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SUPPLIER SELECTION UNDER STRATEGIC DECISION ENVIRONMENT

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ABSTRACT

The world is becoming more and more a global marketplace and the global environment is forcing companies to take almost everything into consideration at the same time. Increase flexibility is needed to remain competitive and respond to rapidly changing markets. an effective supplier selection process is very important to the success of any organization. Supplier selection represents one of the most important decisions in a company to remain competitive, In this context, supplier selection represents one of the most important functions to be performed by the purchasing department. The supplier selection is a multi-criterion problem which includes both qualitative and quantitative factors (criteria). In order to select the best supplier it is necessary to make a tradeoff between these tangible and intangible factors some of which may conflict. This report deals with the supplier selection where a state of the art is presented. The supplier selection process deploys a tremendous amount of a firm's financial resources. In return, firms expect significant benefits from contracting with suppliers offering high value.

Keywords: *supplier selection; SCM; strategic suppliers; multi-criterion.*

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1. INTRODUCTION

Supplier Chain Management (SCM) and strategic sourcing have been one of the fastest growing area of management, particularly over the last ten years. Under the expanded heading of logistics these are now an integral part of company activity covering areas such as purchasing management, transportation management, warehouse management, inventory management……..As technological complexity has increased, logistics and supply chain have become more complex and dynamic. Increase flexibility is needed to remain competitive and respond to rapidly changing markets.

Nowadays, costs of purchasing raw materials and components parts from external vendors (suppliers) are very important. As an example, in automotive industry, costs of components and parts purchased from external sources may total more than 50 costs for high-technology firms (WEBER et al., 1993). It shows the importance of decisions of the purchasing activity. Indeed, they determine the most important part of the final cost of the product. Among the decisions related to this activity, supplier selection is the most capital decision (NYDICK; HILL, 1992; MOBOLURIN, 1995). Without any doubt, this selection is one of the decisions which determine the long term viability of the company (THOMPSON, 1990).

The search for new supplies is a continuous priority for companies in order to upgrade the variety and typology of three products range. This is essentially due to two main reasons. At first, more generally product life cycle is very short (3-4 years) and new models must often be developed by using completely renewed materials or with new technologies. Second, more industries are, historically, a labor intensive sectors these aspects are expressed through a complex pattern of demand for material and labor.

Two different aspects characterize the supplier selection problem;

The first aspect is the determination of the number of the suppliers and the mode of relations with them. Considering the characteristics of the company, product and market, its strategic plan can encourage a large number of suppliers or not. Today, we are involved in a “co-operative logistics” environment. This co-operation requires a low number of suppliers indeed, a strong co-operation with high number of suppliers is very difficult to manage.

Ansari and Modarress (1986) show that in JIT environment, the majority of the companies prefer to follow a strategy of a single supplier or at least with few suppliers. Quarly (1998) presents the factors which determine the policy of a single or multi-suppliers selection.

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An area of a current research focuses on the classification of components or parts or process to externalize in order to establish a suitable relation with the suppliers of each category.

For example the company can consider a relation of partnership or even a strategic alliance with a supplier who provides a part or a component and with which it wishes to have a durable co-operation. On the other hand, this company can hierarchical relation and a significant number of suppliers for the standard parts in order to establish a competition between them and thus to reduce the cost of purchasing.

Several others like Kamath and Likert (1994), Bensaou (1999) and D'Amours et al. (2001) are interested in the problems of suppliers classification. The second aspect is the selection of best suppliers among the existing alternatives.

2. DECISION CRITERIA

Supplier or vendor selection decisions are complicated by the fact that various criteria must be considered in decisions making process. The analysis of criteria for selection and measuring the performance of suppliers has been the focus of many scientists and purchasing practitioners since the 1960's.

An interesting work, which is a reference for the majority of papers dealing with supplier or vendor selection problem, was presented by Dickson (1966). Dickson's study was based on a questionnaire sent to 273 purchasing agents and managers selected from the membership list of the National Association of Purchasing Managers. The list included purchasing agents and managers from the United States and Canada.

A total of 170 (62.3of Deckson's study regarding the importance of 23 criteria for supplier (vendor) selection. Indeed the 23 criteria are ranked with respect to their importance observed in the beginning of the sixties. At the time (1996), the most significant criteria were the "quality" of the product, the "on-time delivery", the "performance history" of the supplier and the warranty policy used by the supplier.

