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A Priority Based Pre-Calculated Weight Fuzzy Neural Network for Supplier Selection in E-Procurement System

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Abstract

E-Procurement, also known as electronic procurement is the purchase and sale of supplies, equipment, works and services through a web interface or other networked system. Multiple vendors or suppliers may show their interest to be in a contract with the authority that needs goods or services. So, supplier selection is an important task to ensure the quality of goods and services. Another important factor is considering the expenditures of multiple vendors against the quality of goods and services they offer.

In this paper, a process of supplier selection is designed for the adoption of e-procurement from the perspective for goods like computer or computer accessories. Several criteria and constraints are proposed based on requirement and modeled using fuzzy neural network based on criteria and feature priority. Then the suppliers have been ranked from the viewpoint of the hiring authority.

Keywords—Multi-objective decision making, e-procurement, fuzzy neural network, supplier ranking, feature priority, Cross-pricing, Fuzzification.

Introduction

The procurement system of a country is an influential factor not only for the national economy of that country but also for various important functions of government. The use of information and communication technology (ICT) in the governments' administrative and decision making processes is being seen from the last decade. One of the most important activities of government is public procurement process. So, there is nothing to wonder that ICT solutions to public procurement, the e-procurement system, are the essential initiative in this decade.

The traditional procurement process, which requires petitioners to go to the government office, to submit their bids, was subject to various collusive and corrupt practices from those who engaged in the bidding processes. The bidders who are involved in politics for local government could physically stop non-collusive bidders from submitting their documents by applying pressure and having the documents stolen – known as "tender snatching".

Such malpractices of traditional procurement process can be avoided through exercising e-procurement system which may ensure equal opportunity for all bidders. So, the result of practicing e-procurement system would be the increased competition and lower cost for the government or hiring authorities. E-procurement systems being used in different countries are not up-to the mark yet. It needs to be done more users friendly and automatic using some of the artificial intelligence and data analytics. More competitive suppliers are being searched by manufacturing firms constantly for reducing manufacturing cost[c]. The system requires a systematic rigorous analysis to make it more effective both for the government and the vendors. A qualitative systematic research is required to e-procurement decision making is that of supplier selection process make the existing system more effective.

The pressure being faced by manufacturing firms includes reducing manufacturing cost and quickly delivers high quality products to meet sophisticated demand. Thus many firms turn to outsource the key components or products to suppliers. That's why, supplier selection and management has become significant for successful organizational management[c,1]. A fuzzy analytic hierarchy process was developed by Lin and Lin [h,5] to identify significant criteria for selection of raw material suppliers by Taiwanese processors of the dried roe of striped mullet Mugil cephalus. Hsu et al. [h,6] proposed the quality-based supplier selection with fuzzy quality data. The resolution identity result was applied to solve non-linear programming problems.

The purpose of this research is to finding suitable suppliers by modeling a multi-objective decision making process using fuzzy neural network.

Methodology

In order to select the best supplier among all bidders, qualitative and quantitative information should be fully utilized in a proper analytical approach. The approach is designed and developed in this section with detailed explanation. The approach involves following seven steps:

1. Requirement description and supplier's information acquisition system.
2. Mandatory criteria identification for product and supplier.
3. Supplier rejection.
4. Prioritizing product's feature.
5. Ranking criteria of suppliers.
6. Design of a fuzzy neural network to rank suppliers.
7. Best supplier selection.

A. Requirement Description and Supplier's Information Acquisition

Under the current infrastructure, the e-procurement system of different countries provides an online platform to carry out procurement activities. It is a web portal from where Procuring Agencies (PAs) and Procuring Entities (PEs) would be able to perform procurement activities using a dedicated secured web based dashboard. To be a user of this e-GP system, a new user has to be registered according to the following flowchart.

