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Abstract

Electronic procurement is frequently defined as the sourcing of goods or services via electronic means, usually through the internet. A major process in the e-procurement decision making is that of supplier selection process. In the real world, the criteria and constraints for such a process are subjective in nature. In this study, the criteria for supplier selection, which already have been established empirically, has been adopted and no new criteria for the same has been proposed. These criteria and constraints have been modeled using fuzzy logic into constraints, which further has been modeled as a multi-objective decision making process, by combining neural networks and analytic hierarchy process. Then the suppliers have been classified into suitable suppliers and unsuitable suppliers, from the viewpoint of the firm.

Keywords: Neural Networks, Classification, Data mining, Business intelligence, Supplier selection, e-Procurement, Supplier pre-qualification, Supplier evaluation

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INTRODUCTION

Electronic procurement is frequently defined as the sourcing of goods or services via electronic means, usually through the internet (Schoenherr and Tummala, 2007). Precursors of e-procurement can be seen as early as the 1980s, with the evolution of Material Requirements Planning (MRP) systems into Manufacturing Resource Planning (MRP II) and then into Enterprise Resource Planning (ERP) systems in the mid-1990s. The practice of Electronic procurement has gained popularity over the last ten years, and so has the research on this emerging area with an identity of its own.

The e-procurement process supports the procurement and sourcing activities via Internet technologies and enables an efficient negotiation between buyers and suppliers. Loosely describing the processes involved, e-procurement is the purchase and sale of products and services through the Internet using websites, as well as other information and networking systems.

Typically, e-procurement web sites allow buyers and sellers facilitate their transactions. Depending on the business model, buyers or sellers may specify costs or invite bids. Transactions can be initiated and completed. E-procurement systems may make it possible to automate some buying and selling and thus cut down on transaction costs. Companies participating expect to be able to control parts inventories more effectively, reduce purchasing agent overhead, and improve manufacturing cycles.

A major process in the e-procurement decision making is that of supplier selection process. Supplier selection studies have been widely reviewed ever since procurement through traditional processes has been studied, since 1960s. In the real world, the criteria and constraints for such a process are soft in nature. In this study, the criteria for supplier selection, which already have been established empirically, has been adopted and no new criteria for the same has been proposed. These criteria and constraints have been modeled using fuzzy logic into constraints, which further has been modeled as a multi-objective decision making process using neural networks, and then the suppliers have been classified into suitable suppliers and unsuitable suppliers, from the viewpoint of the firm. No attempt has been made to validate the proposed methodology with data in this study.

1. LITERATURE REVIEW

2.1 E-PROCUREMENT

Weele (1994) defines e-procurement as the use of internet technology in the process of providing goods and services and this is one of the first conceptualizations of the terminology. Electronic procurement systems experienced a gradual diffusion in the late 1990s (Puschmann and Alt, 2005) due to the advances and adoption of information technology and the internet, the tremendous potential savings achievable via this tool.

According to a study conducted by SAP, e-procurement reduces purchase costs; enhances efficiency at every stage; establishes adaptive, efficient and collaborative supplier relations; monitors and regulates buying behaviors; improves sourcing by discovering more suppliers, ensures deliveries on time; frees up skilled employees; reduces training requirement; permits flexible access time; manage contracts; performs content management functions and reduces maverick purchases.

Purchasing is the primary point of contact with most supply-chain partners and thus among the most important activities. At the strategic level, the firm must define the corporate, manufacturing and sourcing strategies and identify the products and services that should be acquired from outside (Croxton, García -Dastugue et al. 2001). And, at the operational level, all the procurement activities, such as to review suppliers, to identify opportunities, and to develop and implement product or service agreements, should be developed and controlled (Croxton, García -Dastugue et al. 2001). Thus the decisions taken at the purchasing stage can have a great impact on the overall supply-chain and production planning processes and on their overall performance. As a result, many organizations are attempting to redesign and streamline their procurement processes, the performances of which is optimized using web enablement or as termed popularly, e-procurement.

