

Criteria Definition in Green Supplier Selection for Moroccan building material industry

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Abstract. Purchasing management and supplier selection, an important function in the supply chain management, play a significant role in the finished product quality. Since the supplier contributes to the business development and brand image of the company, identifying the most appropriate one is a critical and challenging decision. This decision depends on several factors that need to be carefully identified and clearly defined. They should not be standard or common to all supplier selection problems but rather adapted to the specific case under study. The choice of the selection criteria is affected by different parameters such as the industry studied, the type of production and the requirements of the managers. The aim of this study is to provide decision makers with the most relevant selection criteria to consider when evaluating green suppliers in building materials industry. To achieve this goal, we first conducted a thorough and detailed review of published literature on green supplier selection issues in order to extract the various criteria and sub-criteria recommended by authors. This list was then narrowed down to the most relevant criteria after analyzing the questionnaire results with experts. Finally, a list of criteria for green supplier selection is proposed along with their definitions.

Key words: Green supplier selection, criteria definition, selection criteria, building materials industry

1 Introduction

In a supply chain management context, the relationship with suppliers goes beyond the simple professional relationship. It is a partnership based on common interests [1]. By valuing the supplier and supporting its development, the company demonstrates its trust and its willingness to collaborate with it in the long term. Currently in a competitive environment and faced with an exigent and conscious customer of the environmental impact of the products he is using. Managers are trying to improve their Supply Chain Management SCM and adopt green practices in order to succeed in the transition to a more environmentally friendly supply chain. The new concept of Green Supply Chain Management GSCM appeared first in 1990, There are several definitions of GSCM in the literature. Among the first works that defined GSCM are researchers Wu, H. and Dunn, S.C [2] who mentioned that green logistics is a concept that aims to reduce environmental pollution, eliminate waste and save resource consumption and is not limited to reverse logistics [2]. In 2006, [3] defined GSCM as a set of environmental practices that encourage the improvement of environmental practices of two or more organizations within a single supply chain. The most popular and widely used definition in the literature comes from Srivastava [4], who defines

GSCM as "the integration of environmental awareness into the various functions of the SCM. Since the purchasing and procurement management is a primary function in the SCM it is also strongly concerned with the integration of green practices. The problem of supplier selection is a well-known problem in the literature and has been addressed by researchers from different angles. Determining the most suitable supplier is a critical strategic decision as the supplier contributes directly and indirectly to the economic development and the brand image of the company. The selection of suppliers depends on several factors and in order to maximize the chances to collaborate with the ideal and most suitable supplier these selection factors must be carefully identified and clearly defined. The researchers presented a large number of criteria of which the identification and definition is of great importance. A bad understanding or a wrong criteria choice can bias the results of the selection model. This work focuses on identifying and defining the most relevant selection criteria for green supplier selection.

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2 Literature review

2.1 Green supplier selection

Finding the best supplier is a complex decision relying on several criteria both qualitative and quantitative. In order to facilitate the process and help decision makers making the right choice, researchers are developing mathematical models using different methods and techniques namely Multi-criteria decision making (MCDM) methods, Mathematical Programming (MP) and Artificial Intelligence Technology (AIT) [5]. It is a classical problem that has been covered largely by researchers. Previously, the choice of suppliers was made instinctively, with the decision-maker relying mainly on the classic criteria (cost, quality and delivery time) or on his own preferences. Faced with an increasingly demanding customer and heightened environmental awareness, the decision-maker is forced to reconsider his purchasing strategies and opt for new selection models that integrate the environmental aspect. Indeed, as emphasized by [6], from now on it is not recommended to ignore the environmental aspects if the company intends to continue existing and growing in the future international market [6]. According to our bibliography, the works dealing with the problem of supplier selection are multiple. The first published works date back to the 1960s. [7] was one of the first academics to look at the issue of supplier selection. He reviewed a list of 23 criteria that academics used in their studies. In the early 1990s, the environmental aspect of supplier selection became increasingly important. However, when it comes to changing existing strategies and adopting new practices, it is important to note that it is not easy for a company to accomplish this. Researchers recognize these challenges. [8] demonstrated the difficulty of implementing environmental criteria in the supplier selection process and its economic impact.

