USE OF AN ALTERNATIVE DECISION SUPPORT SYSTEM IN VENDOR SELECTION DECISIONS

By

José Gerardo Martínez-Martínez
Associate Professor
Computer Science Department
Bayamón Campus
University of Puerto Rico

Abstract

This article proposes an alternative decision support system, termed Visual Interactive Goal Programming (VIG). An overview of the complexity and importance of supplier selection problem within the broader context of logistics and supply chain management is presented first. Second, problems are discussed that are related to the application of conventional solutions to supplier selection including goal programming. Third, VIG is introduced as an alternative approach to remedy these problems. Finally the benefits and limitations of VIG are discussed.

KEY WORDS

Conventional Goal Programming, Visual Interactive Goal Programming, Decision Support System, Supply Chain Management, Logistics, Supplier Selection

Introduction

Global competitive environment continues to force many companies to make strategic changes in managing their business. Numerous manufacturers have been downsizing, concentrating on their core competencies, moving away from vertical integration, and

outsourcing more extensively (Goffin, Szwejczewski & New, 2007; Leenders, Nollet, & Ellram, 2004). According to Leenders et al. (2004), in this process, the need to gain a competitive edge on the supply side has increased substantially. Particularly for companies which spend a high percentage of their sales revenue on parts and material supplies, and whose material costs represent a larger portion of total costs savings from supplies are of particular importance. Krajeweski (2006) reported for instance, that the percentage of sales revenues spent on materials varies from more than 80 percent in the petroleum refining industry to 25 percent in the pharmaceutical industry. Most firms have spent 45 to 65 percent of sales revenues on materials. Moreover the emphasis on quality and timely delivery in today's globally competitive marketplace adds a new level of complexity to outsourcing and supplier selection decisions.

Many companies have attempted to streamline the number of suppliers from which they purchase. Goffin and his colleagues (2007) found that in a variety of industries in the United Kingdom between 1990 and 2006, the number of suppliers decreased as much as 36 percent. Collectively, these developments make the supplier selection decisions more critical. Weber and his colleagues argue that given the complexity and economic importance of vendor selection it is somewhat surprising how little attention has been paid in the literature to the application or quantitative methods to vendor selection. Such techniques would enable purchasers to select the vendors who best satisfy the requirements necessary to implement management strategy (Weber, Current and Bestow, 2005, p. 16). A survey by those authors indicated that companies show a growing interest in multiple criteria methods when selecting suppliers (Weber, et al., 2005).

The purpose of this article is to present an alternative decision support system, termed Visual Interactive Goal Programming (VIG). VIG is based on a multi-criteria technique known as Pareto Race (Korhonen and Wallenius, 2006). VIG facilitates the introduction of a decision

support vehicle that helps improve the supplier selection decisions of materials/purchasing teams by allowing them to evaluate tradeoffs among their goals interactively and graphically.

Supplier Selection: A Multi-Objective Decision Problem

With the emergence of global competitive challenges and resulting shifts in business paradigms, academics and practitioners alike have identified the growing importance of purchasing in corporate profitability (Goffin et al., 2007; Markland, Vickery & Davis, 2006, Ch. 10). Many companies have changed their focus from short-term purchasing transactions to logistics or supply chain management where they concentrated on developing long-term relations with suppliers including forming partnerships that resulted in improved coordination or supplier networks (Guinipero & Brand, 2006). There are predictions that in this decade the purchasing of goods and services will move out of purchasing's domain. Like customers, suppliers will be considered everyone's business (Leenders, et al., 2004). In other words, it is expected that more than one functional department will be involved with suppliers. Already, many companies seem to be using supplier selection/purchasing teams to replace the buyers or purchasing departments in the logistics and supply chain management era.

In this new business environment, purchasing's role is one of the most significant strategic elements of the physical supply component of a logistics system, (Morash, Droge, & Vickery, 2006; Markland et al., 2006). According to Goffin et al. (2007), purchasing is not a purely tactical exercise anymore; instead it is now recognized as a strategic function, because external suppliers now exert a major influence on a company's success or failure (Goffin et al., 2007). Therefore a key issue that purchasing must address is effective management of the supplier network, including identification of supplier selection criteria, supplier selection decisions, and monitoring of supplier performance.