Presutti (2003) stated that the adoption of new e-procurement processes have a tremendous impact over the traditional purchasing cycle. The author divides the processes involved into 4 distinct phases. The first phase is the "Definition of buying requirements", where based on final customer's demand, a team of buyers, as decision makers, are involved in this stage. Potential suppliers are then identified and short-listed by the buying team in the next “Identification and pre-qualification of suppliers” stage. The team is then responsible for the “Definition of contract agreements” and subsequently the “Evaluation and rating of suppliers” phases, which encompass generating and evaluating requests for proposals, and assessing suppliers’ performance against a set of relevant criteria. Among the others, the supplier selection process, from pre-qualification to final selection is deeply influenced by the adoption of e-procurement programmes. As this study indicates when e-procurement solutions are adopted, qualitative and quantitative performance data required for pre-qualifying, pondering and ranking viable suppliers may differ significantly from traditional ones, and new important skills and capabilities might need to be added.

Traditional research in e-procurement has been classified into four separate areas based on the themes they address broadly, as per a study done by Schoenherr and Tummala (2007). These broad areas are decision support studies, adoption factors, prescriptions and current state of e-procurement implementation in firms. Studies in prescriptions focus on factors for successful purchasing and best practices, including implementation experiences, outcomes and the impact on performance. Studies focusing on the current state of practice provided general overviews and introductions to the topic, as well as implementation frameworks. Other studies focus on the factors influencing the adoption of e-procurement, its subsequent success, and differences between adopters and non-adopters of electronic procurement. Rest of the studies has been classified as under decision support, which tries to optimize the processes involved in e-procurement. As Schoenherr and Tummala indicate in their study, although the studies in decision support have been many, in the area, it is still an evolving area of study with a huge scope in adding value to the existing body of literature.

It has been established by Swaminathan and Tayur (2003) that firms can apply analytical models to previous data and obtain important information to make better decisions. In this study, the focus has been to provide decision support to one of the key process involved in e-procurement, namely that of supplier selection.

Previous studies in this area that focused on supplier selection using mathematical modeling of the criteria, has focused on providing an optimized single output, by choosing the most suitable supplier, amongst many suppliers, that will benefit the firm the most. In current times, most of the firms have more than one supplier supplying the same product, especially in an e-procurement scenario. Now, multiple suppliers may be equally suitable for supplying a certain product.

In this paper, the e-procurement processes are reviewed with a focus on supplier selection process. A methodology has been proposed to classify suppliers into suitable and unsuitable classes. For the same, already available criteria have been used and modeled using fuzzy logic incorporated within a neural network. The study makes no attempt to add new criteria to the decision making process for supplier selection, but only focuses on using existing theoretically supported criteria as constraints, to model the problem into a linear programming model, and then classify the suppliers into two classes.

2.2 SUPPLIER SELECTION

Supplier selection studies have dated back to as early as 1960s. Few of the more referred papers of that era due to their classical contribution are those by Busch (1962), Dickson (1966), Hakansson and Wootz (1975) and Dempsey (1978). These studies established the importance of quality of products and delivery are important factors for supplier selection.

Traditional methodologies of the supplier selection process in research literature include the cost-ratio method, the categorical method, weighted-point evaluations, mathematical programming models and statistical or probabilistic approaches. One of the more cited conceptual papers in supplier selection literature is that of by Weber, Current and Benton (1991) and they develop an interpretive structural model (ISM) to show the inter-relationship of different criteria and their levels of importance in the vendor selection process. Their study reveals that “attitude”, “willingness for business” and “after sales service” are also important factors for supplier selection.

In contrast with the abundant literature dealing with various domestic supplier selection problems, previous analytical studies on international supplier selection were virtually absent in previous studies. Min (1994) introduced 7 selection criteria such as “financial terms”, “quality assurance”, “perceived risks”, “service performance”, “buyer–supplier partnerships”, “cultural and communicational barriers” and “trade restrictions” and thus addressed the geographically dispersed suppliers, increasingly getting important, with the advent of the e-procurement scenario.

Among recent studies, Petroni and Braglia (2000) suggested that criteria such as “management capability”, “production capacity and flexibility”, “design and technological capability”, “financial stability”, “experience” and “geographical location”, address integration capabilities of viable suppliers, and thus provide an updated framework of criteria in the era of integrated supply chain management, which seems more apt in the wake of e-procurement. Bottani and Rizzi (2005) advanced their work and incorporated electronic transaction capabilities as another key criterion consisting of electronic catalogue management, electronic order management, electronic financial management and supplier e-skills into the supplier selection framework. This was done with a strong focus to study supplier selection in the e-procurement scenario.

