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Supplier Selection Problem: Methodology Literature Review

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ABSTRACT

Supplier selection and evaluation has attracted serious research attention at both the academic and the practitioner levels. In this paper, an attempt is made to review the status of methodology literature in supplier selection. A total of 154 papers from 68 refereed journals were selected and reviewed. This paper provides insights to the literature by considering the breakdown of journals that have published research in this area, by classifying the literature into various categories and considering the various methods/techniques suggested in the literature. Based on the review, avenues for further research are also discussed.

INTRODUCTION

Suppliers have always been an integral component of a company's management policy; however the relationship between a company and its suppliers has traditionally been a distant one. When a supplier selection (SS) decision needs to be made, the buyer generally establishes a set of evaluation criteria that can be used to compare potential sources. The basic criteria typically utilized for this purpose are pricing structure, delivery (lead-time and reliability), product quality, and service (i.e., personnel, facilities, research and development, capability, etc.). Frequently, these evaluation criteria conflict with one another. In addition, the importance of each criterion varies from one purchase to the next. This situation can be complicated further by the fact that some of the criteria are primarily quantitative (price, quality, etc.) and some are qualitative (service, etc.). The literature on supplier selection spans over three decades and covers virtually all the aspects of business. Researchers have long sought to understand and model the relationships between suppliers and buyers. In this paper, the author concentrates on methodology literature and the review covers the period 1986 through the present. Traditionally this field of study has been a subject matter of purchasing or supply chain management literature, however with recent developments and interest in e-Procurement, and related fields, this paper provides the audience of this journal with some background to this area of research, that is being impacted upon by information systems and technologies (including the internet) and provides a rich source of research avenues.

The objective of this study is to provide a review of supplier selection methodology literature. Based on this review avenues of further research are to be identified, including areas of interest in the information systems/technology field. The study includes 154 articles from 68 reputed refereed Journals. More specifically, the purpose of this study is to:

- Classify supplier selection research articles according to their approach and methodologies; and provide a brief overview of these methods/techniques,
- Classify the journals that actively publish SS literature,
- Consider the frequency of literature by year of publication,
- The paper also provides a brief overview of some of the salient methods that exist in literature to tackle the SS problem,
- And suggest a research agenda for future work, with special emphasis on the impact of Information systems on the supplier issue.

The paper is organized as follows: Section 2 provides a methodology of literature review, section 3 presents that classification of literature along several aspects, section 4 looks are various methods advanced to solve the supplier selection problem, and section 5 delineates avenues of further research and provides concluding remarks.

METHODOLOGY OF LITERATURE REVIEW

Extensive literature exists in the field of supplier selection. The author focused on literature for the period 1986-2002. Several excellent papers exist that have focused on reviewing earlier research such as Weber (1991). A survey of literature was carried out based on the editorial scope and contents of the journals and a list of journals was compiled. Journals stating in their editorial scope issues such as purchasing, inventory management, and supply chain management were selected. A comprehensive review of the table of content of the journals, abstracts, and where possible review of the complete paper was carried out. The literature review was augmented by use of online computerized search engines including (ScienceDirect, ABIINFORM, INFOTRAC) using keywords such as supplier selection, vendor selection, modeling, techniques, mathematical modeling, etc. in addition to this search, articles were also included after scanning the reference sections of the initially selected papers. The ultimate list of articles reviewed by this paper covers articles published in reputed refereed scholarly journals. Based on this review, articles that met the criteria of addressing issues related to the supplier selection problem and presented a model or framework were selected.

CLASSIFICATION OF LITERATURE

Frequency of Articles in Journals

Based on the criterion of number of articles published, the journals were categorized as high, medium or low contributors to the supplier selection research. Table 1 presents the outcome of the survey.

As can be seen from Table 1, journals were segmented on the basis of number of articles published. Based on the literature review, International Journal of Purchasing & Material Management, International Journal of Physical Distribution & Logistics Management, and Journal of Business Research have published at least ten articles on SS. journals publishing six or more articles account for approximately 42 percent of the articles. Journals classified as medium contributors published around 19 percent of the articles. It was surprising to the author that nearly 39 percent of the articles on SS were published in journals that published two or less than

two articles on the subject. Approximately 22 percent of the articles appeared in journals that published only one article in the period under review.

