GLOBAL SOURCING: AN APPROACH TO SUPPLIERS SELECTION PROBLEMS USING GENERIC ALGORITHMS AND LINGUISTIC VALUATIONS

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ABSTRACT

Suppliers selection of purchasing activity requires a coherent approach, which cannot be simplistic, lo the information held for the decision making model. The use of flexible computation and the vague representation of knowledge available by means of natural linguistic labels allow the problem to be recognised as it is in real life. This paper is an attempt to supply a satisfactory solution to a real purchasing management problem with linguistic information using genetic algorithms.

KEY WORDS: global sourcing, purchasing, suppliers selection, relationships between inputs, linguistic labels, fuzzy numbers, genetic algorithms.

INTRODUCTION

In recent years, purchasing has undergone a total change of perspective: from an operational function to a strategic one. To cope with the increased significance of purchasing ancf environmental uncertainties, buyers should no longer just be processors of requisitions and order forms, but increasingly need to take on strategic roles within organisations. They take part in decisions concerning supply chain management, product input supplies alternatives for the firm and they participate in future strategy formulation processes. In doing so, purchasing decision-making is improved.

As importance of purchasing decisions has increased, so has the basis of these decisions. Due to the increased attention of top management for the purchasing function, purchasing managers more and more are confronted with questions concerning the rational justifications of their decisions and the corresponding supply performance At the same lime, as a result of the more complex, dynamic, turbulent and volatile industrial environment, the complexity and opaqueness of this decision making basis has increased as well.

As purchasing has an important effect on the profitability of an organisation and forms an potential source of profit for many industrial companies, purchasing should be a well-equipped, professional organisational function and an integrated part in the organisation [VAN STEKELENBORG, 1996], So, a professional approach of purchasing decisions contributes to seizing opportunities that can result in savings as well as a competitive advantage for an organisation. It is essential to today's performance of an organisation as a whole that these benefits achievable through good purchasing practices are obtained. This includes the use of sound decision making bases in purchasing.

PURCHASING OBJECTIVES AND FUNCTIONS

Purchasing is the "process of buying". It is widely assumed that purchasing is exclusively responsibility of the purchasing department. However, the function is much broader and, if is carried out effectively, all departments in the company are involved. Obtaining the right material, in the right quantities, with the right delivery (time and place), from the right source, and at the right price are all purchasing functions.

Choosing the right material requires input from the marketing, engineering, manufacturing, and purchasing departments. Quantities and delivery of finished goods are established by the needs of the market. However, manufacturing planning and control must decide when to order which raw materials so that market demands can be satisfied. Purchasing department is, therefore responsible for placing the orders and for ensuring that the goods arrive on time.

The purchasing department has the major responsibility for locating suitable sources of supply and for negotiating prices. Input from other departments are required for finding and evaluating sources of supply and for helping the purchasing department in price negotiation.

PURCHASING OBJECTIVES

Purchasing is responsible for establishing the flow of materials into the firm, following-up with the supplier, and expediting delivery. Missed deliveries can create havoc with manufacturing and sales, but purchasing can reduce problems for both areas, further adding to the profit.

The objectives of purchasing can be divided into four categories [ARNOLD, 1996]:

• Obtaining goods and services of the required quantity and quality.

• Obtaining goods and services at the lowest cost.

• Ensuring the best possible service and prompt delivery by the supplier.

• Developing and maintaining good supplier and developing potential suppliers.

To satisfy these objectives, some basic functions must be performed:

· Determining purchasing specifications: right quality, right quantity, and right delivery (time and place).

· Selecting supplier (right source).

· Negotiating terms and conditions of purchase.

· Issuing and administration of purchase orders

Identifying and selecting suppliers are the most important responsibilities of the purchasing department, since it makes use of all the information available from the other functions. So, our paper aims to give a solution to select the suppliers team that maximise the purchasing utility when the information on held is complex, imprecise or vague.

