójcik, R., & Banaszak, Z. (2012). Cyclic scheduling for supply chain network. Trends in practical applications of agents and multiagent systems (pp. 39–47). Springer Berlin Heidelberg.
Bosona, T., & Gebresenbet, G. (2013). Food traceability as an integral part of logistics management in food and agricultural supply chain. Food control, 33(1), 1–11.
Cebi, F., & Bayraktar, D. (2003). An integrated approach for supplier selection. Logistics Information Management, 16, 395–400.
Chai, J., Liu, J. N. K., & Ngai, E. W. T. (2013). Application of decision-making techniques in supplier selection: A systematic review of literature. Expert Systems with Applications, 40, 3872–3885.
Chang, B., Chang, C.-W., & Wu, C.-H. (2011). Fuzzy DEMATEL method for developing supplier selection criteria. Expert Systems with Applications, 38, 1850–1858.
Chen, Y., Simon, R., Reich-Weiser, C., & Woo, J. (2013). Green supply chain. In D. A. Donfield (Ed.), Green manufacturing: Fundamental and applications (pp. 83–105). Springer.
Cheraghi, S. H., Dadashzadeh, M., & Subramanian, M. (2004). Critical success factors for supplier selection: An update. Journal of Applied Business Research, 20, 91–108.
Dickson, G. W. (1966). An analysis of vendor selection system and decisions. Journal of Purchasing, 2, 5–17.
Dong, J. L. (1982). Control problems of grey systems. Systems and Control Letters, 5, 288–294.
EU. (2002). Regulation (EC) no 178/2002 of the European parliament and of the council of 28 January 2002. Official Journal of the European Communities, L31, 1–24.
Gendron, C., & Audet, R. (2012). Key drivers of the food chain. In J. L. Boye & Y. Arcand (Eds.), Green technologies in food production and processing (pp. 23–39). Food Engineering Series. New York, NY: Springer.
Ghodsypour, S. H., & O’Brien, C. (2001). The total cost of logistics in supplier selection, under conditions of multiple sourcing, multiple criteria and capacity constraints. International Journal of Production Economics, 73, 15–27.
Ghodsypour, S. H., & O’Brien, C. (1998). A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. International Journal of Production Economics, 56–57, 199–212.
Govindan, K., Rajendran, S., Sarkis, J., & Murugesan, P. (in press). Multi criteria decision making approaches for green supplier evaluation and selection: A literature review. Journal of Cleaner Production. doi:10.1016/j.jclepro.2013.06.046
Grunert, K. G., Hieke, S., & Wills, J. (2014). Sustainability labels on food products: Consumer motivation, understanding and use. Food Policy, 44, 177–189.
Gumus, A. T., Yayla, A. Y., Celik, E., & Yildiz, A. (2013). A combined fuzzy-AHP and Fuzzy-GRA methodology hydrogen energy storage method selection in Turkey. *Energies, 6*, 3017–3032.

Handfield, R., Walton, S. V., Stroufe, R., & 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, 141*, 70–87.

Harland, C. M. (1996). Supply chain management, purchasing and supply management, logistics, vertical integration, materials management and supply chain dynamics. *Blackwell encyclopedic dictionary of operations management*. Oxford, UK: Blackwell.

Haung, S. H., & Keskar, H. (2007). Comprehensive and configurable metrics for supplier selection. *International Journal of Production Economics, 105*, 510–523.

Ho, W., Xu, X., & Dey, P. K. (2010). Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. *European Journal of Operational Research, 202*, 16–24.

Hu, L., Zhang, C., Hu, C., & Jiang, G. (2010). Use of grey system for assessment of drinking water quality: A case study of Jiaozuo City, China. In S. Liu & J. Y. L. Forrest (Eds.), *Advance in Grey Systems* (pp. 469–480). Berlin Heidelberg, Germany: Springer.

Humphreys, P. K., Wong, Y. K., & Chan, F. T. S. (2003). Integrating environmental criteria into the supplier selection process. *Journal of Materials Processing Technology, 138*, 349–356.

Ilbery, B., & Maye, D. (2005). Food supply chains and sustainability: Evidence from specialist food producers in the Scottish/English borders. *Land Use Policy, 22*, 331–344.

Jabbour, A. B. L., & Jabbour, C. J. (2009). Are supply selection criteria going green? Case studies of companies in Brazil. *Industrial Management & Data Systems, 109*, 477–495.

Krohling, R. A., & Campanharo, V. C. (2011). Fuzzy TOPSIS for group decision making: A case study for accidents with oil spill in the sea. *Expert Systems with Applications, 38*, 4190–4197.

Kumar, S., Hong, Q. S., & Haggerty, L. N. (2011). A global supplier selection process for food packaging. *Journal of Manufacturing Technology Management, 22*, 241–260.

Kuo, M. S., & Liang, G. S. (2011). Combining VIKOR with GRA techniques to evaluate service quality of airports under fuzzy environment. *Expert Systems with Applications, 38*, 1304–1312.

Li, G. D., Yamaguchi, D., & Nagai, M. A. (2008). A grey-based rough decision-making approach to supplier selection. *The International Journal of Advanced Manufacturing Technology, 36*, 1032–1040.

