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Evaluation of the Parameters of the Green Supplier Selection Decision in Textile Industry

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Abstract
Green issues are a popular topic in today's business life, and it is possible to see green products or advertisements in many different places due to the demand for a healthier lifestyle. Companies that are willing to be a part of the green concept should integrate this philosophy in all departments. As a result, the procurement might be seen a crucial part of this integration. However, in the emerging markets, green issues might be pushed into the background due to the competitive environment. In this study, we investigated green and other parameters in the supplier selection decision in textile industry. A decision criteria list was created and evaluated by 28 experts using the fuzzy analytic hierarchy process. The results showed that green issues have an influence on the decision environment; however, classical parameters, such as cost, delivery reliability, quality, service, and strategic alliance still carry more priority compared to green criteria consisting of environmental management, green products, and pollution control.

Key words: *textile industry, green consideration, supplier selection, fuzzy analytic hierarchy process.*

Introduction

In today's business world, no company owns all necessary commodities or meets all demands using its own resources. Therefore to gain competitive advantage in the growing global and complex competition, companies need to work in close collaboration with external partners. Simultaneously the external partnership capability of an organisation has effects on its capabilities to develop new skills and products/services [1] as well as on contacting preferable suppliers.

Recently the industry has undergone a great deal of change, particularly with global sourcing and high levels of price competition. In parallel with the lasted two globalization trends, textile supply chains are spreadingaround the globe. In addition, market characteristics of textiles and clothing include a short product lifecycle, high volatility, low predictability, and a high level of impulse purchasing, making such issues as quick response of paramount importance [2].

Concerning the production processes, textile production is based on the conversion of three types of fibers into yarn, fabric, and finally textiles. These are then fabricated into clothes or other artefacts. Various organic and inorganic materials are used in these processes. Therefore the textile industry supply chain is very specific and complex. Hence controlling and managing it is becoming more challenging.

The concept of supply chain management (SCM) has emerged, requiring optimal ways to manage physical distribution and information flow exchanged among all players in the supply chain [2]. In today's highly competitive era, effective supply chains are gaining more importance in achieving a competitive advantage. Moreover this environment is forcing businesses to establish long-term collaborations with efficient organizations. Thus today, the businesses in a supply chain pay particular attention to the identification and selection of alternative supply sources. As a result, an effective supplier selection and management process is crucial for success [3].

Contrary to the benefits of participating in a supply chain, companies in such a network are increasingly vulnerable due to the simultaneous commitment to various external partners. Thus supplier selection has critical effects on the competitiveness of the entire supply chain network. Research results have indicated that the supplier selection process appears to be one of the significant variables in deciding the success of the supply chain. Additionally the selection of suppliers is seen as a vital aspect that firms must incorporate into their strategic processes. Since organizations become highly dependent on suppliers, the direct and indirect consequences of poor decision making in supplier selection will become more critical [3]. Apart from the common criteria, such as cost and quality, this pa-

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per evaluates the priorities of "green" issues, which might play an important role in sourcing, and tries to suggest critical environmental variables that can be used in supplier selection.