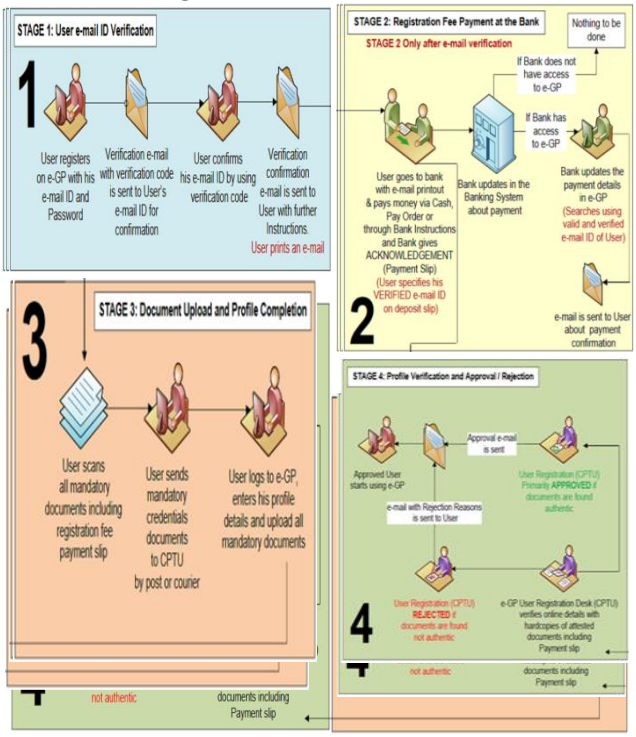

Figure: New user registration procedure in e-GP system

The hiring authorities provide their requirement description about the products and the suppliers and also the budget information to the users through web page and collect necessary documents and information from them through web forms. The users describe the specifications of products they can supply with their budget and also provide necessary documents for verification and validation through the web forms to the authorities. Then these information and documents are analyzed and validated manually to select the appropriate supplier. This manual supplier selection and validation process may involve corruption and decrease transparency and thus the purpose of e-procurement system may fail for these reasons. In the next steps, how supplier can be selected automatically is described using the information they provides.

B. Mandatory Criteria Identification for Product and Supplier

When the requirement description of a product is prepared and the suppliers' information acquisition forms are made, the hiring authority may make some criteria mandatory for all bidders. From the perspective of products, criteria can be:

- Some specifications
- Reasonable pricing

The authority may fix some specifications of the product as mandatory. For example, we can consider that the government may want to buy some computer for the education sector with a mandatory condition that all computers have to be of 8th generation. There can be more than one mandatory specifications based on the requirement of the authority.

Another mandatory condition may be imposed on pricing a product. The price of a product that is offered by a bidder has to be reasonable. Very low cost may reduce the quality of the product and very high cost may reduce profit and budget of the authority. Again cross pricing (*i.e.* very low price for some product and very high price for some product) is a secret hole for the bidders for making high profit. To ensure reasonable pricing, the authority may consider a range of price for a specific product analyzing the current market price of that product. If the offered price is in that range, then the bidder will be eligible for further steps.

From the perspective of the supplier, criteria can be:

- Validation
- Verification

To perform a bid, a supplier must have to be a valid user of the e-GP system. It is ensured by email and password validation.

After the validation process, some mandatory documents provided by the bidder have to be verified automatically. These documents may involve: national identity card, trade license, bank statements, taxation statements etc.

Under the current infrastructure, the NID verification is not a tough job. But the challenge is verifying the other documents automatically because of not having dynamic online platforms of document issuing sectors. Some document issuing sectors have partially automated online platforms but those are not synchronized properly for the verification of all documents issued by those sectors. Thus, the infrastructural improvement and synchronization is required for fully automated verification.

C. Supplier Rejection

The mandatory criteria, introduced by the authority have to be fulfilled by the supplier for further selection procedure. If any mandatory criterion is not fulfilled by a bidder, that bid will be considered as disqualified and will be rejected by the system before further operations automatically.

Thus, the mandatory criteria of an announcement of tender have to be identified carefully by the authority. Only the most important and frequently required criteria should be identified as mandatory. In this step, a short list of bidders will be produced for the further steps by rejecting some bidders who haven't fulfilled the mandatory criteria.