Most of the studies in the area of supplier selection were based on empirical work and qualitative work. Very few work addressed the problem to provide decision support using analytical modeling techniques. Mandal and Desmukh (1994) used an interpretive structural modeling for vendor selection by combining both qualitative and quantitative factors. Youssef, Zairi & Mohanty (1996) developed a simple model for supplier evaluation and selection in an advanced manufacturing environment. Ghodsypour and O’Brien (1998) approached this problem with an integrated analytic hierarchy process modeled through linear programming. Weber, Current and Desai (2000) proposed a linear weighting model for supplier selection by placing a weight on each criterion and providing a total score for each supplier by summing up the supplier’s performance on the criteria multiplying them by the weights. Lam, Hu, Thomas, Skitmore and Cheung (2001) proposed a general feed forward fuzzy neural network approach for contractor prequalification and ranking of suppliers. Zaim, Sevkli and Tarim (2003) proposed a fuzzy analytic hierarchy based approach for supplier selection. Bottani and Rizzi (2005) proposed a fuzzy multi-attribute framework for supplier selection in an e-procurement environment. Kubat and Yuce (2006) proposed a supplier selection methodology by integrating genetic algorithm and fuzzy analytical hierarchy process for choosing the best supplier from a pool of supplier data points. Choi and Kim (2008) proposed a hybrid decision support model based on screening candidate suppliers first by multi-criteria decision making methodologies and then optimization modeling based on rule based reasoning for selecting highly qualified suppliers. Verma and Koul (2008) proposed a methodology for dynamic vendor selection using fuzzy analytic hierarchy process for multi-criteria decision making.

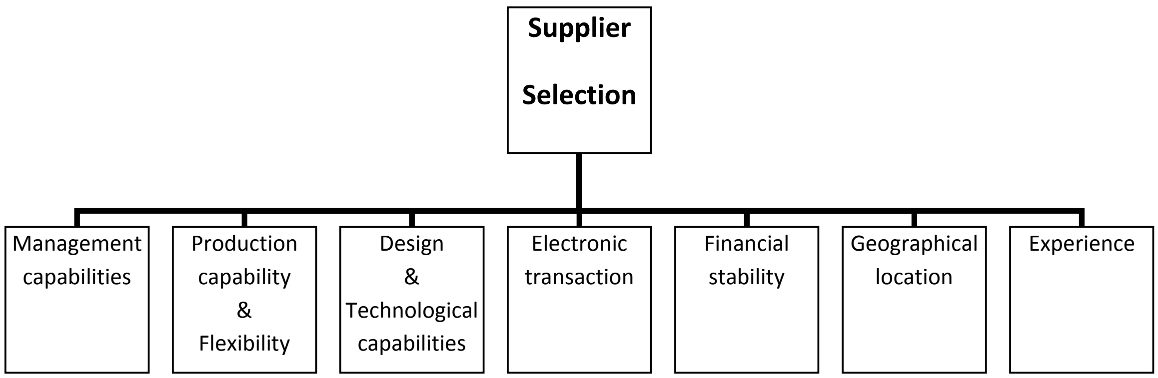

Figure 1: The supplier selection framework in an e-procurement environment, adapted from Bottani and Rizzi (2005).

Today in the wake of e-procurement in B2B transactions, most of the firms have more than a single supplier supplying the same product to the firm. Strategically, being dependent on only one supplier to supply all the needs will shift the greater bargaining power from the firm to the supplier, as per Porter (1980). So it would be actually beneficial to source from more than one supplier. Also, one supplier may not have the technical competence to provide for the complete requirement of the firm. So, multiple suppliers may be equally suitable for supplying a certain product and so, the firm may need to choose more than one supplier to fulfill the needs of the firm.

In this study, the supplier selection framework consisting of 7 criteria as proposed by Bottani and Rizzi (2005), has been utilized to develop a methodology using fuzzy linear programming to classify potential suppliers into two categories, that of suitable suppliers and unsuitable suppliers. In this scenario, the criteria that affect the supplier selection process are essentially fuzzy, and thus, it is essential that the constraints be fuzzy in such a modeling of the criteria. The objective is to provide a multi-objective decision making framework, based on the soft constraints and criteria, with fuzzy neural networks for classification.