SUPPLIERS SELECTION IN AN ATMOSPHERE OF UNCERTAINTY DESCRIPTIVE ANALYSIS AND MODELLING OF THE PROBLEM

The objective of purchasing is to gather all the right things together: quality, quantity, delivery, and price. Once the decision is made about what to buy, the selection of the right supplier is the next most important purchasing decision. A good supplier is the one that has the technology to make the product to the required quality, has the capacity to make the quantities needed, and can run the business well enough to make a profit and still sell a product competitively.

The previous section discussed the importance of functions, quality, service and price specifications. These are what the supplier is expressed to provide and are the basis for selection and evaluation. Considering this, there are several factors in selecting a supplier [ARNOLD, 1996]:

• Technical ability. The supplier must have the technical ability to make or supply the product wanted. Also, he has to assist in improving the products and have a program of product development and improvement. These capacities are important since, often, the buyer will depend upon the supplier to provide product improvements that will enhance or reduce the cost of the buyer's products. Sometimes the supplier can suggest changes in product specifications that will improve the product and reduce the cost.

• Manufacturing capability. Manufacturing must be able to meet the specifications for the product consistently while making as few flaws as possible. This means that the supplier's manufacturing facilities must be able to supply the quality and quantity of the products wanted. The supplier must have a good quality control program, competent and capable manufacturing personnel, and good manufacturing planning and control systems to ensure on time delivery. These are important in ensuring that the supplier can provide the quality and quantity wanted.

• Reliability. In selecting a supplier, it is desirable to choose a reputable, stable, and financially strong one. If the relationship is to continue, there must be an atmosphere of mutualtrust and assurance that the supplier is financially strong enough to stay in business.

• After sales service. If the product is of a technical nature or likely to need replacement parts or technical support, the supplier must have a good after-sales service. This should include a good service organisation and inventory of service parts.

• Supplier location. Sometimes it is desirable that the supplier is located near the buyer, or at least maintain an inventory locally. A close location helps to shorten delivery times and means emergency shortages can delivery quickly.

• Price. The supplier should be able to provide competitive prices. This does not necessarily mean the lowest price. It is the one that takes into account the ability of the supplier to provide the necessary goods in the quantity and quality wanted, at the time wanted, as well as any other services needed.

• Other considerations. Sometimes other factors such as credit terms, reciprocal business, and willingness of the supplier to hold inventory for the buyer should be considered.

Some factors in evaluating potential suppliers are quantitative. Price is the obvious example. On the other hand, there are qualitative factors that demand some judgement to determine then. These are usually set out in a descriptive fashion. The supplier's technical competence might be an example.

The challenge is finding some method of combining these two major factors that will enable a buyer to choose the best suppliers.

Thus, if the best possible value is to be achieved from suppliers selection, this must not merely consider the requirements of each of the goods and suppliers to be chosen, in comparison with the capacities of the candidates. It should also address the compatibility of the suppliers, because if they are chosen they will belong to a team made up of suppliers with whom they must get along in order to achieve a common goal.

An attempt to collect and evaluate all this information arises interest in the possible application here of the theory of fuzzy sets [ZADEH, 1965; KAUFMANN AND GIL-ALUJA, 1990] with the aim of being able to handle suitably the uncertainty which is characteristic of the decision-making processes in suppliers selection. This paper specifically proposes the use of linguistic labels to represent the information on these variables and lead to a decision-making model, which is able to handle such information.

In this respect, it is clear that purchasing managers and others charged with determining the standards attained by each supplier in the requirements needed for the demanded good prefer to use natural language for this. This is because it is quite divorced from reality to express these standards in terms of strict numerical values [ARNOLD, 1996], Using normal language may lead to the loss of the precision that numbers can give, but there is a positive counterpart in greater closeness to the problem.

In addition, if the problem is selecting suppliers for several goods, then those inputs of greatest importance for the purchasing management should be weighted in some way, as these are the ones which should be most effectively matched to the ideal supplier.