Supplier selection decisions determine how many and which vendors should be selected as supply sources and how order quantities should be allocated arming the selected vendors. Supplier selection is inherently a complex decision. There are three main reasons for this complexity. First, such a decision involves more than one selection criterion when choosing among the available suppliers. Products of suppliers have many attributes such as price, quality, and service. Additionally, members of purchasing teams bring diverse criteria to the purchasing decisions driven by their departmental interests such as cost, quality, and delivery reliability. In studying supplier selection literature, Dickson (2006) identified 23 factors as meaningful in supplier selection decisions. While Lehmann and O'Sbaughnessy (2004) included 17 criteria in their study, Rao and Kiser (2004) developed a list of 60 items that they later categorized into six groups. Hence, in practice, purchasing teams' decisions may be influenced by multiple decision criteria that are context specific (Goffin, et. al., 2007).

Second- criteria included in the supplier selection process may frequently contradict each other. Wind and Robinson (2006) identified possible contradictions such as the vendor with the lowest price may not have the test quality, or the vendor with the best quality may not deliver on time. Therefore, the purchasing teams must take into consideration the tradeoffs among the criteria they would like to use. If the vendor selection problems were approached with single-objective models, these tradeoffs may not be apparent (Weber & Current, 2003).

Third, within the supply chain management environment the implementation of modern production strategies such as JIT and TQM may increase the importance of the analysis of tradeoffs among the selection criteria. This analysis may necessitate the addition of new criteria and a reordering of existing ones (Weber & Ellram, 2005). Purchasing in the supply chain management environment emphasizes a fundamentally different buyer-seller relationship

compared to traditional supplier interaction. The trend today is toward fewer but higher quality suppliers, reflecting the recognition that suppliers are business partners (Markland et al. 2006, p. 394).

This new relationship is largely based on a long-term cooperative buyer-seller partnership, and calls for sliming the long-run benefits between, the partners in alliances (Krause & Ellram, 2007). Mutual dependence becomes the key to this partnership. Under this new arrangement short-term supplier performance in cost, quality, and delivery is viewed as the natural result of long-term supplier capabilities. Therefore, the development of long-term supplier capabilities in terms of cost savings, quality improvement, and delivery reliability is critical for their mutual success (Watts, Kim, & Hahn, 2004). In their review article focusing on publications between 2006 and 2003, Weber et al. (2005) contend that all thirteen articles specifically on JIT logistics strategy recognized the fact that supplier selection is a multi-objective task.

Several authors find that tradeoffs among price, product reliability, service delivery reliability and other factors are particularly important in a supply chain management environment (Ansari & Modarres, 2006; Rao & Scheraga, 2006). The incorporation of criteria such as quality, service, and delivery in supplier selection decisions in addition to price explicitly recognizes the interdependence of the three logistics system components (i.e., supplier network manufacturing system and customer network). The performance of the supplier network has a direct effect on the performance of the other two components. Hence the goals of the supplier network are guided by the performance requirements of the entire logistics system.

Conventional Solutions to Supplier Selection

Supplier selection questions have always been encountered as multiple criteria problems, but multiple criteria techniques have not been used exclusively in their solution. Instead, the

problem has been converted to a single objective formulation, and the resulting single criterion model has been solved to deliver an optimal solution. In this context, the most frequently utilized approach has been the application of linear weighting models (Wills & Huston, 2003). The linear averaging or weighted point method assigns subjective weights to the selection criteria based on their relative importance. The suppliers are then rated on each criterion according to a numerical scale. The scores on each criterion are multiplied by that criterion's weight and summed to provide an overall score or each vendor. The supplier with the highest score is then selected.