2.3 CLASSIFICATION WITH FUZZY NEURAL NETWORKS

A pattern classification problem is essentially mapping an input pattern, represented as an input vector, to a particular class or category. Thus given a database $D=\{t_1,t_2,\ldots,t_n\}$ and a set of classes $C=\{C_1,\ldots,C_m\}$, the classification problem is to define a mapping $f:D\rightarrow C$ where each t_i is assigned to one class (Dunham, 2006). Traditionally classification (Duda, Hart and Stork, 2001) has been studied using Bayesian decision theory and parameter estimation, non-parametric techniques, linear Discriminant functions, multi-layer neural networks, stochastic methods and non-metric methods.

Multilayer neural networks have been used for a very long time for classification purposes using feed forward and back propagation algorithms. These techniques all have used the network learning properties of neural networks, where one set of data has been used for training the network and another set of data has been used for classification of data points or vectors. Networks have two primary modes of operation: feed-forward and learning (Duda, Hart and Stock, 2001). Feed-forward operation, consists of presenting a pattern to the input units and passing the signals through the network in order to yield outputs from the output units. Supervised learning consists of presenting an input pattern as well as a desired, teaching or target pattern to the output layer target and changing the network parameters (e.g., weights) in order to make the actual out- pattern put more similar to the target one.

To deal with vagueness of human thought, Zadeh (1965) first introduced the fuzzy set theory, which was oriented to the rationality of uncertainty due to imprecision or vagueness. Fuzzy modeling is a method for describing the characteristics of a system using fuzzy inference rules as was described by Takagi and Sugeno, (1985). Fuzzy neural networks combine the advantages of both fuzzy reasoning (i.e. ability in handling uncertainty associated with qualitative information) and neural networks (i.e. ability in learning and generalizing from prequalification cases).

The current study proposes a neural network for classifying suppliers in an e-procurement scenario, into two classes, namely suitable and unsuitable classes. For a particular firm, it will make business sense and create more value for the firm, if it gets its supplies from the class of “suitable” suppliers. Similarly, it will not benefit that firm, if the same activities are carried out with unsuitable suppliers.

2.4 ANALYTIC HIERARCHY PROCESS

Tam and Kiang (1992) discussed the failures of back propagating algorithms used for the purpose of classification. Wang (1995) discussed the relative unpredictability of standard multilayer neural networks for usage in classification problems. Much of this classification errors were often raised due to the errors in the weights of the branches in the network.

So a different approach has been taken in this paper for deciding the weights of the branches in the network. For deciding the weights, the Analytic Hierarchy Process, which was first proposed by Saaty (1980) has been used in this paper.

The Analytic Hierarchy Process (AHP) is a general theory of measurement. It is used to derive ratio scales from both discrete and continuous paired comparisons in multilevel hierarchic structures. These comparisons may be taken from actual measurements or from a fundamental scale that reflects the relative strength of preferences and feelings. The AHP has a special concern with departure from consistency and the measurement of this departure, and with dependence within and between the groups of elements of its structure. It has found its widest applications in multi-criteria decision making, in planning and resource allocation, and in conflict resolution (Saaty and Alexander, 1989; Saaty, 2008).

In this study, Analytic Hierarchy Process has been used to find the relative importance of not only the criteria for the decision making for supplier selection, but also the relative importance of the individual sub-criteria or items used for the measurement of each criterion.

2. PROBLEM DEFINITION AND RESEARCH GAP

Presutti (2003) stated that the adoption of new e-procurement processes have well defined benefits for the business by lowering the time taken in each of the four stages of a procurement process, namely “Definition of buying requirements”, “Identification and pre-qualification of suppliers”, “Definition of contract agreements” and subsequently the “Evaluation and rating of suppliers” phases, in order. As this study indicated, when e-procurement solutions are adopted, qualitative and quantitative performance data required for pre-qualifying, pondering and ranking viable suppliers may differ significantly from traditional ones, and new important skills and capabilities might need to be added. The current study seeks to provide decision support for the second stage, namely, “Identification and pre-qualification of suppliers” stage.

Angeles and Nath (2007) studied the critical success factors behind e-procurement success. According to their study, some of the major success factors are reducing the number of suppliers, consolidating suppliers and contracts and involving preferred and strategic suppliers in planning for e-procurement. In the e-procurement scenario, generally, multiple suppliers quote for a tender when the same is floated by a company. All these success criteria provide a clear indication that lowering the possible number of total suppliers who applied for a tender to the number of possible suppliers who would actually be more suitable in the supplier prequalification stage would play a key role in the success of a e-procurement implementation process.