In supplier evaluation, it is necessary to determine the aptitude of a regarding the specific capacities needed to comply with the requirements of a demand correctly. However, it is also advisable to keep in mind not just the requirements for the needed good but also the conditions surrounding it, and especially those concerning the compatibility with other suppliers.

It is during this phase that analysis of potential interactions between suppliers comes into full play. The reason is that when demanded goods in which there is relationship or which form the same outputs, it is essential to ensure that the suppliers involved co-operate, that is, that they are compatible when it comes to carrying out their joint work.

This justifies looking into the possible relationships among demanded goods, and into the level of compatibility between suppliers, during the selection process. Such considerations are often made in a subjective way, so that the use of linguistic labels would allow greater closeness to the realities of the decision-making procedure being investigated.

Once the degree to which each candidate for supplier has a given ability is established, this is compared to the capacities stated in the profile set up for the good demanded in question. This shows how far each candidate matches up to them, and allows an order of preference among candidates to be drawn up, though not without taking into account their compatibility, which is an objective in parallel with the good match of candidates for supplier to the requirements.

However, to optimise the assignment or selection envisaged, there is a need for some tool able to grasp all the complexity which vague information brings with it, as is also the case if the decision-maker is to reach a good solution [LÓPEZ-GONZÁLEZ *et al.,* 1995a; LÓPEZ-GONZÁLEZ *et al.,* 1995b; LÓPEZ-GONZÁLEZ *et al.,* 1997]. Thus, for the purposes of this paper it has been decided to use a genetic algorithm. The reason for this is that it is a heuristic method of searching solutions and so does not impose restrictions upon the posing of a problem, however complex it may be. In this study, the algorithm is characterised by its use of a fitting function which allows the evaluation of linguistic information, which is a clear innovation both by way of the novelty of the means used in aiding decision making and because of the contribution regarding treatment with fuzzy technology of the genetic algorithm being put forward.

FUZZY-LINGUISTIC MODEL FOR SUPPLIERS SELECTION

The model proposed here consists of the following phases;

1. Step one is to determine for which goods are demanded:

$$X' = \{X'_1,\ X'_2, \ldots, X'_{m1}\}$$

Associated with each goods we have the estimation of the quantity to be purchased in monetary units, that can be expressed easily by trapezoidal fuzzy numbers:

$$B = \{B_1, B_2, \ldots, B_{m1}\}$$

Each good has also associated with it known requirements,

$$C = \begin{Bmatrix} C_{11}, \ldots, C_{1m2} \\ \vdots \qquad \vdots \\ C_{m11}, \ldots, C_{m1m2} \end{Bmatrix}$$

together with the weighting that each requirement has for the various goods.

$$IC = \begin{Bmatrix} IC_{11}, \ldots, IC_{1m2} \\ \vdots \qquad \vdots \\ IC_{m11}, \ldots, IC_{m1m2} \end{Bmatrix}$$

Normally, in a quantitative situation this information is expressed as numerical values. However, when working in qualitative areas such as suppliers selection, which are characterised by vague or imprecise knowledge, the information cannot be set out in a precise numerical way. Thus, it would be a more realistic approach to use linguistic information instead of numbers, provided that the variables involved in the problem lend themselves to expression in this manner [DELGADO *el al.,* 1993]. This way of looking at things can be applied to a wide range of problems, since it allows information to be represented in a more suitable fashion [YAGER, 1992; HERRERA *el al.,* 1995].

This paper supports the possibility of establishing in linguistic terms information relating to the weighting of the requirements needed. It would appear clear that a purchasing manager might not know in a precise numerical way what the weighting of a requirement is, but could indicate it in normal linguistic terms. To estimate weightings, and indeed other features, it has been chosen to use a set of nine linguistic LABELS [BONISSONE AND DECKER, 1986], which are as shown in Figure 1.