Journal Outlets of Selected Articlesⁱ	# of Papers	Percentage
High Contributors		42.13
International Journal of Purchasing and Materials Management	13	8.18
International journal of Physical Distribution and Logistics Management	10	6.29
Journal of Business Research	10	6.29
Purchasing	9	5.66
The journal of Supply Chain Management - A Global Review of Purchasing and Supply	7	4.40
International Journal of Production Economics	6	3.77
Journal of Purchasing and Materials Management	6	3.77
Supply Chain Management: An International Journal	6	3.77
Medium Contributors		18.90
European Journal of Operational Research	4	2.52
International Journal of Operations & Production Management	4	2.52
Production & Inventory Management Journal	4	2.52
European Journal of Purchasing & Supply Management	3	1.89
International Journal of Retail & Distribution Management	3	1.89
Journal of Operations Management	3	1.89
Logistics Focus	3	1.89
Supply Management	3	1.89
Low Contributors		38.97
Decision Sciences	2	1.26
Industrial Marketing Management	2	1.26
Integrated Manufacturing Systems	2	1.26
International Journal of Logistics Management	2	1.26
International Journal of Physical Distribution & Materials Management	2	1.26
Journal of Accounting and Public Policy	2	1.26
Journal of Cost Management	2	1.26
Journal of Supply Chain Management	2	1.26
Long Range Planning	2	1.26
Management Science	2	1.26
Production & Inventory Management Review & Apics News	2	1.26
Purchasing & Supply Management	2	1.26
British Journal of Management	2	1.26
International Journal of Physical & Logistics management	1	0.63
Logistics Information Management	1	0.63
Logistics Management & Distribution Report	1	0.63
Production & Operations Management	1	0.63
Others ⁱ	35	20.07

Table 1: Frequency of Supplier Selection in Journals

Classification of Articles by Content

The literature was classified into seven broad categories based upon the content of the articles as shown in figure 1. It maybe noted that the articles considered have to do primarily with SS and not necessarily other aspects of purchasing and supply chain management. The classification schema used is based on earlier work by researcher including Weber (1991) and Ellram (1993) with some modifications.

In the vast majority of literature the issues of supplier selection and evaluation has been dealt with synonymously. The author acknowledges that there is a conceptual difference between selection and evaluation of suppliers and this distinction is depicted in Figure 1. However the

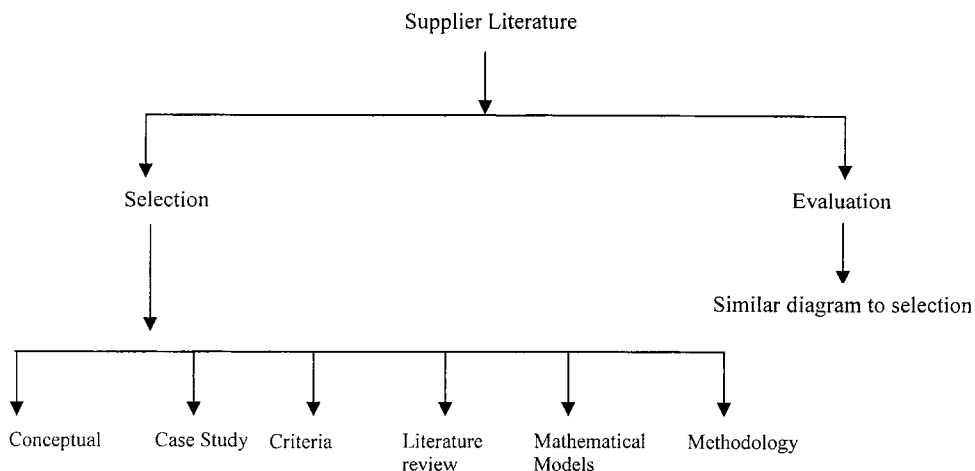


Figure 1: Classification Schema

author in this paper has chosen to concentrate on the selection issue.