2.1. Criteria used in Dickson's study

1) The net price (including discounts and freight charges) offered by each supplier.
2) The ability of each supplier to meet quality specifications consistently.

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Table 1: Dickson's supplier or vendor selection criteria

RANK	CRITERIA	MAIN RATING	EVALUATION
1	Quality	3.508	Extreme importance
2	Delivery	3.147	
3	Performance history	2.998	
4	Warranties and claim policies	2.849	
5	Production facilities and capacity	2.775	Considerable importance
6	Price	2.758	
7	Technical capability	2.545	
8	Financial position	2.514	
9	Procedural compliance	2.488	
10	Communication system	2.426	
11	Reputation and position in industry	2.412	
12	Desire of business	2.256	
13	Management and organization	2.216	
14	Operating controls	2.211	
15	Repair service	2.187	Average importance
16	Attitude	2.120	
17	Impression	2.054	
18	Packaging ability	2.009	
19	Labor relations record	2.003	
20	Geographical location	1.872	
21	Amount of past business	1.597	
22	Training aids	1.537	
23	Reciprocal arrangements	0.610	Slight importance

3) The repair service likely to be given by each supplier.

4) The ability of each supplier to meet specified delivery schedules.

5) The financial position and credit rating of each supplier.

6) The geographical location.

7) The production facilities and capacity of each supplier.

8) The amount of past business that has been done with each supplier.

9) The technical capability (including research and development facilities) of each supplier.

10) The management and organization of each supplier.

11) The future purchases each supplier will make from your company.

12) The communication system (with information on progress data of orders) of each supplier.

13) The operational controls (including reporting quality control, and inventory control systems) of each supplier.

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14) The position in the industry (including production leadership and reputation) of each supplier.

15) The labor relations record of each supplier.

16) The attitude of each supplier toward your organization.

17) The desire for your own business shown by each supplier.

18) The warranties and claims policies of each supplier.

19) The ability of each supplier to meet your packaging requirements for his product.

20) The impression made by each supplier in personal contacts with you.

21) The availability of training aids and educational courses in the use of the product of each supplier.

22) Compliance or likelihood of compliance with your procedures (both bidding and operating) by each supplier.

23) The performance history of each supplier.

Overall, the 23 criteria presented by Dickson still cover the majority of the criteria presented in the literature until today. On the other hand the evolution of the industrial environment modified the degrees of the relative importance of these criteria. For example, Weber et al. (1991) insists on the high importance of the geographical position of the supplier in Just-In-Time environment, whereas this criterion appeared in the 20th position in 1966.

Also the criterion in the 10th, 12th and 13th positions (communication system, desire of business, management and organization), of Dickson's study, are very important for the actual industrial environment. Indeed the actual situation requires a perfect co-ordination and a durable co-operation between various actors of the supply chain.

More and more companies establish close connection with their suppliers. This leads to the concepts of partnership, privileged supplier, long-term agreement, etc (DYER; FORMAN, 1992). The traditional management of customer-supplier (or customer-vendor) relationships, which encouraged competition between suppliers (or vendors), made place with new fashions of arrangement based on the co-operation between supplier and company starting from the design of the product.

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This mode of relation privileges selection criteria which are, more particularly, the capacity of co-operation, communication system, and control and co-ordination of flows rather than the traditional criterions which are cost, quality, etc. (HALLEY, 2000)

As an example related to a practical study, the most important criteria presented in Barbarosoglu and Yazgac. The hierarchy developed in Barbarosoglu and Yazgac, (1997) is a five level, incomplete hierarchy in which the top level represents the main mission of the supplier selection and the last level consists of the alternative suppliers.

The primary objectives affecting the supplier selection are grouped under three main categories: performance assessment, business structure/manufacturing capability assessment and quality system assessment. The evaluation criteria that influence each of the primary objectives are included at the second level. The sub-criteria which are related to the second level criteria are given in the third and fourth levels.

2.2. The summary of the different criteria presented by Barbarosoglu and Yazgac which are basically related to a practical case study.