2.2 Criteria selection

The supplier selection issue is a question that is widely covered in the literature, whereas the works on green supplier selection are limited and only emerged after the 1990's. Based on the literature review, green supplier selection studies are classified into two categories: those considering both traditional and ecological criteria and those focusing only on environmental criteria when evaluating green suppliers [5,6,9,10]. [11] noted the importance of combining traditional and ecological criteria to develop an effective and relevant green supplier selection model. Now, finding the most suitable green partner is a challenging decision that is based on several factors. Those factors need to be well defined and understood [7] is among the first authors to analyse selection criteria in vendor evaluation. He presented a list of the most relevant factors where 23 criteria are ranked by degree of importance. In 1991 [12] reorganized this list according to the frequency of citations in published papers from 1966 to 1990 and found that quality, cost, capacity and delivery time are

considered as the most essential criteria. Later in 2010 [13] HO conducted a literature review on supplier selection work with a focus on identifying the most popular approaches and pertinent evaluation criteria. This research concluded that quality is the most relevant criteria, followed by delivery, price/cost, manufacturing capability, service, management, and technology. Regarding green criteria, [14] classified environmental criteria into two categories: quantitative environmental criteria and qualitative environmental criteria. These latter have only emerged in the last decade and are becoming more prominent in the green supplier selection process. Despite their unquestionable importance, they are making the decision making process more complex. [15]. In 2013, a review of the main studies in the field of green supplier selection is conducted by [15], who analysed research published from 1997 to 2011 related to this subject and found that the most common green criterion is environmental management systems (EMS). Lee [6], when evaluating green supplier's performance, he based his model on the following green criteria as the most suitable ones: Technology Capability, pollution control, EMS, green product and green competencies. In two thorough review papers, authors [15] and [16] gathered the existing green criteria in the published literature related to the selection of green suppliers. The result of these two studies is presented in table 1 where the ecological criteria are classified according to their use frequency.

Table 1. Frequency of the most important green criteria.

	Govi ndan et al	Nielsen et al
Duration	1996- 2011	1996- 2014
Number of reviewed papers	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

3 Methodology

The criteria selection process follows the following steps:

Step 1: Review of the existing literature.

Researchers have shown that for best results GSS model should consider both green and traditional criteria [15]. We started by gathering the different works published in last two decades in international scientific journals. In

our research we focused first on works dealing with supplier selection problems in general in order to collect conventional or economic selection criteria. We used the following keywords: supplier selection supplier evaluation vendor selection. Then we directed the literature search towards ecological supplier selection problems in order to collect ecological selection criteria using the following keywords: GSCM GSS Green supplier evaluation. After a detailed and thorough review of the literature, we identified a list of 54 general criteria and 36 green criteria.

Step 2: Selection of the most important criteria and sub-criteria

In order to exploit the findings of the literature search and to identify the most relevant selection criteria that best meet the needs of the building materials sector, we opted for a questionnaire-based investigation involving a group of experts. The first task is to form the expert team. Our group is composed of six experts that includes both professionals and academics with more than 15 years of experience in the field of Moroccan building material manufacturing. To determine the most relevant criteria that best fit the characteristics of the sector, questionnaires were distributed to the experts to evaluate the criteria and only those with the highest scores were retained. The questionnaire is based on Likert scale to represent importance of each criterion. After various meetings where we discussed the results of the survey. We were able to narrow down the list of selection criteria and sub-criteria and keep only the most relevant ones.

Table 2. Snapshot of the ranking of most important green supplier selection criteria.

criteria	Ranking
Cost	4
Quality	1
Delivery	2
Service	7
Technology capability	9
flexibility	8
Design for environment	12
Environmental management system	3
Green image	8
Green product	6
Green technology innovation	11
Green purchasing	13
Pollution control	5
Environmental Performance	10

4 Criteria definition

Cost is a very important criterion in supplier selection as it allows the company to maximize its profit margin. This criterion is considered as the basis for the evaluating suppliers, it must be considered seriously so that it does not compromise the quality. Several researchers in the literature have considered this criterion as the main criterion [17, 18]. Cost reduction capability is the company's ability to be flexible in its pricing and to respond favourably to price negotiations and discussions. purchasing price represents the gross unit price set by the supplier. This criterion allows the selection of the supplier with the lowest price without compromising the product quality.

Quality Among the most important disciplines of management is Quality Management QM, a concept that emerged after the industrial revolution with Walter A. Shewhart in 1924. QM corresponds to the different activities aiming to satisfy the customers' expectations. There are several measurable quality criteria that facilitate the evaluation of the supplier's quality such as Reject rate which refers to the percentage of supplied materials that are rejected by the quality control. The disposal of quality systems is an important factor as it reflects the degree of importance given by the supplier to quality management [21]. Through compliance with the requirements of standards and regulations, such as ISO 9000 and QS 9000. [22].