Various studies have focused on green supplier selection issues, and different approaches have been used to reach this crucial decision [4]. These various methods aim to seek a convenient partner for collaboration in the focused time window. Multiple criteria decision making for supplier selection processes is one of the best known and widely used approaches due to its ability to compare tangible and intangible criteria [5]. Considering the multiple criteria approach, the structure of green supplier selection issues focuses on applying (i) the multi criteria decision-making tools, (ii) evaluation criteria, and (iii) sensitivity analysis [6]. Supplier selection has been a research area for the textile industry as well as other application areas. To establish a methodology for supplier selection, Chen [8] used a multi-attribute decision analysis for the Taiwanese textile industry and considered a set of criteria, such as quality, cost, technology, production, and organization management. Hongwei et al. [9] proposed a simulation optimization methodology and applied their it to a European multi-national textile company. In this study the lead time, on-time delivery rate, inventory level, resource utilization and cost are accepted as evaluation parameters. Guneri et al. [10] proposed a set of decision criteria for the supplier selection decision and accepted five decision criteria, specifically, relationship closeness, reputation and position in the industry, performance history, conflict resolution, and delivery capability. In another study, Guneri et al. [11] used ANFIS based methodology in the supplier selection process and used the same evaluation parameters. Shaw et al. [12] used a fuzzy multi-objective linear programming approach with *f*-AHP to evaluate suppliers and price, the unit rejection rate, available quantity, the late delivery rate, greenhouse emissions and the total carbon emission cap for the sourcing of material. Teng and Jaramillo [13] proposed a supplier evaluation structure with main criteria, such as delivery, flexibility, cost, quality, and reliability. Chan and Chan [14] clustered decision parameters into two main criteria, which are performance and company background, and then thesewere combined with nine criteria and twenty-nine sub-criteria. Koprulu and Albayrakoglu [15] considered cost, quality, delivery, flexibility, innovation, and trust criteria via AHP. Altinoz and Winchester [16] proposed a fuzzy solution approach with five criteria; quality, order fill rate, access to management and inventory turns with their attributes. The studies mentioned showed that researchers frequently consider classical decision parameters, including cost, delivery reliability, and quality, while the number of studies that consider green parameters is significantly limited in the existing literature.

The aim of the current study was to combine classical supplier selection parameters with green criteria to obtain a comprehensive selection frameworkwhich is capable of prioritizing the parameters. Thus a criteria tree in a hierarchical structure is determined based on previous studies and experts' expressions. The criteria tree comprises eight main criteria and thirty-one sub-criteria. The decision criteria proposed do not rely solely on green issues owing to the problems with applicability in traditionally working companies [7] which do not consider green issues. The traditional selection criteria are represented by cost, delivery, quality, service, and strategic alliance. Additionally pollution control, green products and environmental management are accepted as the green criteria. After creating a green integrated criteria list, we applied that criteria tree to the textile industry's selection process by considering experts' thoughts through the fuzzy analytic hierarchy process (*f*-AHP).

The next section describes the methodology and theoretical background of the study. The third chapter reviews the decision criteria. The fourth chapter is dedicated to application, which contains the experts' evaluations for green integrated supplier decision. The subsequent discussion chapter summarizes the study and reviews the conclusions.

Methodology

The first step of the study involved a literature review and interviews with experts to determine the parameters that are relevant to the selection of a green supplier. After determining the criteria that have an influence on the decision, Buckley's *f*-AHP approach [8] was considered due to its capability to conduct pairwise comparisons based on weight calculation. Experts' judgments are required to complete the analysis successfully. To avoid any misunderstanding personal interviews are suggested. During these interviews, general aspects of the research should be explained before making the comparisons. To express experts' thoughts, the fuzzy linguistic scale needed to be used. ***Table 1*** summarizes the linguistic scale, and its triangular fuzzy equivalents. The fuzzy numbers showed lower, median, and upper values of the linguistic expressions.

Table 1. *Fuzzy scale.*

Linguistic scales	Triangular fuzzy numbers
Equally important	(1, 1, 1)
Slightly important	(2, 3, 4)
Essentially important	(4, 5, 6)
Very strongly important	(6, 7, 8)
Extremely important	(9, 9, 9)
	(1, 1, 1)
	(0,25, 0,33, 0,5)
	(0,17, 0,2, 0,25)
	(0,13, 0,14, 0,17)
	(0,11, 0,11, 0,11)

The comparisons should be made by experts through a one- to- one interview to avoid any misunderstanding in the questionnaire. Afterwards a pairwise comparison matrix (C) for both the main and sub-criteria was built based on the expressions of the experts, where $\check{c}_{ij}$ represents the comparison values of the criteria. The comparison matrix $\check{c}_k$ includes each decision maker's judgments (k) and the structure of the matrix, illustrated in ***Equation 1*** [9].

$$\tilde{C}_k = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

$k = 1, 2, \ldots, n$

After constructing the comparison matrix, a weight calculation should be made using ***Equation 2*** and ***3***. ***Equation 2*** shows how to calculate the geometric means of the $\tilde{r}_i$, and ***Equation 3*** does the same for the $\tilde{w}_i$.