2.2.1. First level: Performance assessment

(a) Second level: Shipment quality

i. Rejection in incoming quality control: the percentage of defective incoming material detected by the incoming quality control;

ii. Rejection in the production line: the percentage of defective incoming material not detected by the incoming quality control, but noticed during production.

iii. Rejection from final customer: the percentage of incoming material accepted by the incoming control and production line, but returned from the customer.

iv. Lot certification: the practice of using a reliable lot certification in all procurement transactions.

v. Sorting effort: the man hours spent for sorting the defective material shipped to the company.

vi. Defective acceptance: the percentage of defective material which can be tolerated in the final product.

(b) Second level: Delivery

i. Compliance with quantity: the supplier’s compliance with the predetermined order

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quantity within the tolerance limits;

ii. Compliance with due date: the supplier's compliance with the predetermined order due date within the tolerance limits;

iii. Compliance with packaging standards: the supplier's compliance with the packaging standards (dimension, labeling, etc.)

(c) Second level: Cost analysis

i. Compliance with the cost analysis system: the consistency of the price increase request made by the supplier with the costing system agreed upon between the supplier and the company.

ii. Compliance with sartorial price behavior: the consistency of the price increase request made by the supplier with the scrotal average;

iii. Cost reduction activities: the actual cost reduction achieved by the supplier as a result of corrective actions and technological investments and reflected upon its pricing policy;

2.2.2. First level: Business structure/ manufacturing capability assessment

(a) Second level: Technical co-operation

i. Response to quality problems: the supplier's ability to solve the quality problems detected by the company during audit, incoming quality control, production or new product development.

ii. Design capability: the supplier's capability to develop a new design.

iii. Level of co-operation and information exchange: the supplier's co-operation and information exchange with the company about technical processes like design, prototype building, die alterations and other phases from design to production;

(b) Second level: Employee profile.

i. Organizational structure: the organizational structure of the supplier and the clarity of the employee job definitions within the structure;

ii. Number of employees: the total number of employees;

iii. Number of technical staff: the number of employees in technical departments (i.e., purchasing, quality, production, laboratory);

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iv. Education: the availability of professional education activities and scheduled yearly training program; the accurateness of personnel educational database, and the percentage of staff attending the training programs in the supplier manufactory;

(c) Second level: Financial status

i. Total revenue: the total revenue of the previous year;

ii. Profitability: the total profit of the previous year;

iii. Company share within the work volume: the share of the company within the total work volume of the supplier;

(d) Second level: Equipment

i. Production machinery: the number, model, capacity utilization ratio and the energy requirement of the production, repair/maintenance, laboratory and die-shop machine groups;

ii. Technological compatibility: the technological compatibility of the service, material or part provided to the company;

iii. Computer hardware: the capability of the computer hardware and basic software packages available in the supplier manufactory;

(e) Second level: Manufacturing

i. Production planning system: the effectiveness of the production planning functionality and communication with the shop floor;

ii. Lead time: the time taken from the receipt of an order to delivery;

iii. Maintenance activities: the extent of preventive maintenance and the conformance between the actual and planned activities;

iv. Plant layout and material handling: the efficiency of the plant layout from the material handling point of view;

v. Transportation, storage and packaging: the effectiveness of the transportation, storage and packaging functions;

2.2.3. First level: Quality system assessment

(a) Second level: Management commitment

i. Quality assurance system documents;

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ii. Role of the quality functions in the supplier manufactory;

iii. Internal audit;

iv. Work force participation in quality improvement;

(b) Second level: Product development

i. Assessment of design development activities;

ii. Design functionality and reliability experiments;

iii. Quality techniques in design.

(c) Second level: Process improvement

i. Process improvement activities;

ii. Process and machine capability indices;

iii. Quality techniques in process improvement;

(d) Second level: Quality planning

i. Compliance with company specifications;

ii. Prototype controls;

iii. Traceability;

iv. Assessment of quality improvement activities;

v. Quality costs;

vi. Quality database;

(e) Second level: Quality assurance in supply

i. Purchasing procedures and supplier evaluation;

ii. Quality certified shipment;

iii. Approval of changes;

iv. Incoming quality control procedures;

(f) Second level: Quality assurance in production

i. Part/product definition and sorting;

ii. Rework;

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iii. Process control and interference;

iv. Statistical applications;

v. Application of advanced quality techniques.

vi. Corrective action response.