Delivery can be defined as the ability of each supplier to meet specified delivery schedules. [7] has emphasized the importance of this criterion and has considered the ability to meet quality standards and delivery times as the most critical factors in supplier selection decisions. Various indicators can be used to evaluate this selection criterion, such as order fill rate, which reflects compliance with specified order quantities, lead time, which is the time elapsed between the release and arrival of an order, order frequency [9], returns management, the availability of the product, which means the company's ability to meet the future order based on the stocks it has and the delivery of products in good condition (Wisner, Tan, & Leong, 2009).

EMS is typically considered a main criterion, with sub-criteria such as environmental policies, environmental planning, and ISO14001 certification it is a primary factor in identifying environmentally friendly suppliers. [15] For suppliers who claim to be environmentally friendly, the main concrete measure is the award of at least one environmental certificate or label such as ISO14000, Ecolabel and Carbon Footprint Label, etc. [17]. The most important criterion allowing to gain customers' trust is the international standards one criterion allowing to gain customers' trust is the international standards. In this case, no detour is possible, the most well-known standard (ISO 9001) specifies the need to control and manage the purchasing process.

Pollution control Industrial activity is a major contributor to the degradation of the environment. It releases many wastes in different forms; from solid wastes to gaseous emissions. These polluting wastes are

very dangerous and must be controlled and disposed of properly from the nature. authors [6,20] has presented this criterion as the initiatives taken by the supplier in pollution reduction related to air emissions, wastewater disposal and solid waste control and treatment, as well as control of extensive and intensive use of materials and energy. Controlling the production of pollution therefore means controlling various factors such as controlling energy consumption, controlling the amount of hazardous emissions, such as SO₂, NH₃, CO and HC1, and controlling the amount and treatment of wastewater and solid waste.

Green product: Green product is Factors that demonstrate the supplier's effort in implementing green solutions for its products. Several sub-criteria can illustrate this capability, such as recycling and green packaging. The capacity to treat used items or their accessories, reprocess the materials, and replace the needed fresh materials for making new products is referred to as recycling [21]. Green packaging is a form of packaging that uses environmentally friendly materials to safeguard the environment. Its key quality is that it dissolves or disappears quickly in nature without causing any harm.

5 Discussion

The literature contains a variety of selection criteria. After a review of the literature we came up with a list of 54 general criteria and 36 green criteria. So far there is no consensus on the decision criteria regarding Green Supplier selection [19]. The criteria are multiple but how to choose the most suitable one. In order to answer this question, we turned to the expert's opinion. The results of our survey ranked the following criteria as the most relevant selection criteria that meet the characteristics of the building materials manufacturing sector. As shown in table 2 quality is the most significant criteria followed by delivery, EMS and cost. Construction materials are the main foundation of a good building. They are intended to last for a long time, so high quality products are essential to avoid any possible accidents. The quality criterion is considered as the most important criterion in the building materials sector, no compromise or indulgence is tolerated in the quality of the raw material products or components. This sector is among the most energy-intensive sectors. In case of combustible energy supply difficulties, the company risks a production stoppage causing a huge loss in terms of costs. Decision makers insist on the supplier's ability to meet deadlines. EMS is considered by researchers as the most important criterion [15,16]. For suppliers who claim to be environmentally friendly, the most important concrete measure is the award of at least one environmental certificate or label. [16] Regarding general criteria our findings are consistent with the results obtained by researchers [12,13] who both concluded that quality and delivery are the most important general criteria when evaluating suppliers. [23] conducted a study to identify the most relevant selection criteria across different industries. Our results are consistent with his work where he found that for the

building materials sector product quality is considered as the most important selection criteria followed by delivery and price. Regarding the green criteria our findings are also consistent with the outcomes of [15,16] which identified EMS as the most important green criteria.

6 Conclusion

The environmental consequences of rapid industrialization have been illustrated by the countless incidents in which soil, air and water resources have been contaminated by toxic materials and other pollutants. Being aware of this threat, business leaders are working harder to control and limit the environmental impact of their companies' activities. Researchers are now increasingly interested in Green Supplier Selection (GSS) to assist companies in evaluating suppliers and finding the best partner that will maintain a beneficial long-term relationship and meet the company's environmental vision and goals. GSS relies on several factors. Identifying the selection criteria is a decisive step in designing the Supplier Selection problem. This paper presents the most important selection criteria that should be considered when evaluating green suppliers. It also provides a definition of each criterion for a better understanding and to avoid confusion and ambiguity. This paper proposes 6 criteria: cost, quality, delivery, EMS, pollution control and green product. Regarding the limitations of this work, this study has been carried out in a Moroccan context and is focused on the building materials sector, future studies can be carried out in different countries in order to present different results and enrich the literature.

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