- Conceptual articles: these included articles that dealt with the SS process and provide a logical or conceptual approach to selection of suppliers.
- Case studies: includes articles that provide detailed applications of SS methodologies as they are used in companies or countries/regions.
- Criteria papers: papers that include studies on criteria used to select or evaluate suppliers. Some of these papers are based on surveys, while others are theoretical.
- Literature review: articles that review the SS literature.
- Mathematical modeling: includes papers that use mathematical modeling techniques and other heuristics. These articles included specific numerical examples to apply the methods.

- Methodology papers: articles providing methods to solve SS problems. These articles provide a framework or specific approach to solve SS problems but do not necessarily show the application.
- Strategy papers: providing strategies to SS problems. Strategies are either on selecting suppliers or on eliminating uncertainties or threats in the SS domain.

	Count	Percent
Conceptual	56	36
Case Study	21	14
Criteria	16	10
Lit Review	2	1
Mathematical Models	27	18
Methodology	32	21

Table 2: Classification of the Articles

As can be seen from Table 2, a vast majority 56 of the 154 papers reviewed were Conceptual, accounting for 36 percent of the total. The Methodology and Mathematical Modeling categories accounted for 39 percent together. Several excellent case studies also exist in literature (21 papers) showing the practical aspects of these theoretical frameworks/models. This is also depicted in Figure 2.

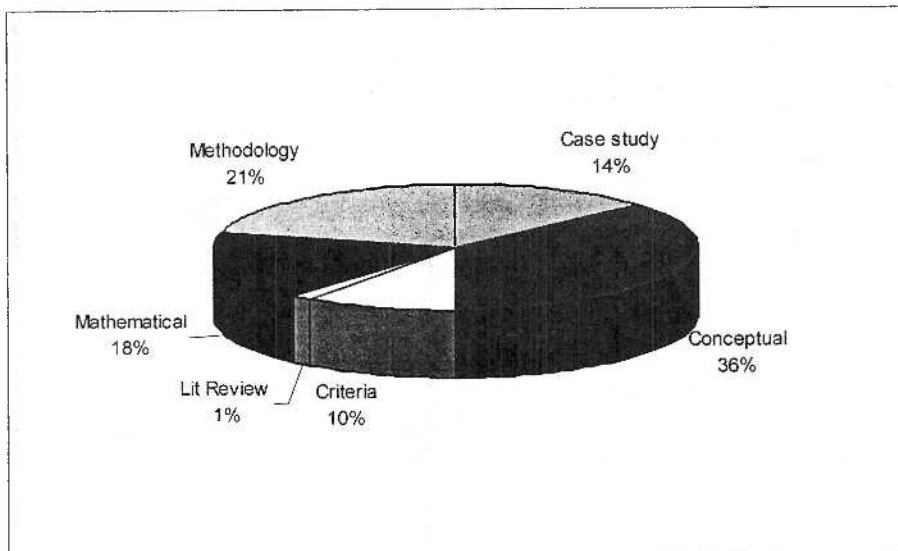


Figure 2: Classification by Content

Frequency of Articles

Articles were also analyzed to consider any relationship of SS articles over time. Figure 3 presents the publication history of these articles and as can be observed, methodological research was on the rise from the mid 1980s and peaked in 1998-1999 with 21 articles being published in each of these years. Following this peak the numbers have drastically fallen to around 5 in each of the subsequent years.