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i1} \otimes \ldots \otimes \tilde{a}_{in})^{\frac{1}{n}} \quad (2)$$

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{a}_{i1} \oplus \tilde{a}_{i1} \oplus \ldots \oplus \tilde{a}_{in})^{-1} \quad (3)$$

The fuzzy relative matrix could then be obtained and defuzzification of the fuzzy values into crisp value can be completed. The total integration value method with an index optimism $\omega \in [0,1]$ should be used and expressed [10]. The fuzzy term of $\tilde{A}$ has a left membership function $f_{\tilde{A}}^{L}$ and right membership function $f_{\tilde{A}}^{R}$. The total integration is defined in the ***Equations 4, 5*** & ***6*** [11].

$$E_{\omega} = \omega E_R(\tilde{A}) + (1-\omega) E_L(\tilde{A}) \quad (4)$$

where:

$$E_R = \int_{\propto}^{\beta} x f_{\tilde{A}}^{R}(x) dx \quad (5)$$

and

$$E_L = \int_{\gamma}^{\delta} x f_{\tilde{A}}^{L}(x) dx, \quad (6)$$

where, $-\infty < \alpha \leq \beta \leq \gamma \leq \delta < \infty$. As a result, the total integral value $\tilde{A} = (a, b, c)$ will be obtained with the ***Equation 7*** as:

$$E_{\omega} = \frac{1}{2}[\omega(a+b) + (1-\omega)(b+c)] \quad (7)$$

Evaluation of the determinants of green supplier selection can be made with these formulas within the given methodology, and the next section summarises its application.

Decision criteria

Evaluation of the green supplier selection criteria starts with the determination of the convenient decision criteria. For this purpose, we accepted the criteria list of our previous study [12], and the green decision criteria evaluated in the current study. The main classical factors of supplier selection comprised 5 main criteria which can be integrated with green issues. Quality (c1), delivery (c5), service (c6), cost (c7) and strategic alliance (c8) represent these classical decision factors. Additionally the study considered three green criteria: pollution control (c2), environmental management (c3), and green products (c4).

Quality (c1) can be seen as one of the key criteria for meeting customer demands, and was accepted as the most important criterion to evaluate suppliers. The criterion comprises four sub-criteria, which are the quality assurance (c11), process improvement (c12), quality related certificates (c13), and quality management (c14).

The second criterion is pollution control (c2). Three sub-criteria are used to elaborate it in detail. The first sub-criterion is solid waste (c21), which refers to wastes disposed in solid form that are able to cause environmental pollution and need to be controlled according to the regulations [13]. The second sub-criterion is energy consumption (c22), which is considered because of the growing energy needs, although it can be expensive for companies. Hence programs relevant to the criterion implying proper usage of energy consumption should be promoted [14] to suppliers. The final criterion is the use of harmful material (c23), which needs to be avoided.

Environmental management (c3) is the third criterion that represents the standards and certifications. This criterion must be considered due to the high number of buyers expecting a good level of applying environment management systems from their suppliers [16]. This criterion has five sub-criteria, as follows;

The Energy Using Product (EUP) (c31) is an international guideline for regulating the environmental consequences of all energy using products. Its directives are to measure the effect of energy using products on the environment [26]. The International Organization for Standardization (ISO 14001) (c32) is a certification program. Its necessities are based on the identification of “environmental aspects” in firms. Ozone Depleting Chemicals (ODC) (c33) are substances which are responsible for the depletion of the ozone layer by human-made chemicals [18]. The restriction of hazardous substance (RoHS) (c34) aims to reduce hazardous chemicals and stop the generation of toxins and harmful materials caused by electronic devices. Waste electrical electronic equipment (WEEE) (c35) aims to conserve the environment and restrict electronic wastes. It also aims to raise the awareness of customers, manufacturers and suppliers to wastes [19].