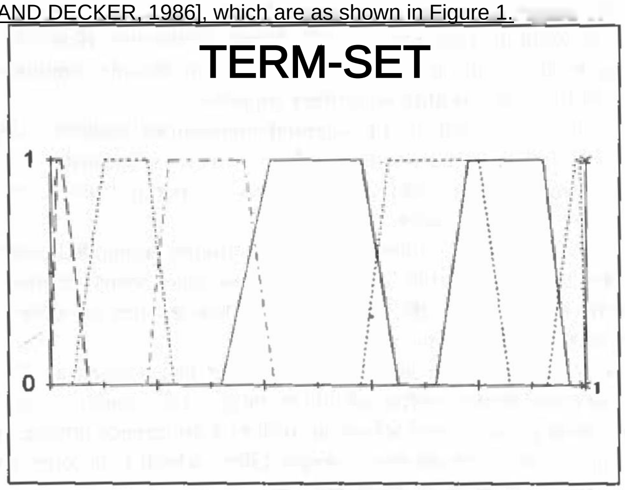


Figure 1

Thus, to stablish the weighting and other features, the labels and the trapezoidal fuzzy numbers associated with them that are proposed would be the following:

Essential	*(1, 1, 1, 1)*
Extremely High	*(.93, .98, .99,1)*
Very High	*(.72, .78, .92, .97)*
Fairly High	*(.58, .63, .80, .86)*
Moderate	*(.32, .41, .58, .63)*
Fairly Low	*(.17, .22, .36, .42)*
Very Low	*(.04, .1, .18, .23)*
Extremely Low	*(0, .01, .02, .07)*
Unnecessary	*(0, 0, 0, 0)*

In addition, when suppliers are being selected for several goods demanded, the expert or decision-maker may consider that not all the goods have the same weighting, and prefer solutions aimed at putting the most suitable supplier into the most crucial good. For this reason, a label associated with each demand must be included to show the weighting that the Good has for the recruitment procedure which is under way, that can be related with the purchasing quantity in monetary units or not. This characteristic is defined in this paper in exactly the same way as requirements, that is, with nine labels.

$$IP = \{IP_1, IP_2, \ldots, IP_{m1}\}$$

Moreover, since the goods are not independent of one another, the links between them should be analysed, as well as the weighting of such links. Here, too, the use of nine labels is considered appropriate.

$$RP = \left\{ \begin{matrix} -, RP_{12}, \ldots, RP_{1m1} \\ \vdots & \vdots \\ RP_{m11}, \ldots, RP_{m1m1-1}, - \end{matrix} \right\}.$$

2. Once the goods demanded have been characterised, the candidates for supplier are considered, $C = \{C_1, C_2, \ldots, C_n\}$. Information relating to them includes both the operational levels, which they demonstrate in the varying requirements needed for the goods,

$$N = \left\{ \begin{matrix} N_{11}, \ldots, N_{m2} \\ \vdots & \vdots \\ N_{n1}, \ldots, N_{nm2} \end{matrix} \right\},$$

and the relationships linking suppliers with one another:

$$RC = \left\{ \begin{matrix} -, RC_{12}, \ldots, RC_{1n} \\ \vdots & \vdots \\ RC_{n1}, \ldots, RC_{nn-1}, - \end{matrix} \right\}.$$

The two types of information are recorded in the form of nine labels, as in previous details, indicating both levels and relationships, thus:

LEVEL	*RELATIONSHIP*
Optimum	*xcellent*
Very High	*ery Good*
Fairly High	*Fairly good*
High	*Good*
Moderate	*Indifferent*
Low	*Bad*
Fairly Low	*Fairly Bad*
Very Low	*Very Bad*
Lowest	*Vile*

Using this approach, it comes down to a problem of optimisation using imprecise information and having two aims: good levels in the requirements needed for the goods on the part of candidates for suppliers and good relationships between their for related goods.

3. For evaluating the solutions we propose a model that uses the semantic of fuzzy numbers representing the linguistic labels.