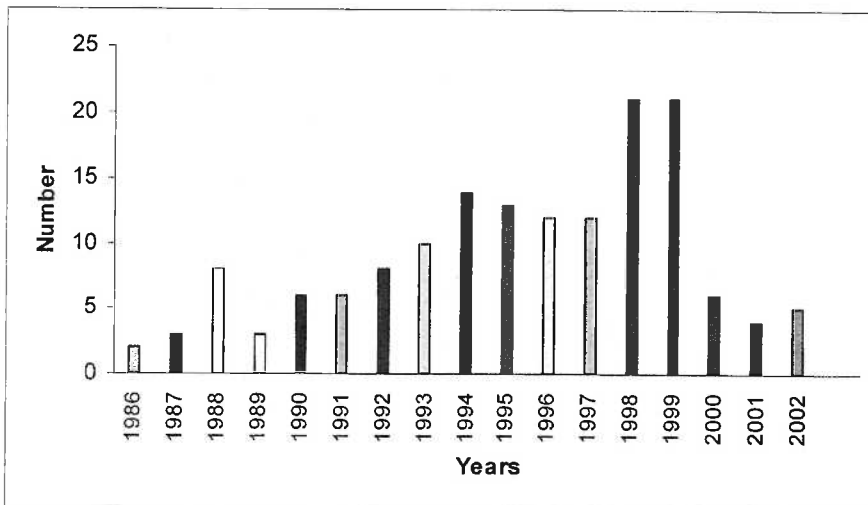


Figure 3: Frequency of Articles 1986-2002

METHODOLOGY PROFILE OF ARTICLES

The articles reviewed were categorized in six categories as shown in Table 2. Emphasis again is on papers that presented methods/frameworks of supplier selection rather than general strategy papers.

Existing Approaches in Supplier Selection

While most buyers still consider cost to be their primary concern, new more interactive and interdependent selection criteria are increasingly being used. A survey of supplier selection criteria yielded the following salient mathematical approaches to the supplier selection problem.

Figure 4 depicts the breakdown of the various approaches used to solve SS problems. Total Cost of Ownership accounts for around 33 percent of the total articles, followed by various Total Cost approaches (19 percent), Analytical Hierarchy Process approach (15 percent), and Multiple Attribute Utility Theory accounts for 7 percent of the modeling papers. Several other

variations of the above and other optimization methods account for the remaining 26 percent of the papers. Following is brief description of each of these approaches, followed by Table 3 that provides a brief overview of some of the approaches.

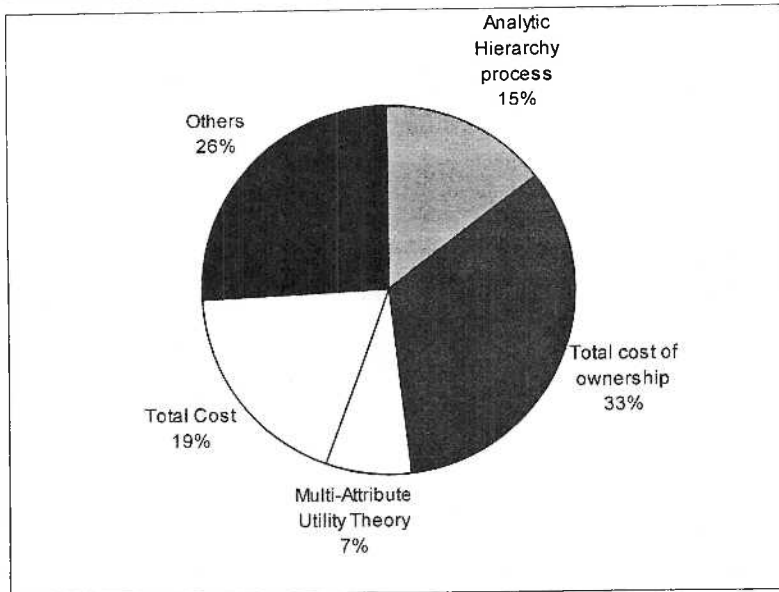


Figure 4: Mathematical Models Used

Total Cost Approach: Companies wanting to implement a total cost-based supplier selection process often stumble over how to include non-monetary issues such as delivery and quality performance, lead time, services, and social policies (Monckza, 1988; Porter, 1993). Unit Total Cost is the total cost to the purchaser per unit after inclusion of all relevant factors. Harding (1998) provides a detailed application of this approach.

Multiple Attribute Utility Theory: Multiple Attribute Utility Theory (MAUT) is especially appropriate in situations where there are a variety of uncontrollable and unpredictable factors affecting the decision as it is capable of handling multiple conflicting attributes inherent in international supplier selection,. It also enables the purchasing manager to evaluate 'what if' scenarios associated with changes in company policy (Bard, 1992; Von, 1993).