Green product (c4), which is an unusual agent to be applied [19] in the supplier selection criteria, is accepted as the fourth criterion with four sub-criteria. The first is green packaging (c41), which protects nature by using environmentally friendly subgradients. The second is recycling (c42), which reflects the recycling capabilities of the candidate suppliers. The third is remanufacturing (c43), which represents a large quantity of products restored to a new state, and the forth is reusing the (c44) capabilities of suppliers.

Delivery (c5) is accepted as the fifth main criterion with three sub-criteria. The first is the order frequency (c51), which expresses the intensity of the business connection between the buyer and supplier. The second, the success of the order fulfillment rate (c52), which represents the supplier’s capability to respond to demand, is seen as adequate for order deliveries due to the service level needs of customers. Finally the lead time (c53), which is formed with the delivery time and set-up time [20], is accepted as important for supplier selection.

The sixth criteria is the service (c6). The service level is one of the most crucial parts of service-based industries due to the expectations of customers. Thus responsiveness (c61), stock management (c62), and design capability (c63) were considered the under service criterion. To meet the expectations, these three criteria are important for directly improving the service parameter. A firm needs to be more responsive to the demands of customers in a rapidly changing decision environment [21] and also needs to build a good stock management system to fulfill the orders of customers under uncertain market conditions. Additionally suppliers should be able to design better distribution channels to provide services.

In the classical supplier selection approaches, cost is usually the primary evaluation factor. The cost (c7) parameter includes purchasing, transportation, inventory, operation, maintenance, energy, inspection, delivery, security, ordering, and holding, among others. Costs can be expanded or subdivided into many other others [22]. Within the study, the cost criterion is divided into three sub-criteria, which are compliance with buying friendly materials (c71) in terms of costs, sectoral pricing strategy (c72), price/performance value (c73), and transportation costs (c74). The first cost criterion is buying friendly materials to reduce costs in order to eliminate discordance with buyers’ processes. The second

Table 2. Determinants of the green supplier selection concept [13].

Criteria	Quality - c1	Pollution Control - c2	Environmental Management - c3	Green Product - c4	Delivery - c5	Service - c6	Cost - c7	Strategic Alliance - c8
Sub-Criteria	Quality Assurance c11	Solid wastes c21	EUP c31	Green Packaging c41	Order Frequency c51	Responsiveness c61	Buying Friendly Materials c71	Willingness to Information Sharing c81
	Process Improvement c12	Energy consumption c22	ISO14001 c32	Recycle c42	Order Fulfillment Rate c52	Stock management c62	Compliance with Sectoral Pricing Strategy c72	Capability of Sharing Benefits & Risks c82
	Quality related certificates c13	Use of harmful material c23	ODC c33	Remanufacturing c43	Lead time c53	Design Capability c63	Price/Performance Value c73	Capability of Understanding Ultimate Aims and Business Processes c83
	Quality management c14		RoHS c34	Reuse c44			Transportation Cost c74	Capability of Building Long-Term Relationships c84
			WEE c35					To Share Culture and Business Policies Ultimately c85

sub-criterion is compliance with sectoral pricing strategy, which supports a harmonized cost management system for both suppliers and companies. The third, one of the est known cost analyses based on comparison with supplier performance, is the price performance value [23], which is an accepted measure used to evaluate suppliers. The final cost parameter is then accepted as transportation costs, which is important for textile companies due to the high frequency of deliveries.

Strategic alliance (c8) is the last main criterion in the criteria set, which represents the important short and long-term connections with suppliers. The aim of the criterion is to establish an indispensable and beneficial relationship between suppliers and firms to support their competitiveness and decrease the cost parameter as well as the complexities of several processes. To meet these objectives, the main-criterion is separated into five sub-criteria, specifically the willingness to share information (c81), the capability to share benefits & risks (c82), the capability to understand ultimate aims and business processes (c83), the capability to build long-term relationships (c84), and the ability to ultimately share culture and business policies (c85).

Application

The main goal of the study was to determine the priority of the decision criteria that affect the supplier selection decision the in textile industry, and to determine whether the green criteria really matters. Thus the research is structured to answer that question.