(g) Second level: Inspection and experimentation

i. In-process inspection and reliability tests;

ii. Final inspection and reliability tests;

iii. Product audits;

iv. Measuring and testing equipment;

v. Calibration activities;

(h) Second level: Quality staff

i. Number of quality staff;

ii. Education of quality staff;

3. SELECTION METHODS

The supplier selection can be classified in three principal categories. A method can of course be the combination of elementary methods presented below.

3.1. Elimination method

For this method, on each level, from the supplier list, suppliers that do not satisfy the selection rule are eliminated. With a “conjunctive” rule Crow et al. (1980) the supplier whose mark, with respect to a criterion, is lower than the minimal work, are eliminated. Thus one of the suppliers satisfying the minimum level of all the criteria is chosen.

In a “lexicographic” rule Wright (1975), on the first level, the most significant criterion are selected and then they are compared with the criterion. If a supplier satisfies this criterion much better than the other suppliers then it is chosen, if not then it is compared with respect to second criterion , and soon.

3.2. Optimization method

For the optimization method, an objective function can be optimized, which can consist of a single criterion or a set of criteria subject or not a set of constraints.

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3.2.1. Multi criteria decision making (MCDM)

Multiple criteria decision making (MCDM) is the process of selecting the best alternative from a set of feasible alternatives considering multiple conflicting criteria. In precise terms criteria are considered to be 'strictly' conflicting if the increase in satisfaction of one results in a decrease in satisfaction of the other. An MCDM process always contains at least two alternatives and two conflicting criteria (BHATTACHARYA et al., 2003). MCDM are divided two broad categories: Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM). Several useful tools for solving of MCDM problems are

- Simple Additive Weighting method (SAW)
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
- Multi Objective Optimization Ratio Analysis(MOORA)
- Analytical Hierarchy Method (AHP)
- Analytical Network Method ANP etc.

The rest of the paper is organized as follows. Section 2 furnishes a detailed literature review on robot selection. Section 3 introduces the proposed approach. Section 4 illustrates the proposed method with a numerical example and also presents its sensitivity analysis. Section 5 envelops the framework with some essential conclusions

3.2.2. SIMPLE ADDITIVE WEIGHTING (SAW)

- **Step 1 Formation of decision matrix**: Criterion outcomes of decision alternatives can be collected in a table called Decision Matrix comprised of a set of columns and rows. The matrix rows represent decision alternatives, with matrix columns representing criteria. A value found at the intersection of row and column in the matrix represents a criterion outcome - a measured or predicted performance of a decision alternative on a criterion. The decision matrix is a central structure of the MCDA/MCDM since it contains the data for comparison of decision alternatives.

$$X = \begin{array}{c} \\ A_1 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} \mathbf{C_1} & & \mathbf{C_J} & & \mathbf{C_n} \end{array} \\ \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} \end{array} \quad (1)$$

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x_{ij} is the performance rating of alternative ***i*** with respect to criterion ***j***,

A_j is i^{th} alternative, C_j is the j^{th} criterion

- **Step 2 Formation of Weight Matrix:** Different importance weights to various criteria may be awarded by the decision makers. These importance weights forms the weight as follows.

$$W = [W_1 \cdots W_j \ \ldots \ W_n] \quad (2)$$

- **Step 3 Normalization of performance rating:** Units and dimensions of performance ratings of columns under criteria differ. For the purpose of comparison, these performance ratings are converted into dimensionless units by normalization using following equations

$$\bar{x}_{ij} = \frac{x_{ij}}{\max_i(x_{ij})} \text{ for benefit criteria } \boldsymbol{j} \quad (3)$$

$$\bar{x}_{ij} = \frac{\min_i(x_{ij})}{x_{ij}} \text{ for non-benefit criteria } \boldsymbol{j} \quad (4)$$

Normalized decision matrix

$$\bar{X} = \begin{matrix} A_1 \\ \vdots \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} \bar{x}_{11} \cdots & \ldots \bar{x}_{1j} \ldots & \bar{x}_{1n} \\ \vdots & \vdots & \vdots \\ \bar{x}_{i1} \ldots & \ldots \bar{x}_{ij} \ \ldots & \bar{x}_{in} \\ \vdots & \vdots & \vdots \\ \bar{x}_{m1} & \bar{x}_{mj} & \bar{x}_{mn} \end{bmatrix}_{m \times n} \quad (5)$$

- **Step 4 composite score:** Computation of composite score (CS_i) for alternative *i*

$$CS_i = \sum_{j=1}^{n} \left(\bar{w}_j * \bar{x}_{ij} \right)$$

- **Step 5 Ranking and selection of best alternative:** Ranking of products in descending order of composite scores (CS_i).