Multi-Objective Programming: This approach is especially suitable to just-in-time scenarios (Weber, 1993). The analysis occurs in a decision support system environment. A multi-objective programming decision support system allows for judgment in decision making while simultaneously trading off key supplier selection criteria. An additional flexibility of this model is that it allows a varying number of suppliers into the solution and provides suggested volume allocation by supplier.

Total Cost of Ownership: Total Cost of Ownership (TCO) is a methodology, which looks beyond the price of a purchase to include many other purchase-related costs. This approach has become increasingly important as organizations look for ways to better understand and manage their costs. (Ellram, 1995). TCO may include, in addition to the price paid, elements such as order placement costs, research costs, transportation costs, receiving, inspecting, holding and or disposal costs and so on. In their book (Handfield et al.,1999), explore the understanding of TCO using the product life-cycle approach. They note that the costs related to a product are

directly related to where the product is in its life cycle. Though there are other selection and evaluation approaches closely aligned with TCO such as life cycle costing (Ellram,1993), Zero-base pricing (Monckza,1988), and cost-based supplier performance evaluation (Handfield et al.,1999) among others. None of these approaches has received significant, widespread support in literature or in practice for a variety of reasons (Soukup,1987).

Analytic Hierarchy Process: The Analytic Hierarchy Process (AHP) provides a framework to cope with multiple criteria situations involving intuitive, rational, qualitative and quantitative aspects (Bhutta et al., 2002). The primary objectives affecting supplier selection criteria are grouped under three main categories: performance assessment, business structure capability assessment and quality system assessment.(Bard, 1992;) The AHP is used as a framework to formulize the evaluation of tradeoffs between the conflicting selection criteria associated with the various supplier offers. This is the main reason for selecting the AHP as the decision support model for solving the supplier selection problem, which involves many intangible factors, but still requires a logical and rational control of decisions (Nydick et al., 1992). Generally the hierarchy has three levels: the goal, the criteria and the alternatives. For the supplier selection problem, the goal is the best supplier, the criteria could be quality, on-time delivery, price, etc and the alternatives are the suppliers or proposals of the suppliers.

Data Envelopment Analysis: Recent work by authors such as Weber (1996) has shown the efficacy of using Data Envelopment Analysis (DEA) in Supplier selection problems especially when multiple conflicting criteria have to be considered. DEA identifies an 'efficient frontier' from the inputs and outputs to be evaluated creating Decision Making Units (DMU's) and then the efficiency of each of these DMUs are compared to the 'efficient frontier'. Identifying the most efficient DMU. This method can be applied to SS. An excellent example is shown in Weber (1996) and Sarkis et al.(2002).

Optimization Techniques: Several optimization techniques have been applied to SS. Among the more commonly applied techniques are Dynamic Programming (Masella,2000), Linear programming (Ghodsypour et al.,1998), and Multi-Objective Programming (Weber et al., 1993).

Technique	Proponents	Methodology	Applications
Analytic Hierarchy Process (AHP)	Saaty, Belton, Dyer, Bard, Bhutta, Nydick, Hill	AHP provides a framework to cope with multiple criteria situations involving intuitive, rational, qualitative and quantitative aspects.	Prioritizing Alternatives
Unit Total Cost	Harding, Porter, Monckza.	Unit Total Cost is the total cost to the purchaser per unit after inclusion of all relevant factors	Cost of product is less significant than other costs
Total Cost of Ownership (TCO)	Ellram, Carr, Cavinto, Porter, Bhutta	TCO is a methodology and philosophy, which looks beyond the price of a purchase to include many other purchase-related costs. This approach has become increasingly important as organizations look for ways to better understand and manage their costs	Cost of product is less significant than other costs
ABC costing Approach	Tyndall, Morris, Kaplan	Categorizing costs into ABC categories and then making a selection based on the criteria selected	When cost categories of parts is critical
Life Cycle Costing Approach	Jackson, Ostrom, Handfield, Pannesi	Looks at the cost of the product over its whole life	When periodic maintenance or replacement is needed and costs are high
Multi-Objective Programming	Weber, Ellram	The use of a multi-objective programming approach is generally used in the just-in-time scenarios. The analysis occurs in a decision support system environment	Where multiple conflicting criteria have to be considered in a JIT environment.
Multi-Attribute Utility Theory (MAUT)	Weber, Nitzsch	Use of MAUT, can help purchasing professionals to formulate viable sourcing strategies, as it is capable of handling multiple conflicting attributes inherent in international supplier selection	In situations of International supplier selection, where the environment is more complicated and risky.
Dynamic Programming	Masella, Rangone	By setting Input Variables as Control & Environmental variables, State Variables as the internal workings of the organization, and the Output variables as the performance achieved by the organization based on the selection of suppliers made.	Where output is a measured quantity. And discretization of variables can be achieved.
Data Envelopment Analysis (DEA)	Weber, Kleinsouza, Clarke, Kent	DEA is an optimization method of mathematical programming used to generalize single-input/single-output technical efficiency measure to the multiple-input/ multiple-output case by constructing a relative efficiency score as the ratio of a single virtual output to a single virtual input.	Where there are multiple inputs and outputs that make comparisons difficult