Schoenherr and Tummala (2007) indicate that the studies in decision support have a huge scope in adding value to the existing body of literature and to the business community also. Multiple studies have been conducted in the area of optimizing the supplier selection process to provide decision support. These studies use various techniques to optimize multiple criteria in the supplier selection process and choose one supplier who would be most effective and suitable for the company who is seeking tenders from multiple suppliers.

In the current scenario, choosing only one supplier may not be prudent for a firm, for any requirement, even if the supplier has the necessary capabilities as this will increase the supplier bargaining power to a huge extent. In the current e-procurement scenario, sourcing raw materials or products from multiple suppliers may be more beneficial to the company. In such a context, the current study provides a methodology to classify suppliers into two classes, suitable and unsuitable. The suitable suppliers would be the class containing all the suppliers taking raw materials from who would be beneficial for the company. The unsuitable suppliers would form another class of suppliers from whom the company would not want to engage in a business contract. This ensures that the company will get a larger pool of suppliers choosing who would be beneficial for the company, while negating tenders from suppliers who would not be suitable for the company.

Thus the current study aims in providing decision support to the supplier prequalification stage only, and thus lower critical response time in one of the four phases in e-procurement. The study makes no attempt to check the existing criteria and their usefulness in an e-procurement scenario and does not attempt to add any criteria to the existing criteria for supplier selection.

3. METHODOLOGY PROPOSAL

4.1 NETWORK DESCRIPTION

In order to prequalify suppliers on an impartial and objective basis, both qualitative and quantitative knowledge should be fully utilized and analyzed. So a fuzzy neural network is being proposed for fulfilling this objective. A fuzzy neural network is a layered, feed-forward network that processes fuzzy set signals and/or has fuzzy set weights as was defined by Buckley and Hayashi (1994).

The proposed network is essentially a multi-layered network. The network will be made of essentially three hidden layers, one input layer and one output later.

The first layer will be the input layer that will take the inputs according to the items on the scale consisting of the criteria for supplier selection. The next layer will be the fuzzification layer and will convert the crisp and linguistic values from the scale to fuzzy values, each ranging from 0 to 1. The third layer will sum the fuzzified values of the items (from the scale) to map them against the criteria and add the degree of satisfaction the values provide on a fuzzy scale. The fourth layer will accept the fuzzy satisfaction values of each of the criteria for supply selection and sum them up, and then defuzzify them. The fifth layer will accept the defuzzified values and classify the data points.