D. Prioritizing Product's Features

The suppliers will provide information about the features of the product offered by them. For selecting the best supplier for a considered tender, authority can prioritize the features of the product. The supplier with the product of highest priority has better chance to be selected. The following features or attributes of a product can be prioritized for supplier selection:

- Brand
- Origin
- Generation
- Price
- Packaging
- Guarantee and Warrantee
- Lifespan

Let's consider a tender to buy some computer. The authority may prioritize the brands of computer using numeric value as -

Brand	**Priority**
Apple	7
HP	6
Dell	5.5
Lenovo	5
Asus	4.5
Acer	4
Toshiba	3.8
Others	3.5

Table: Example of Brand Prioritizing

Similarly, other features can be prioritized based on their value and the requirement of the user. Total priority value for all features of the product will have an important impact for the selection of supplier.

E. Ranking Criteria of Suppliers

Suppliers in the e-procurement system can be considered in terms of several criteria. An e-procurement platform is a place of competition for the suppliers and to find the suitable supplier, these criteria can be used in an efficient way. In an e-procurement system, a supplier can be considered based on the follow criteria:

- Experience
- Service
- Documents
- Location
- Delivery
- Risk

A bidder may have a long term experience as a supplier. He or she would have maximum priority in the field of experience. Again the experience can be in the similar field of tender or can be in the different field. If the field is similar, the priority will be larger. So, the experience can be considered in terms of-

- Duration of experience and
- Field of experience.

The services offered by bidders can be ranked to find the best bidder. Services may include-

- Repairing
- Payment in installment
- Replacement

The bidders may have several documents like bank statement, experience certificate, previous contracts etc. These documents can be ranked after automatic verification with the purpose of finding suitable bidder.

The location of supplier is a factor to contact him when required. Location of the supplier is also

important to receive the services offered by the supplier.

Delivery of the product is a criterion which should be analyzed to select suitable supplier. Because the criterion delivery involves the following factors-

- Cost of delivery and
- Duration of delivery.

Risk assessment factors should be analyzed for the supplier which includes-

- Financial credibility
- Fulfillment of legal requirement
- Business loyalty
- Electronic transaction

F. Design of A Fuzzy Neural Network to Rank Suppliers

To fulfill the objective of prequalifying suppliers, both qualitative and quantitative information have to be utilized in a technically sound manner. For the fulfillment of this objective, a fuzzy neural network is being proposed. The proposed fuzzy neural network is a multi-layered neural network having three hidden layers, one input layer and one output layer. The whole network is actually divided into two individual portion and they are combined in the output layer. The first portion of the network contributes in decision making through analyzing features of the product. The second portion of the network contributes in decision making through analyzing the criteria of suppliers.

First layer of the network is the input layer. Input for the first portion of the network is the numeric values of features of the product. Input for the second portion is the crisp and linguistic values derived from the criteria of suppliers.

Second layer of the network is the 'Feature Prioritizing' and 'Criteria Fuzzification' layer. First portion of second layer is for the use of priorities of features.

Let's consider the set X= {F_1, F_2, ……, F_i} is the set of features of the product. Each element of X, F_n may has multiple values based on the number of priority defined by the authority. Thus, each element F_n may have multiple priority values. The maximum value of a feature is expressed by F_n^{max}.

The set of all maximum priorities of all features is expressed as, $F^{max} = \{F_1^{max}, F_2^{max}, ….., F_i^{max}\}$.

The weight for the first portion of second layer is calculated as-

$$W_1 = \frac{1}{\sum Fmax}$$

W_1 is multiplied with the inputs of first portion and the prioritized feature values become within 0 and 1.

$$F_{2n} = W_1 \times F_{1n}$$

Second portion of second layer is for the use of crisp and linguistic values derived from the criteria of suppliers. A numeric value is assigned for each crisp or linguistic value of criteria by the hiring authority.