Steuer (2006, p. 198-199) discusses complications in using weights. He contends that there may be good weights producing bad solutions and bad weights producing good solutions. For example, it can be shown that the optimal solution can be found by placing a zero weight on the purchasing manager's most important criterion. Moreover, these methods provide a single optimal solution whereas the purchasing team may have a set of preferred solutions given the tradeoff among the criteria as discussed earlier. In other words, there may be more than one adequate solution to the same problem.

Among the few multi-criteria applications in purchasing, goal programming is the most frequently used approach (Buffa & Jackson, 2003; Chaudhry, Forst, & Zycliak, 2005; Sharma, Benton & Srivastava, 2004). Goal programming takes vendor selection a step further than the traditional methods by incorporating multiple goals. The technique requires that purchasing teams must decide on a preemptive priority order of their goals, i.e. they must first specify the goals for selected criteria and set priorities for the attainment of these goals (Buffa & Jackson, 2003). Although the resulting solution may sometimes be acceptable to the purchasing manager, many times, it may not be adequate. If the solution is unacceptable, the priority structure may be reorganized and the problem re-solved once more. In this fashion, it may be possible to generate

a solution interactively that finally satisfies the decision-maker. Unfortunately, the number of potential priority re-orderings may be very large. A problem with five selection criteria has up to one hundred-twenty (5!) re-orderings. The purchasing manager or purchasing team would have to be very confident in their priority structure to generate good solutions because trial and error is a laborious process at best.

A variety of multiple criteria methods can be used in the supplier selection process to address these concerns. Review articles and chapters that provide background on these methods can be found in Ignizio (2006), Zeleny (2006), Yu (2005), Steuer (2006), and Aksoy (2003). Among the available approaches, it was chosen Visual Interactive Goal Programming (VIG) because it overcomes some of the limitations of goal programming. It is a decision support system available as a PC based software package.

An Alternative Technique: Visual Interactive Goal Programming

Visual Interactive Goal Programming (VIG) is a decision support system (Korhonen, 2007) based on a multi-criteria technique known as Pareto Race (Korhonen & Wallenius, 2006). This method treats constraints as a subset of purchasing teams' goals. Constraints of the problem define the feasible but not necessarily optimal solutions. Among these, there are some solutions such that no other feasible solution will yield an improvement in one goal (objective) without degrading the value of another goal (objective). These feasible solutions are referred to as "non-inferior", "efficient", "non-dominated", or "Pareto optimal" solutions. The method asks the decision-maker to give target values for each goal. It then finds the deviation of each goal from the target value, thereby defining a reference direction. Finally, it projects the reference direction on the set of non-dominated, efficient solutions. Therefore, in multiple criteria problems the notion of the optimal solution is replaced by the concept of the "best compromise solution". Best

compromise solution is the efficient and non-dominated solution that is selected by decision-makers as their preferred solution among alternative courses of action provided by the technique.

In VIG, while the goals of the decision-maker are termed flexible goals, constraints are called inflexible goals. This helps to formulate both goals and constraints similarly and to examine them simultaneously. The goal functions can be specified (i.e., minimize (</=) or maximize (>/=)). VIG starts by finding the best possible value for flexible goals. If some goals are defined as inflexible, VIG may not be able to find a feasible solution during the initial process. However, the method still gives the current achievement levels for the inflexible goals, although some of these goals may not be satisfied. The inflexible goals (constraints) can be relaxed by changing the status of the goal from "inflexible" to "flexible". This helps to obtain feasible and non-dominated solutions. If the solution is still unfeasible, it is recommended that the decision-maker continue relaxing inflexible goals consecutively.

As a decision support system, VIG can assist purchasing teams in solving the supplier selection problem interactively on the personal computer and in identifying their best compromise solution. The values of the goals to be optimized are displayed on a computer monitor in numeric form as well as bar graphs in different colors whose lengths dynamically change as the user travels on the efficient surface, i.e., explores alternative courses of action. On the respective bar graph of each goal the software indicates whether this goal has been defined to be minimized (min) or maximized (max). The right and left arrows indicate the direction in which the decision maker has to start moving in the beginning to search for alternative efficient non-dominated solutions. At the right hand side of each bar, their corresponding numerical values are displayed indicating the current achievement level of each goal.