In the first step of the research, decision criteria are determined. In this step, the research group's previous study [12] was accepted as the starting point. Then, in this study, the evolutions were made to extend the previous research and also existing literature. The decision criteria table created is illustrated in ***Table 2*** under a hierarchical approach. In this table, 8 main criteria comprise 31 sub-criteria.

In the evaluation phase of the decision criteria, Turkey was selected as the study area. The reasons for this selection is its share of the textile industry in the total export and its crucial effect on the economy. Additionally Turkey is an emerging market, and the results are likely to be applicable to the emerging markets.

After determining the study area, an evaluation phase should be undertaken with experts who have enough knowledge and/or experience of the problem considered. The evaluations were made with twenty-six experts, selected carefully from textile manufacturing companies located in the study area. Turkey is a textile producing country, offering a wide range products that spread within the textile supply chain, from the initial process of cotton and other organic and nonorganic raw materials to end products, and distributing them on the domestic or international market. To represent the entire industry rather than solely one part of the industry, such as a fast-fashion producing company, the experts will be selected from various kinds of manufacturing companies. Thus we will pay special attention to sampling in order to represent all stages of the textile supply chain equally. The experts are general managers or relevant department heads of their companies. Thus their judgments represent experiences of manufacturing, international trade, and transportation departments of the textile industry.

As the next step of the determination of the experts, the research group's members supervized the application of a questionnaire to clarify any misunderstandings in the comparisons and ensure consistency in the answers. In this process, the research problem was explained first and the solution approach given. Subsequently the comparisons were conducted with personal interviews. This process was repeated for each expert, and it took one hour on average to complete the evaluations. The opinions of the experts were represented on a linguistic scale and the equivalents of these judgments were converted to fuzzy numbers after the interviews. The conversions were made based on the scale in ***Table 1***.

The linguistic evaluations collected were converted to fuzzy values. Then Buckley's *f*-AHP analysis methodology was applied in the study. The analysis was done in two steps. The first involved cluster comparisons followed by sub-criteria comparisons. The cluster's comparisons and fuzzy geometric means of the expert judgments are given in a

Table 3. *Cluster comparison.*

	c1	c2	c3	c4	c5	c6	c7	c8
c1	(1, 1, 1)	(1.293, 1.464, 1.665)	(1.064, 1.225, 1.4)	(1.269, 1.466, 1.664)	(0.607, 0.715, 0.84)	(0.736, 0.866, 1.0)	(0.439, 0.5, 0.577)	(0.772, 0.961, 1.219)
c2	(0.601, 0.683, 0.774)	(1, 1, 1)	(0.703, 0.815, 0.963)	(0.8, 0.964, 1.132)	(0.495, 0.58, 0.682)	(0.334, 0.397, 0.481)	(0.312, 0.365, 0.436)	(0.445, 0.557, 0.715)
c3	(0.714, 0.816, 0.94)	(1.039, 1.227, 1.423)	(1, 1, 1)	(0.512, 0.594, 0.692)	(0.455, 0.546, 0.662)	(0.399, 0.518, 0.651)	(0.399, 0.465, 0.565)	(0.622, 0.762, 0.956)
c4	(0.601, 0.682, 0.788)	(0.884, 1.038, 1.251)	(1.445, 1.684, 1.954)	(1, 1, 1)	(0.43, 0.513, 0.616)	(0.383, 0.466, 0.594)	(0.392, 0.466, 0.573)	(0.447, 0.581, 0.772)
c5	(1.19, 1.398, 1.647)	(1.467, 1.725, 2.021)	(1.511, 1.831, 2.198)	(1.624, 1.949, 2.325)	(1, 1, 1)	(0.988, 1.15, 1.318)	(0.716, 0.806, 0.925)	(1.125, 1.357, 1.603)
c6	(0.994, 1.155, 1.359)	(2.078, 2.521, 2.996)	(1.537, 1.932, 2.358)	(1.682, 2.144, 2.609)	(0.759, 0.869, 1.012)	(1, 1, 1)	(0.565, 0.652, 0.788)	(1.213, 1.408, 1.617)
c7	(1.732, 2.001, 2.278)	(2.293, 2.737, 3.204)	(1.77, 2.152, 2.507)	(1.746, 2.145, 2.548)	(1.081, 1.241, 1.396)	(1.268, 1.533, 1.77)	(1, 1, 1)	(1.655, 1.991, 2.344)
c8	(0.821, 1.041, 1.294)	(1.398, 1.794, 2.249)	(1.046, 1.312, 1.608)	(1.295, 1.72, 2.235)	(0.624, 0.737, 0.889)	(0.618, 0.71, 0.824)	(0.427, 0.502, 0.604)	(1, 1, 1)