3.2.3. Experiment

For a particular type of Supplier/vendor selection in industry,assume that, four different Supplier/vendor provided (S1, S2, S3, S4) four different machine those are to be ranked or selected considering four conflicting criteria Velocity in m/sec (C1), Load carrying capacity in Kg (C2) Cost in dollars (C3) and Repeatability in mm (C4). Table 1 shows the performance rating of the alternative robots with importance weight of criteria. The present problem of robot

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selection with four alternatives and four conflicting criteria satisfies the condition of MCDM. The proposed approach has been applied to find the best robot as well as their ranking.

Table 02: Decision Matrix

Supplier/vendor selection	**Machine velocity(m/sec)**	**Load Capacity (kg)**	**Cost($)**	**Repeatability(mm)**
Weight(w_1)	**0.2**	**0.3**	**0.35**	**0.15**
S1	**1.8**	**90**	**9500**	**0.45**
S2	**1.4**	**80**	**5500**	**0.35**
S3	**0.8**	**70**	**4500**	**0.20**
S4	**0.8**	**60**	**4000**	**0.15**

- **Using SAW Method:**

$$\begin{bmatrix} \frac{1.8}{1.8} & \frac{90}{90} & \frac{4000}{9500} & \frac{0.15}{0.45} \\ \frac{1.4}{1.8} & \frac{80}{90} & \frac{4000}{5500} & \frac{0.15}{0.35} \\ \frac{0.8}{1.8} & \frac{70}{90} & \frac{4000}{4500} & \frac{0.15}{0.20} \\ \frac{0.8}{1.8} & \frac{60}{90} & \frac{4000}{4000} & \frac{0.15}{0.15} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0.42 & 0.33 \\ 0.77 & 0.88 & 0.73 & 0.42 \\ 0.44 & 0.77 & 0.89 & 0.75 \\ 0.44 & 0.66 & 1 & 1 \end{bmatrix}$$

Calculation of composite performance score

- **CS1=(0.2 1)+(0.3×1)+(0.35×0.42)+(0.15×0.33)=0.6965**
- **CS2=(0.2×0.77)+(0.3×0.88)+(0.35×0.73)+(0.15× 0.42)=0.7365**
- **CS3=(0.2×0.44)+(0.3×0.77)+(0.35 0.89)+(0.15×0.75)= 0.743**
- **CS4= (0.2×0.44)+(0.3×0.66)+(0.35×1)+(0.15×1)=0.786**

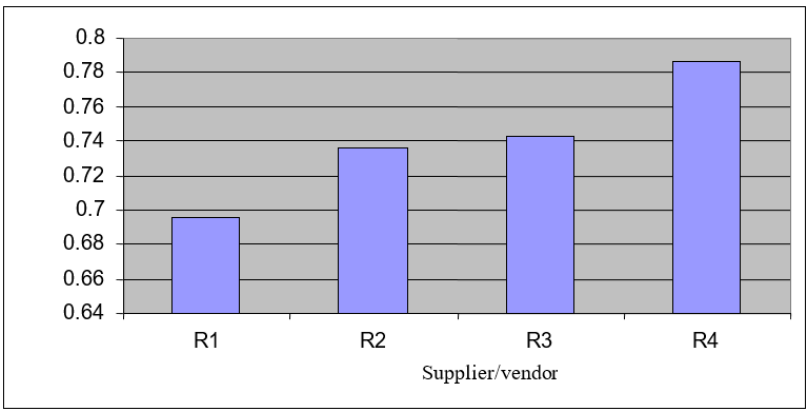

Figure 01: Graphic Supplier vs Vendor

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It is seen that $CS_4>CS_3>CS_2>CS_1$, So ranking of Supplier/vendor is S4>S3>S2>S1.

3.2.4. Sensitivity Analysis

Introduction of sensitivity analysis

In actual situation decision-making is rather dynamic process not static. It varies in the continuous changing environment. The value of decision making attitude in measuring robot measure has been considered as 0.67. In reality the value of decision making attitude depends upon decision maker's personal choice. Under such circumstances decision making attitude behaves as a variable that may yield different results. Keeping it in mind, the proposed model for the selection of robots has been enhanced by sensitivity analysis to provide a readymade solution of the current problem under variable decision making attitude. The governing equation of the robot measure (RM) is given by

$$RM_i = \alpha\left(OFM_i - SFM_i\right) + SFM_i$$

where, i = 1, 2…m.