Table 3: Overview of Analytic Methods in Supplier Selection

AVENUES OF FURTHER RESEARCH

The review of literature leads the author to believe that there are still several avenues of research that need to be addressed. The following are some of the salient ones;

Impact of Information Technology: Literature does exist on EDI and other specific techniques but not on the use of the Internet which is much more wide spread, and based on conversations the author has had with purchasing managers, is increasingly providing sources of supply. Recently, literature has started discussing the issue of 'e-Procurement' E-procurement involves the company's use of the internet for procuring materials, quality control, financial transactions, transportation, warehousing, customs clearing, and documentation (Johnson et al., 2002). This field promises to yield efficiencies in procurement strategies on several levels. The author is currently engaged in one such endeavor, an empirical study into the impact of Information Technology and specifically the internet on procurement strategies for small and medium sized firms in the sugar and marine industry.

Information Systems in SS: Another salient avenue seems to be the systems involved in supplier selection and evaluation. Literature does identify role of systems such as EDI (Walton et al., 1997), however little exists (Bakos, 1993) in terms of other systems and how they can be incorporated.

Software Issues in SS: Another interesting subject for further investigation would be to look at the various software's (stand alone, bundled with EDI/ERP modules) used in the procurement process. Specifically in selecting suppliers and then maintaining working relationships. Trend analysis and economic benefits in this area would be of particular interest to small and medium sized companies, helping in software justification issues.

Intra-Industry and Inter-Industry Research on SS methods: Literature seems to be quite on this question, with no evidence of research on Intra-industry or Inter-industry work. Practitioner magazines do provide some insight to these areas but the academic literature has not focused on this issue.

Global Issues: Globalization has lead to intense competition and purchasing is no longer restricted to one or a few countries in a region but has truly become global. It would be interesting to compare the purchasing practices across countries or regions.

Effect of Green policies on SS: Companies are under increasing pressure from various stakeholders to become "environmentally friendly". This provides another area of research that remains untapped. Few studies include "green" issues as primary reasons for supplier selection and evaluation.

Relevance of SS techniques in Small/Medium Sized Enterprises: Most research in evidence concentrates on the purchasing behaviors of large companies. Attention needs to be paid to Small/Medium Enterprises (SMEs) and how these companies cope with SS. There are several factors that make SMEs unique including resources available; type of products; numbers of companies that fall in these categories, these factors make it important to consider the SS of SMEs independently. Research into SMEs is important to larger companies as well because many-a-time these companies form the Ist or IInd tier suppliers of the larger companies and hence their practices affects the supply chain of the larger companies.

CONCLUSION

This paper provides a brief yet incisive insight into the existing literature. A breakdown of journals publishing supplier selection research, classification of supplier selection methodology literature into categories and a summary of some of the most frequently cited supplier selection techniques are presented in this paper. It is hoped that the suggested scheme would benefit researchers studying the SS problem by helping focusing on issues of specific interest. Avenues of further research are also presented.

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ⁱ The period under consideration may not be representative of the over-all articles published through the lifetime of the journal.

ⁱⁱ Includes journal that published only 1 SS article and did not have other articles in similar fields.