pairwise structure in ***Table 3***. ***Equation 1*** expresses the structure of the comparison table and ***Equation 2*** is used to calculate the geometric means.

For these calculations, ***Equations 1*** to ***7*** are used, and the priorities given in the ***Table 4***. ***Table 4*** shows the local and overall values calculated. Local values give the fuzzy numbers and crisp values. The overall values are gathered by multipliying the local values and main criteria values.

The methodology stated was used to finalise the calculation of the priorities of the decision criteria. The results show that each decision criteria has different priorities. Based on the results, the priority orders include cost, delivery, service, strategic alliance, quality, green products, environmental management, and pollution control.

Discussion

In accordance with the improvements and changes in the business environment to be sustained in any industry within a long-term perspective, green issues should be considered. The green marketing concept and green demands of customers force companies to consider green issues. However, many previous studies showed that green parameters are not the most popular criteria in supplier selection. This study proposed a new criteria list that integrates frequently used parameters with green criteria. The criteria list includes tactical parameters, such as delivery and quality, along with strategic parameters, such as strategic alliance.

In this study, in addition to the criteria list proposed, evaluations are made to measure the effects of these criteria on the supplier selection decision. The results showed that each decision criteria influence the supplier's decision at different levels. In the previous section, it was stated that the decision criteria are made based on classical and green criteria. According to the results of the current study, the classical criteria are more important compared to the green in Turkey, as an emerging market. The most important criterion is the cost parameter. Delivery, service, strategic alliance and quality criteria, followed by the cost parameter based on the weight value in sequence. The total weight of the classical criteria was 0.756, which can be interpreted as classical criteria, still being of approximately 75% importance in supplier selection decisions.

Green parameters have a 25% influence on the supplier selection decision, which cannot be ignored by any private company that wants to survive in a highly competitive business environment. On the other hand, the results show a precise output for the parameters considered. Additionally the priorities calculated can be used in future studies, which are to be confirmed. In a recent study, Deshmuck and Vasudevan [24] suggested a green criteria list without quantitative application which identifies the importance of those criteria. Another study found that green criteria is not substantially important within supplier selection criteria in emerging markets [7]. However, Büyüközkan [5] indicated that green criteria emerged as the most important in her study performed in Turkey. These findings show a lack of consensus in the literature about green supplier selection criteria. Subsequently the criteria list and calculated priorities identified in our study also contribute to the literature.

Lastly the findings not only contribute to academic literature, but also show the importance of green parameters from private firms' point of view. For the reasons stated, companies should evolve their evaluation process to reach a better structure. The criteria list is convenient for the case study considered, but it should be customised for new studies. In the case of any updates, a group of experts should discuss the new criteria before finalising them.

Conclusions

This paper considered the green supplier selection problem and discussed a novel comprehensive evaluation structure in an emerging market. The study focused on prioritization and measuring of the effects of the parameters that have an influence on the supplier selection process, which is a crucial part of supply chain management systems, particularly by considering green criteria. The results showed that each decision criteria has effect on decisions with different weights. Based on the results, the classical decision criteria carried a large portion of the total weights. Additionally the green criteria showed significant importance that cannot be ignored by any firm. However, these criteria were not one of the most important factors within supplier selection criteria, as was expected. Thus it can be said that an integrated evaluation process is beneficial for any company to achieve success in its processes.