OFM_i = Objective factor measure for the alternative i

SFM_i = Subjective factor measure for the alternative i

α = Objective factor decision weight/Coefficient of attitude

The equation of the RM represents a straight line and the lines for the 4 robot measure (RM) are drawn between α = 0, and α = 1. Using equation (21) sensitivity analysis has been carried out and the mathematical result has been shown in Table 11 and the graphical representation of the sensitivity analysis is shown in figure 3. The sensitivity analysis clearly supports the proposed methodology for selecting robots under the conflicting multi criteria decision making environment with variable coefficient of decision making attitude towards objective factor measure and subjective factor measure.

The governing equation of the Supplier/vendor measure (RM) in sensitivity analysis is given by the following equation-

$$RSI_i = \alpha B_i + (1-\alpha) NB_i$$

RSI_1=0.75 and 2

RSI_2=1.15 and 1.65

RSI_3=1.64 and 1.21

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RSI_4=2 and 1.10

Putting the value of α as 0 and 1 respectively in the equation

Table 3: Supplier/vendor selection index

Robots	Score under benefit criteria (B_i)	Score under non benefit criteria (NB_i)
R1	2.00	0.75
R2	1.65	1.15
R3	1.21	1.64
R4	1.10	2.00

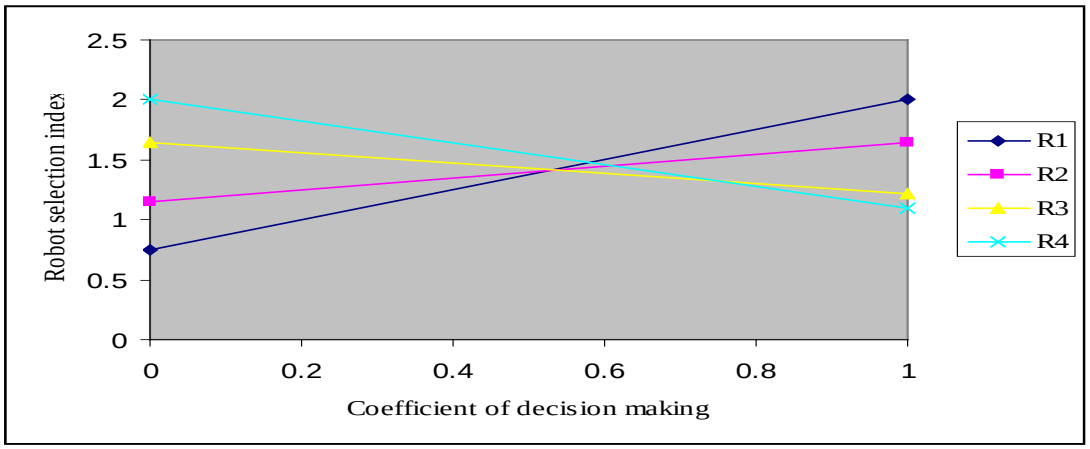

Figure 02: Graphics Supplier/vendor selection index

3.3. Without constraints

In the situation with a single criterion, generally one retains the cost like the most important criterion. All the direct costs are computed, like the purchase price, the transport cost, etc., associated to each supplier and the least expensive one is chosen. A considerable number of companies choose practically their suppliers starting from this method. The companies which choose a strategy of "domination by the costs" are susceptible to use this method.

4. CONCLUSIONS

Finally, the analysis of strategic decision making in vendor selection is another important area for future research. Once solely considered an operational function within companies, many companies are now examining the purchasing function with a strategic orientation (ADAMSON, 1980; SHARMA, 1989; BROWNING et al., 1983; FARMER, 1978; SPEKMAN, 1981; SPEKMAN; HILL 1980).

Decisions such as length of contracts, vendor of vendors employed and location of vendor should be analyzed in light of their strategic implications. Given the inherent multi-objective nature of vendor selection decisions and the financial importance of such decision in

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highly competitive environments it appears that multi-objective programming techniques could prove extremely useful in such strategic planning.

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