4.2 NETWORK DESIGN

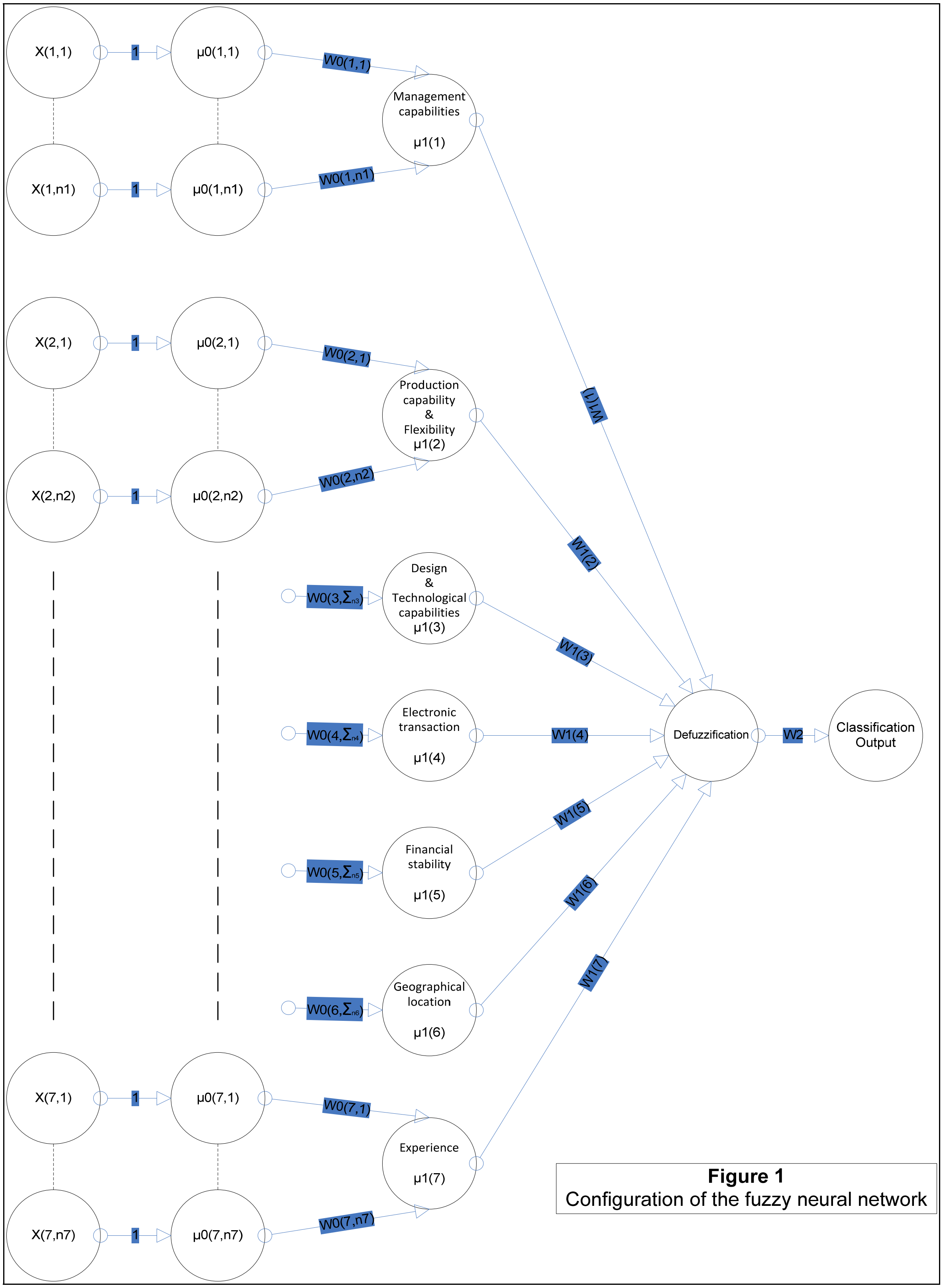

Figure 1
Configuration of the fuzzy neural network

4.3 LAYER DETAILS

In the first layer, the inputs to the nodes in the input layer X (i, j) would be the values of the items of the supplier selection scale, where i would be the i-th item for the j-th criteria on the scales, the criteria being among “management capability”, “production capacity and flexibility”, “design and technological capability”, “financial stability”, “electronic transaction”, “experience” and “geographical location”.

The next layer is the fuzzification layer. In this layer, for each of the response values generated for each item for the criteria in the scale, there would be degrees of satisfaction for the company, which would then be addressed by the fuzzification layer. In this layer the highest or the most satisfying value of the response would be converted to a 1 while the response value which would provide the lowest satisfaction, would be converted to a 0. Any value which would provide a lower satisfaction than is acceptable would also be converted to a 0 in this fuzzification layer. For doing this, there would be two models, M1 and M2, which would be defined as follows:

Model M1	$\mu_{i,j} = 1$	for $X_{i,j} \geq X_{max}$
	$\mu_{i,j} = (X_{max} - X_{i,j}) / (X_{max} - X_{min})$	for $X_{max} \geq X_{i,j} \geq X_{min}$
	$\mu_{i,j} = 0$	for $X_{i,j} \leq X_{min}$

Model M2	$\mu_{i,j} = 1$	for $X_{i,j} \leq X_{min}$
	$\mu_{i,j} = 1 - [(X_{max} - X_{i,j}) / (X_{max} - X_{min})]$	for $X_{min} \leq X_{i,j} \leq X_{max}$
	$\mu_{i,j} = 0$	for $X_{i,j} \geq X_{max}$

Model M1 would be used for fuzzyfying values of those items where a higher value would give the company more satisfaction. Similarly Model M2 would be used for fuzzyfying values of those items where a lower value would give the company more satisfaction.