Let $S_i = \{X_1, X_2, \ldots, X_n\}$, a solution be randomly generated for a problem with *n* demanded goods. For each Good there are *m2* requirements which define it, with *m2* degrees of importance for each requirement. Thus, to assess the suitability of each supplier for each good a link must be established between the level the candidate has of a given requirement and the weight assigned to that requirement for the good demanded. To achieve this, the proposal is to multiply each fuzzy number associated with the weighting of each requirement by the fuzzy number attributed to the level that the candidate for supplier has in that requirement, then add up the results of this multiplication [KAUFMANN AND GIL-ALUJA, 1990],

By taking the steps outlined above, it is possible to obtain a fuzzy number setting a value on the ability of each candidate for supplier relative to each good demanded. However, the intention is to give an overall value covering the suitability of candidates to demanded goods that will include the fact that the various goods are themselves of different levels of importance. In view of this, it is proposed that the fuzzy figures for the requirements of each candidate should be multiplied by the importance assigned to each demanded good, then add them up, so that the solution as to suitability for supply may be obtained in the form of a fuzzy number.

Nevertheless, the goodness of the solutions will also be determined by the relationships between the candidates for suppliers included in them. On the one hand, the connections between goods are known, as is the weighting for each, and on the other the relationships between candidates for suppliers are known. So, a link is established for each good between the weighting of its connections to other goods and the degree of relationship that the candidate that supply one good has with candidates for related goods. To achieve this, the proposed method would be to multiply the fuzzy numbers associated with the weighting of a link between one good and the others by the level of relationship that the supplier of this good has with the other selected for related goods.

Once this has been done, a fuzzy number setting a value on the relationships between each candidate and the rest can be obtained. To set a value on the overall solution, the proposal is to add up all the relationships between all the candidates involved in it and multiply this result for the fuzzy monetary quantity to be purchased of that good.

Finally, the intention is to add the level of requirement to the degree of relationship of the solution, so as to get a single value for the goodness of selection of suppliers that the solution represents. In this phase the purchasing manager's preferences must be taken into account, in so far as more weight might be assigned to suppliers' suitability for demands or to suppliers' compatibility.

GENETIC ALGORITHMS FOR SUPPLIERS SELECTION UNDER LINGUISTIC VALUATIONS

Genetic algorithms are adaptive searching and optimisation tools based on the mechanisms of natural selection and genetics [HOLLAND, 1965, GOLDBERG, 1989; DAVIS, 1991; KOZA, 1994; HERRERA AND VERDEGAY, 1996). Although many variants are possible, the fundamental rules under which they function are, to operate on a population of suppliers (feasible solutions for a problem) which is normally randomly generated and to change the suppliers on each iteration by reference to the following four steps:

1. Evaluation of individuals in the population.
2. Selection of a new set of individuals.
3. Reproduction based on relative suitability or adaptation.
4. Recombination to form a new population by crossover and mutation.

The individuals resulting from these operations form the next population, with iteration of the process until the system presents no improvement possibilities.

As they are simple, easily handled, with few restrictions and good generalisability, these algorithms have been successfully applied to a wide range of problems [LUKASIUS AND KATEMAN, 1989; SANDGREN AND JENSEN, 1990; DEB, 1991; BIETTHAHN AND NISSEN, 1995].

In this paper the genetic algorithm proposed has as its principal characteristic real codification of the solutions. Chains of candidates for suppliers are generated of the same size as the number of goods demanded taking into account that only suppliers that provides each good can be assigned to do this.

An example of a solution for a case of five demanded goods with ten candidates for supplier available to provide (I and 2 for first good, 3 and 4 for second good, and so on), them would be:

S, ={2,4, 5, 7, 9}

This solution indicates that candidate no. 2 comes in the first place and provides the first good, no. 4 comes in second place and supplies the second good, no. 5 supplies good 3, no. 7 supplies good 4, and no. 9 good 5.