Let's consider the set Y= {C_1, C_2, ……, C_j} is the set of criteria of a supplier. Each element of Y, C_n may have multiple values based on the number of crisp or linguistic values defined by the authority. Thus, each element C_n may have multiple numeric values according to the satisfaction of the authority. The maximum value of a criterion is expressed by C_n^{max}. Thus, the fuzzification is performed.

The set of all maximum values of all criteria is expressed as, $C^{max} = \{C_1^{max}, C_2^{max}, ….., C_j^{max}\}$.

The weight for the second portion of second layer is calculated as-

$$W_2 = \frac{1}{\sum Cmax}$$

W_2 is multiplied with the inputs of second portion and the fuzzy criteria values become within 0 and 1.

$$C_{2n} = W_2 \times C_{1n}$$

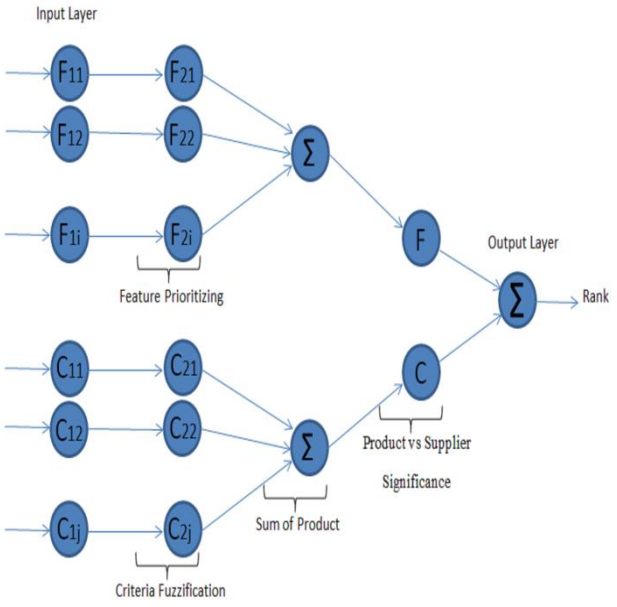

Figure: Configuration of Fuzzy Neural Network

Third layer is named 'Sum of Product' layer. Values coming from the second layer are summed individually for first and second portion in this layer.

The fourth layer is the last of three hidden layers and named 'Product vs. Supplier Significance' layer. The authority may give more priority either on the

quality of the product or on the criteria of the supplier.

Let the hiring authority defines the relative priority of product and supplier by two numeric variables a and b respectively.

The weight for the first portion of fourth layer is calculated as-

$$W_F = \frac{a}{a+b}$$

W_F is multiplied with the inputs of first portion as-

$$F = W_F \times \text{input}$$

The weight for the second portion of fourth layer is calculated as-

$$W_C = \frac{b}{a+b}$$

W_F is multiplied with the inputs of first portion as-

$$C = W_C \times \text{input}$$

The output of two individual portions of the network is combined in the fifth or output layer. Two outputs of fourth layer are summed and the value of the sum is the rank of a supplier considering all qualitative and quantitative information.

G. Best Supplier Selection

Analyzing the qualitative and quantitative information provided by bidders, the designed network will assign a numeric value termed as 'rank' for all bidders. The bidder with the highest value of rank will be treated as the best supplier for a certain announcement of tender. The system will confirm the best bidder automatically without involving any manual operations.

Conclusion

A fuzzy neural network based e-procurement system is designed from the perspective of OECD countries in this paper. Significant potential can be presented through e-procurement solution with a number of tangible and intangible benefits. The framework proposed in this paper for the products like computer or computer accessories. This framework may have to be altered for other types of goods or services.

The implementation of this framework to solve the current issues of existing procurement system in OECD countries may have to face some challenges. One of the worst challenges is verifying all documents automatically because of the manual system of document issuing sector. Besides, the administrative infrastructure needs to be slightly modified to implement and execute the presented solution in a proper way.

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