Now the output of each fuzzification would be multiplied to the weight of the network branch connecting it to the node of the next layer, such that the weights would be indicative of the relative importance of each item of the scale for the particular criteria. The nodes of the next layer consist of the criteria checkers, where, for each criterion, the node will sum up the products of the fuzzified responses on its individual responses and the network weights. Again at this layer, this sum S_i will be fuzzified again against the minimal performance score to the actual score, as follows, for each criteria:

Model M3	$\mu_{i,j} = 1$	for $S_i \geq S_{max}$
	$\mu_{i,j} = 1 - [(X_{max} - X_{i,j}) / (X_{max} - X_{min})]$	for $S_{max} \geq S_i \geq S_{min}$
	$\mu_{i,j} = 0$	for $S_i \leq S_{min}$

For this step, the optimal performance range will have to be provided by the decision maker.

Now the output of these nodes will be multiplied with the weights of the connector to the node in the next layer. These weights would signify the relative importance of each criterion to the supplier selection decision making process. The sum of these products would be fed as input to the node in the last layer.

The input from the previous node would be denoted as Sup_Score. The Sup_Score for each supplier data point will be compared with a b-value which will be obtained after training the network as indicated in Model M4.

Model M4	Sup_Class = 1	for Sup_Score ≥ b
	Sup_Class= 0	for Sup_Score < b

Now if for any supplier, the Sup_Class value is 1, then the supplier would be classified as suitable, else if the Sup_Class value is 0, then the supplier would be classified as unsuitable.

4.4 DETERMINING WEIGHTS OF THE INTER LAYER NODES CONNECTIONS

The weights of the network would be determined using Analytic Hierarchy Process, which was first proposed by Saaty (1980) for usage in multi-criteria decision making. The relative importance of each criteria, i.e., the weights **W1(i)**, for i=1 to 7, and those of the sub-criteria, i.e., those of **W0(i, j)** for i=1 to 7 and j=1 to n_i, would be found out using the mentioned technique. Here there are ***i*** main criteria, each with $\mathbf{n_i}$ sub-criteria.

Say for a particular criterion, there are **n** items/sub criteria which affect it. For each of these items, the relative importance of each item/sub-criterion is found out using the 9 point Saaty scale. A key respondent of the firm which is implementing the proposed methodology would respond to the questionnaire to get the relative importance of each criterion and sub-criterion. The responses would be collected on a Saaty scale, as described below.

Rating	Definition
1	Equal importance
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus importance
7	Very strong importance
8	Very very Strong importance
9	Extreme importance

Table 1: Saaty scale

Item	1	2	3	-	-	n_i
1	$X_{1,1}$	$X_{1,2}$	$X_{1,3}$	-	-	$X_{1,ni}$
2	$X_{2,1}$	$X_{2,2}$	$X_{2,3}$	-	-	$X_{2,ni}$
3	$X_{3,1}$	$X_{3,2}$	$X_{3,3}$	-	-	$X_{3,ni}$
-	-	-	-	-	-	-
-	-	-	-	-	-	-
n_i	$X_{ni,1}$	$X_{ni,2}$	$X_{ni,3}$	-	-	$X_{ni,ni}$
	$\sum_{ni,1}X$	$\sum_{ni,2}X$	$\sum_{ni,3}X$	-	-	$\sum_{ni,ni}X$

Table 2: Relative importance table

The $X_{i,j}$ variables in the table indicate the relative importance of item I with respect to item j in the upper triangular matrix, the leading diagonal values all being 1, and the lower triangular matrix having the inverse values of the relative importance of item I with respect to item j. The summation of each column is done and then the relative contribution of Xi,j to the summation value of the column is calculated as follows:

Item	1	2	3	-	-	n_i
1	$X_{1,1}/ X_{ni,1}$	$X_{1,2}/X_{ni,2}$	$X_{1,3}/\sum_{ni,3}X$	-	-	$X_{1,ni}/\sum_{ni,ni}X$
2	$X_{2,1}/ X_{ni,1}$	$X_{2,2}/X_{ni,2}$	$X_{2,3}/\sum_{ni,3}X$	-	-	$X_{2,ni}/\sum_{ni,ni}X$
3	$X_{3,1}/ X_{ni,1}$	$X_{3,2}/X_{ni,2}$	$X_{3,3}/\sum_{ni,3}X$	-	-	$X_{3,ni}/\sum_{ni,ni}X$
-	-	-	-	-	-	-
-	-	-	-	-	-	-
n_i	$X_{ni,1}/ X_{ni,1}$	$X_{ni,2}/X_{ni,2}$	$X_{ni,3}/\sum_{ni,3}X$	-	-	$X_{ni,ni}/\sum_{ni,ni}X$