Despite its application to the textile industry, the structure proposed is a novel approach for supplier selection in manufacturing industries and contributes to the existing literature. Thus professionals and researchers should integrate green and classical decision criteria in their evaluations. Disregarding any of these criteria may misrepresent the exact decision environment and harm the company in the end.

A green criteria list was developed and integrated into our supplier selection criteria by considering the government regulations and customers' environmental sensitivity. Of course, the list might vary according to the buying company's environmental policy.

In this context, with the rising importance of environmental issues today, decision-makers need to consider a trade-off between conflicting traditional cost-based and green-focused approaches. By considering customers' growing resistance to emerging profit-oriented goods which ignore environmental issues, firms should use such the criteria list, including green issues, and modify them according to their business environment.

Table 4. *Local, total and overall values of criteria and sub-criteria for green supplier selection*

Criteria	Local		Overall
	Fuzzy value	Crisp value	Crisp values
Quality	(0.847, 0.97, 1.11)	-	**0.114**
Process improvement	(0.647, 0.745, 0.873)	0.241	0.050
Quality assurance	(1.014, 1.155, 1.308)	0.254	0.052
Quality management	(1.16, 1.326, 1.513)	0.258	0.053
Quality related certificates	(0.757, 0.876, 1.005)	0.245	0.050
Pollution control	(0.545, 0.631, 0.736)	-	**0.075**
Solid waste	(0.309, 0.39, 0.495)	0.390	0.061
Energy consumption	(0.189, 0.238, 0.3)	0.237	0.037
Harmful material	(0.294, 0.373, 0.468)	0.371	0.059
Environmental management	(0.601, 0.703, 0.825)	-	**0.083**
Eup	(0.152, 0.198, 0.259)	0.198	0.022
Iso 14001	(0.203, 0.268, 0.349)	0.267	0.030
Odc	(0.138, 0.18, 0.235)	0.180	0.020
Rohs	(0.132, 0.17, 0.223)	0.170	0.019
Weee	(0.141, 0.184, 0.238)	0.183	0.021
Green product	(0.621, 0.726, 0.864)	-	**0.086**
Green packaging	(0.163, 0.21, 0.273)	0.210	0.033
Recycling	(0.219, 0.276, 0.346)	0.275	0.043
Remanufacturing	(0.174, 0.223, 0.283)	0.222	0.035
Reuse	(0.23, 0.291, 0.371)	0.291	0.045
Delivery	(1.166, 1.347, 1.549)	-	**0.159**
Order frequency	(0.182, 0.226, 0.279)	0.224	0.027
Order fulfillment rate	(0.299, 0.37, 0.458)	0.369	0.044
Lead time	(0.331, 0.404, 0.495)	0.403	0.049
Service	(1.136, 1.327, 1.544)	-	**0.156**
Design capability	(0.184, 0.229, 0.314)	0.234	0.017
Responsiveness	(0.249, 0.329, 0.423)	0.326	0.024
Stock management	(0.332, 0.442, 0.57)	0.438	0.032
Cost	(1.516, 1.769, 2.013)	-	**0.207**
- Sectoral pricing strategy	(0.159, 0.217, 0.3)	0.218	0.018
- Compliance with sectoral Pricing strategy	(0.165, 0.226, 0.309)	0.225	0.019
- Price/performance value	(0.212, 0.29, 0.391)	0.288	0.024
- Transportation cost	(0.194, 0.266, 0.37)	0.267	0.023
Strategic alliance	(0.843, 1.013, 1.211)	-	**0.12**
- Capability of sharing Benefits & risks	(0.518, 0.6, 0.71)	0.115	0.009
- Share of culture and business Policies ultimately	(0.728, 0.848, 0.978)	0.161	0.013
- Willingness to information Sharing	(1.129, 1.333, 1.556)	0.254	0.021
- Capability of understanding Ultimate aims and business Processes	(0.957, 1.142, 1.362)	0.219	0.018
- Capability of building Long-term relationships	(1.077, 1.29, 1.549)	0.248	0.020

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