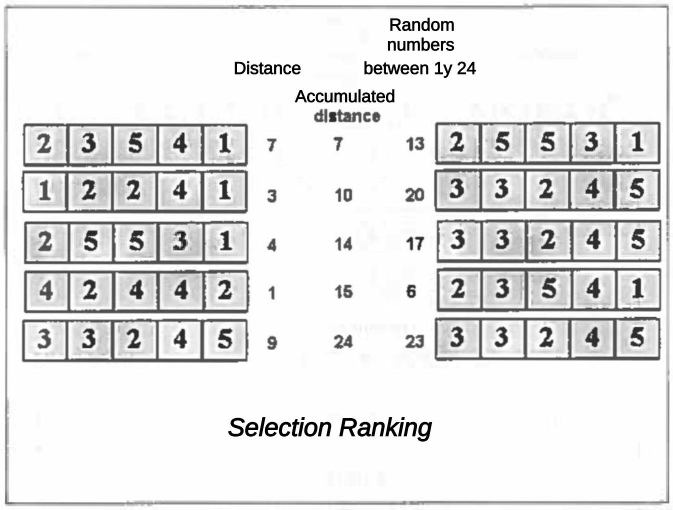
Once the coding has been decided upon, a battery of these solutions is generated by random processes, taking into account that only feasible solutions are allowed.

SUITABILITY OR FITNESS FUNCTION

To work out the suitability of solutions, the fuzzy evaluation model described in the previous section is used. From this a fuzzy number is obtained as an indicator of the goodness of each solution. To set up a hierarchy among them, the proposal is to use the fuzzy distance [KAUFMANN AND GIL-ALUJA, 1990] each one is from the origin (singleton 0).

SELECTION OF PARENTS

The next step is the selection, by means of a Roulette Selection Ranking [DAVIS, 1991] of the most suitable individuals, which will become the parents of the next generation, as shown in Figure 2.



Selection Ranking

Figure *2.*

CROSSOVER

Traditional crossover (single point, uniform, and so on) cannot be used for cross from the parents, because these are an ordered decimal list, assignment of suppliers to tasks having been done as a function of the place they occupy in the solution chain. Thus, the option taken is the use of one crossover proposed by authors, which conplies with the need for the solutions generated by it to continue to be feasible responses to the problem.

The functioning of this method may be described as follows. After the selection process, there are two parents:

$$S_1 = \{2, 4, 5, 7, 9\}$$

$$S_2 = \{1, 4, 6, 8, 9\}$$

A start is made by maintaining the suppliers that are repeated in both parents, and the process yields:

$$s_1' = \{, 4, , , . 9\}$$

$$S_2' = \{, 4, , , 9\}$$

The second and last step is changing randomly (yes or no) the remaining suppliers between the chains. The result would be:

$$s_1' = \{2, 4, 6, 8, 9\}$$

$$s_2' = \{1, 4, 5, 7, 9\}$$

MUTATION

The intention of this operator is to add diversity to the solutions. The mutation used involves bringing in suppliers not contained in the chain, taking into account that only one supplier can be replaced for other that provides the same good.

HALT CRITERIA FOR THE BEST SOLUTION SEARCH

The proposal is for the algorithm to go through a number of generations specified by the user until the best solution is found. Moreover, in order not to lose good solutions, the characteristic termed élitism [GOLDBERG, 1989] has been introduced. This procedure consists of keeping the best individual from a population in successive generations unless and until some other individual succeeds in doing better in respect of fitness. In this way, the best solution for a previous population is not lost until outclassed by a more fitness solution, as may be seen in Figure 3.

Company 11	*S.ll*	*Good: HUB-CAB*
Company 12	*S.12*	*Good: RIM*
Company 13	*S.13*	*Good: TYRE*
Company 14	*S.14*	*Good: NUT*
Company 15	*S.15*	*Good: SCREW*

For each one it is necessary to find out by some appropriate means the levels in each of the requirements required for the supplies, as shown in Chart 2.