Let each decimal be denoted as $Y_{i,j}$ for each ratio in the above matrix. Now we compute the average of each row i as follows:

$W_i = (\sum_j Y_{i,j}) / n_i$

W_i is the relative weight of the item or construct for the i-th criteria or sub-criteria. After the relative weightage of each criteria and sub-criteria have been found out, the same is checked by first calculating the consistency index for each criteria and then comparing it with the specific random index, and then checking the consistency factor (the ratio of the consistency index and the random index) whether it is lower than 0.1. If the ratio is greater than 0.1, a second response is collected and the process is repeated, till consistency factor is obtained lower than 0.1.

4.5 STEPS FOR IMPLEMENTATION OF THE METHODOLOGY

The following steps should be followed in ordered sequence to classify the suppliers into two classes, suitable and unsuitable.

1) First the cleaned data set is to be developed so that for all the data points Sup_i, the data is available for all the r items (where r=n1 + n2 +.. + n7) so that the data set contains the records for **n** suppliers.
2) Now the entire data set is divided into two data subsets, one of which would be used to the train the method or find out the appropriate b level for the data of size n_1, and the other would be for testing the data of size n_2 so that $n_1 + n_2 = n$. Care should be taken so that the representation of suitable and unsuitable suppliers in n1 is sufficient and their numbers comparable.
3) Now we define a metric to calculate the actual classification error level **e** as follows: e = [(wrongly classified as unsuitable but actually suitable supplier count) + (wrongly classified as suitable but actually unsuitable supplier count)] / (total number of data points)

4) Then we define a boundary value **b-value** for classification of suppliers and an acceptable classification error level e-acc.

5) Now we use the training data set for the neural network and compare it to a particular b-value.
6) If for the given b-value, the classification error e exceeds e-acc we change the b-value as follows:
   a. If the error is more due to the wrong classification of suitable suppliers into unsuitable supplier class, lower the b-value by Δ.
   b. If the error is more due to the wrong classification of unsuitable suppliers into suitable supplier class, increase the b-value by Δ.
   c. Return to step 5 after changing the b-value
7) The previous step is repeated until (e ≤ e-acc) is achieved.
8) The corresponding final b-value is used to classify the second set of n_2 records by using the n_2 data points the testing data set.

The proposed sequence of steps achieves classification in broadly two steps. In the first step, the network is trained, while based on the training, in the next step, the rest of the data points are classified.

In the first step, the data mart is prepared by cleaning the available data. In the second step, the data is divided into two subsets, such that, one may be used for training, while the other may be used for testing the capabilities of the methodology. The type of data in the training set would also affect the b value, and hence the classification output in the next stage. Thus it would be necessary to have sufficient representation of both the classes in the training data set to obtain an ideal b-value, so that prediction of classes may be done optimally.

After the b value is obtained, during classification phase, if the b value is increased on the test data, it will serve to choose the better suitable suppliers amongst all the suitable suppliers. Thus, by changing the b-value, it will be possible to actually get the subset of the best "n" suppliers, from a class of suitable suppliers. Conversely, if sufficient suitable suppliers are absent, lowering the b-value nominally will present the decision maker with the set of the most suitable suppliers amongst the otherwise unsuitable set of suppliers.

4. CONCLUSION

In this paper, a classification scheme using fuzzy neural networks has been proposed for supplier classification in an e-procurement scenario. The proposed methodology has ensured that the relative importance of each criterion and the relative importance of each item in their scale have been considered thoroughly in the supplier classification process.

The addressing of the problem of choosing suitable suppliers will ensure that the time spent on the prequalification of suppliers will be minimized to a large extent by automating much of the process. This solution will also ensure that the company will get a larger pool of suppliers choosing who would be beneficial for the company, while negating tenders from suppliers who would not be suitable for the company, thus keeping a healthy supplier bargaining power.

No attempt has been made in this paper to redefine or add criteria for the selection of suppliers in an e-procurement scenario. The study adapts already developed criteria and provides decision support to select suitable suppliers from a pool of suppliers, or rather classify a pool of suppliers into suitable and unsuitable supplier classes.

Thus, the sole focus of this paper is to provide decision support for the e-procurement division of a company for choosing its suppliers when multiple suppliers float tenders for a particular call for tenders.

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