Liao, C. N., Fu, Y. K., Chen, Y. C., & Chih, L. (2012). Applying Fuzzy-MSGP approach for supplier evaluation and selection in food industry. *African Journal of Agricultural Research, 5*, 726–740.

Listone, H. A., & Turoff, M. (2002). *The Delphi Method: Techniques and Applications*. College of Computing Sciences. Newark, NJ: New Jersey Institute of Technology.

Losito, P., Visciano, P., Genualdo, M., & Cardone, G. (2011). Food supplier qualification by an italian large-scale-Distributor: Auditing system and non-conformances. *Food Control, 22*, 2047–2051.

Magdalena, R. (2012). Supplier selection for food industry: A combination of Taguchi loss function and fuzzy analytical hierarchy process. *The Asian Journal of Technology Management, 5*, 13–22.

Nielsen, I. E., Banaeian, N., Golinska, P., Mobli, H., & Omid, M. (2014). Green supplier selection criteria: From a literature review to a flexible framework for determination of suitable criteria. In P. Golinska (Ed.), *Logistic operations, supply chain management and sustainability* (pp. 79–100). Springer.

Olugu, E. U., Wong, K. Y., & Shaharoun, A. M. (2011). Development of key performance measures for the automobile green supply chain. *Resource, Conservation and Recycling, 55*, 567–579.

Pluimers, J. C., Kroeze, C., Bakker, E. J., Calla, H., & Hordijk, L. (2000). Quantifying the environmental impact of production in agriculture and horticulture in The Netherlands: Which emissions do we need to consider? *Agricultural Systems, 66*, 167–189.

Prusak, A., Stańnow, P., Niewczas, M., & Sikora, T. (2013). Application of the AHP in evaluation and selection of suppliers, 57th EQO congress quality renaissance – co-creating a viable future, June 17–20, 2013, Tallinn, Estonia.

Prusty, S. K., Pratap, K. J., Mohapatra, C. K., & Mukherjee (2010). GOS tree (Goal–Objective–Strategy tree) approach to strategic planning using a fuzzy-Delphi process: An application to the Indian Shrimp Industry. *Technological Forecasting and Social Change, 77*, 442–456.
Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. *European Journal of Operational Research, 48*, 9–26.

Schoenfeldt, T. I. (2008). Make or buy: The first step in supply chain management. In P. O’Mara (Ed.), *A practical application of supply chain management principles* (pp. 53–59). Milwaukee, WI: American Society for Quality Press.

Shen, J. L., Liu, Y. M., & Tzeng, Y. L. (2012). The cluster-weighted DEMATEL with ANP method for supplier selection in food industry. *Journal of Advanced Computational Intelligence and Intelligent Informatics, 16*, 567–575.

Shen, L., Olfat, L., Govindan, K., Khodaverdi, R., & Diabat, A. (2013). A fuzzy multi criteria approach for evaluating green supplier’s performance in green supply chain with linguistic preferences. *Resources, Conservation and Recycling, 74*, 170–179.

Sirvastava, S. K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews, 9*, 53–80.

Sitek, P., & Wikarek, J. (2014). Hybrid solution framework for supply chain problems. Distributed computing and artificial intelligence (DCAI 2014). *Book Series: Advances in Intelligent Systems and Computing, 290*, 11–18.

Tektas, A., & Aytekin, A. (in press). Supplier selection in the international environment: A comparative case of a Turkish and an Australian company. *IBIMA Publishing*. doi: 10.5171/2011.598845

Thiruchelvam, S., & Tookey, J. E. (2011). Evolving trends of supplier selection criteria and methods. *International Journal of Automotive and Mechanical Engineering, 4*, 437–454.

Toloo, M. (2014). Selecting and full ranking suppliers with imprecise data: A new DEA method. *The International Journal of Advanced Manufacturing Technology, 74*, 1141–1148.

Vachon, S., & Klassen, R. D. (2006). Green project partnership in the supply chain: The case of the package printing industry. *Journal of Cleaner Production, 14*, 661–671.

van der Vorst, J. G. A. J., van Dijk, S. J., & Beulens, A. J. M. (2001). Supply chain design in the food industry. *The International Journal of Logistics Management, 12*, 73–86.

Weber, C., Current, J., & Benton, W. (1991). Vendor selection criteria and methods. *European Journal of Operation Research, 50*, 2–18.

Wikipedia contributors, S. C. M. (2014). Wikipedia, The Free Encyclopedia. Retrieved 30 June, 2014, from http://en.wikipedia.org/wiki/Supply_chain_management#cite_note-11

Wu, D. D., Zhang, Y., Wu, D., & Olson, D. L. (2010). Fuzzy multi-objective programming for supplier selection and risk modeling: A possibility approach. *European Journal of Operational Research, 200*, 774–787.

Zadeh, L. A. (1965). Fuzzy sets. *Inform Control, 8*, 338–353.

Zhang, S. F., & Liu, S. Y. (2011). A GRA-based intuitionistic fuzzy multi-criteria group decision making method for personnel selection. *Expert Systems with Applications, 38*, 11401–11405.