Finally, as there are links between the goods, the candidates for suppliers must be looked at in order to find out the relationships that there would be between them, as shown in Chart 3.

	S. 1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	S.9	S. 10	S. II	S. 12	S. 13	S. 14	S. 15
Technical ability	Very High	Very high	Low	High	High	High	Fairly High	Very High	Very High	Very High	Fairly High	High	High	Mode-rate	Mode-rate
Technological innovation	Fairly High	Fairly High	Mode-rate	Fairly High	Fairly High	Mode-rate	Mode-rate	High	Fairly High	Fairly High	Low	High	High	Fairly High	Fairly High
Manufacturing capacity	Mode-rate	Fairly High	Mode-rate	Fairly Low	Low	High	Mode-rate	Fairly High	Mode-rate	High	Fairly High	High	Fairly High	Mode-rate	High
Quality	High	High	Fairly Low	Low	Fairly High	Low	Low	Mode-rate	High	High	Fairly Low	Fairly High	Mode-rate	High	Mode-rate
Standardisation	High	High	Low	Mode-rate	Fairly Low	Fairly High	Mode-rate	Fairly High	High	High	Very High	Low	Mode-rate	Fairly High	High
Reliability	Very Low	Mode-rate	Mode-rate	Fairly Low	Lowest	High	Fairly Low	Lowest	Very High	Mode-rate	Mode-rate	Mode-rate	Lowest	Very High	Mode-rate
Financial fortress	Fairly High	Fairly High	Low	High	Mode-rate	Fairly High	High	Very High	Fairly High	Fairly High	Very High	Mode-rate	Very High	Fairly High	Mode-rate
After-sales service	Very High	Very High	Mode-rate	High	Fairly Low	Very High	Fairly High	Fairly High	Very High	Very High	Fairly High	Low	High	Very High	Very High
Flexibility	High	High	Low	Mode-rate	Very Low	Fairly High	High	Low	High	High	High	Mode-rate	Low	High	Mode-rate
Supplier location	High	High	Mode-rate	Fairly High	Low	Fairly High	Low	Fairly High	High	High	High	Mode-rate	Fairly High	High	High
Fast supply	Low	Fairly High	Mode-rate	Mode-rate	Very Low	Mode-rate	Low	Fairly Low	Low	Fairly High	Low	Low	Mode-rate	Low	Mode-rate
Credit terms	Fairly High	Fairly High	Low	High	Lowest	High	Fairly Low	Very High	Fairly High	Fairly High	Fairly High	Fairly Low	Very High	Fairly High	Fairly High
Reciprocal business	Very Low	Mode-rate	Mode-rate	Fairly Low	Lowest	Fairly High	Low	Lowest	Very High	Mode-rate	High	Mode-rate	Lowest	Fairly High	Mode-rate