The ability to "relax" or "tighten" the goals (constraints) in an interactive manner on the screen, and graphically see the tradeoffs between the goals is a unique feature of VIG. This gives the ability to do tradeoff analysis and to answer "what if" questions in an interactive manner without the necessity for reformulating the problem. A number of alternative solutions can be developed and evaluated by the supplier selection team without the need for an analyst's intervention during the problem solution process.

VIG has been implemented in a variety of problems such as pricing decisions, input-output models for emergency management, and media selection. However, to the best of the author's knowledge, it has not yet been applied to purchasing decisions. The availability of VIG for personal computers should encourage the use of this decision support system also by purchasing teams and managers.

Discussion and Conclusion

VIG can be used to identify the best suppliers for a company to include in its supplier network and how to allocate purchase amounts among multiple suppliers. At the same time this procedure permits the purchasing teams to analyze tradeoffs among multiple goals such as cost quality, and delivery reliability simultaneously and interactively.

VIG has several similarities with conventional goal programming. Both techniques can be used to solve supplier selection and volume allocation problems. In both methods, the decision-makers and analysts need to know the target level of their goals. However, these methods can handle tangible goals only, and this is a weakness for both of them.

In spite of similarities, several advantages make VIG a more preferable method over the conventional goal programming. Technically, VIG is a more advanced technique as it does not differentiate between goals and constraints, and does not require specification of preemptive

priorities of multiple goals. In addition, it provides both extreme and non-extreme point solutions and current values of goals even if there is no feasible solution to the problem. From the implementation perspective, VIG facilitates a process of finding alternative solutions without re-formulation of the problem. One can analyze tradeoffs interactively once the problem is formulated with the help of an analyst.

Although no mathematical assistance is needed during the later phases of decision making, because the original formulation would require an experienced analytical staff, it may be seen as a weakness also of this method. From the users' perspective, the ability to use VIG in an interactive manner and graphically in the PC screen is a unique feature of the technique. The comparison of VIG with conventional goal programming is presented in Table 1.

Visual Interactive Goal Programming can help the purchasing teams to make important contributions to the performance of their company. This assistance can be particularly invaluable in the logistics/supply chain management environment within which cost containment for material purchases and recruitment of high-quality suppliers play major roles.

Table 1: Comparison of VIG with Goal Programming

Legend for Chart:

A - Conventional Goal Programming
B - VIG

Basis of Technique Similarities

A. Based on linear Goal Programming
B. Based on Pareto Race

Both techniques require target levels of goals

They can handle tangible goals only
Both can solve supplier selection and volume allocation problems

Technical Differences

A. Need to differentiate between goals and constraints.
B. No needs to differentiate between goals and constraints. It allows decision-maker to charge the status of goals and constraints during the solution process. This enables one to explore alternative solutions.

A.Need to specify preemptive priorities by multiple goals
B.No need to specify preemptive priorities

A. Provides only efficient extreme point solutions.
B. Provides efficient extreme as well non-extreme point solutions. When multiple goals are being considered extreme point solutions have no superiority over the non-extreme ones.

A. No solution provided if there is no feasible solution for the problem.
B. Current values of goals are found even if there is no feasible solution. This helps in re-examination of model parameters (capacities, etc.) and in the selection of goals to be flexed.

Application Differences

A. Need to modify the formulation and to re-solve the linear programming problem for each alternative solution to be explored interactively.
B. Managers can be trained to interactively analyze tradeoffs among multiple goals and generate alternative solutions.

A. Less flexibility and control for decision makers in exploring alternative solutions.
B. Gives flexibility and control to decision-makers in exploring tradeoffs.

A. Analyst's involvement in initial formulation and during the tradeoff exploration stages
B. Analysts involvement in initial formulation only

Platform Differences

A No graphical presentation facility
B. Graphical presentation on PC monitor is convenient and effective in exploring tradeoffs among goals

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