Chart 2

	C 1	C2	C3	C4	C5	C6	C7	C8	C9	C 10	C 11	C 12	C 13	C 14	C 15
C 1	■	Very Good	Bad	Good	Indifferent	Very Bad	Indifferent	Very Bad	Vile	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C2	Fairly Bad	-	Bad	Indifferent	Indifferent	Good	Indifferent	Fairly Bad	Good	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C3	Very Good	Fairly Good	-	Bad	Good	Indifferent	Good	Vile	Very Good	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C4	Fairly Bad	Good	Indifferent	-	Bad	Good	Indifferent	Indifferent	Fairly Bad	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C5	Very Good	Good	Good	Bad	-	Good	Fairly Bad	Fairly Bad	Vile	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C6	Very Good	Good	Indifferent	Bad	Good	-	Indifferent	Bad	Good	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C7	Bad	Good	Good	Fairly Good	Very Good	Fairly Good	-	Very Bad	Fairly Bad	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C8	Bad	Fairly Good	Good	Very Good	Indifferent	Fairly Good	Indifferent	-	Fairly Bad	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C9	Vile	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent	Very Bad	-	Very Good	Bad	Good	Indifferent	Fairly Bad	Indifferent
C 10	Fairly Bad	Very Good	Bad	Indifferent	Indifferent	Good	Indifferent	Fairly Bad	Good	-	Bad	Good	Indifferent	Fairly Bad	Indifferent
C 11	Indifferent	Good	Indifferent	Good	Fairly Good	Fairly Good	Bad	Indifferent	Fairly Good	Fairly Good	•	Indifferent	Fairly Good	Indifferent	Very Bad
C 12	Fairly Good	Fairly Bad	Bad	Good	Good	Good	Very Bad	Indifferent	Indifferent	Fairly Good	Indifferent	-	Bad	Indifferent	Bad
C 13	Indifferent	Indifferent	Indifferent	Very Good	Indifferent	Indifferent	Fairly Bad	Bad	Fairly Bad	Very Bad	Bad	Very Bad	-	Fairly bad	Very Bad
C 14	Fairly Good	Very Good	Fairly Good	Good	Indifferent	Good	Indifferent	Fairly Good	Good	Very Good	Fairly Good	Good	Indifferent	-	Fairly Good
C 15	Indifferent	Fairly Good	Bad	Indifferent	Indifferent	Good	Indifferent	Fairly Bad	Good	Indifferent	Bad	Good	Indifferent	Fairly Bad	■

Chart 3

For the purposes of application of the operational model, the parameters used in finding the solution by means of the model proposed were:

- Number of generations: 50
- Number of individuals: 5
- Crossover probability: 50%
- Mutation probability: 50%

It should be pointed out that the use of a high mutation probability was motivated by the need to bring new suppliers into the chains, since if this were not so all that would be obtained would be the best combination of those initially considered who got past the first selections.

In the practical example analysed the final solution obtained was:

Good I: SCREW	*Company: S. 2*
Good 2: NUT	*Company: S. 1*
Good 3: TYRE	*Company: S. 8*
Good 4: RIM	*Company: S. 12*
Good 5: HUB-CAB	*Company: S. 6*

The graph of the evolution of the best individual in each generation is displayed in Figure 5.

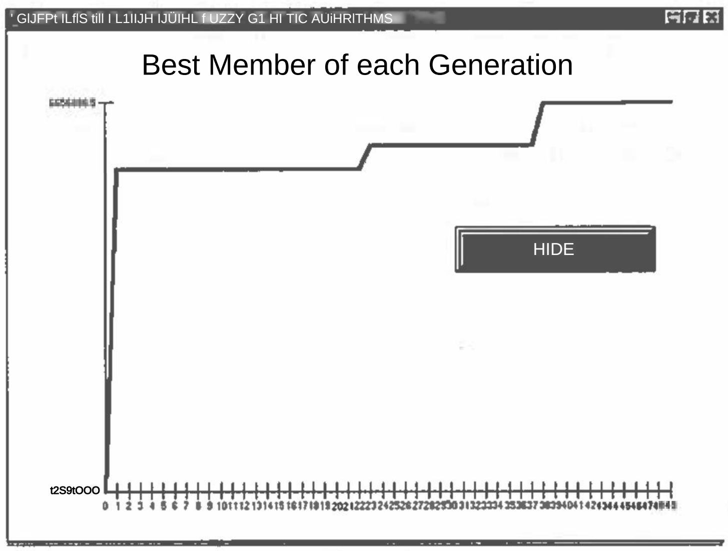


Figure 5

CONCLUSIONS AND FUTURE DEVELOPMENTS

The results obtained from this work fall into two clusters. The first consists of the formulation of a suppliers selection model that could be adapted to the problem under consideration. The second has to do with the establishment of a specific procedure.

In addition, as a proposal for future work, this research has backed the interest in using natural linguistic operators with the aim of handling linguistic information without having to transform it into a semantic representation [HERRERA AND HERRERA-VIEDMA, 1997],

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