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A neural networks approach for forecasting the supplier's bid prices in supplier selection negotiation process

Chun Ching Lee, C. Ou-Yang *

Department of Industrial Management, National Taiwan University of Science and Technology, 43, Keelung Road, Section 4, Taipei 106, Taiwan

Abstract

Supplier selection negotiation is a sophisticated and challenged job due to the diversity of intellectual backgrounds of the negotiating parties, the many variables involved in supply–demand relationship, the complex interactions and the inadequate negotiation knowledge of project participants. To do the job well, it is necessary to develop an intelligent system for negotiation support in supplier selection process. Therefore, an artificial neural network-based predictive model with application for forecasting the supplier's bid prices in supplier selection negotiation process (SSNP) is developed in this paper. By means of the model, demander can foresee the relationship between its alternative bids and corresponding supplier's next bid prices in advance. The purpose of this paper is applying the model's forecast ability to provide negotiation supports or recommendations for demander in deciding the better current bid price to decrease meaningless negotiation times, reduce procurement cost, improve negotiation efficiency or shorten supplier selection lead-time in SSNP.

Keywords: Supplier selection negotiation process; Artificial neural networks; Bid price forecast

1. Introduction

Supplier selection strategy is a critical issue in a supply chain management (SCM) system. Its outcomes impact relationships, profitability and reputation of businesses. Most of supplier selection processes are based on bidding and negotiation mechanism (Cakravastia & Nakamura, 2002; Cakravastia & Takahashi, 2004; Cakravastia, Toha, & Nakamura, 2002; Murthy, Soni, & Ghosh, 2004; Sadeh & Sun, 2003). In general, the negotiation decision of supplier selection usually depends on experience of managers. Negotiations in industries are often inefficient due to the diversity of intellectual backgrounds of the negotiating parties, the many variables involved, the complex interactions and the inadequate negotiation knowledge of project participants (Ren & Anumba, 2002). Situated in the strange and changeful environment, it is necessary to develop an intelligent system for negotiation support in supplier selection process to reduce dependence on personal experience, forecast the preference of opponents, improve negotiation decision quality and shorten required negotiation time. There has been an increased interest in autonomous interacting software agents for negotiation support. Zeng and Sycara propose a sequential decision-making negotiation model, which provides an adaptive, multi-issue negotiation model capable of exhibiting a rich set of negotiation behaviors (Zeng & Sycara, 1998). Faratin et al. present a formal model of negotiation between autonomous agents, which defines a range of strategies and tactics that agents can employ to generate initial offers, evaluate proposal and offer counter proposals (Faratin, Sierra, & Jennings, 1998). Ren and Anumba state that multi-agent system (MAS) offer an innovative approach towards reducing the tremendous time and human resources invested in negotiation and present an agent learning approach integrated in MAS for construction claims negotiation (Ren & Anumba, 2002). To increase the social welfare of agents, Faratin et al. present a trade-off strategy where multiple

* Corresponding author. Tel.: +886 2 27376340.
E-mail address: ouyang@im.ntust.edu.tw (C. Ou-Yang).

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negotiation decision variables are traded-off against one another (Faratin, Sierra, & Jennings, 2002). Following Faratin et al. (2002), Jonker and Robu model a mechanism in which agents are able to use any amount of incomplete preference information revealed by the negotiation partner to improve the efficiency of the reached agreements (Jonker & Robu, 2004).

Intelligent systems for negotiation support that aim at enhancing the negotiator's abilities to understand the counterparts, their needs and limitations and to predict their moves could be very valuable tools to be used in negotiation tasks (Carbonneau, Kersten, & Vahidov, 2008; Zeng & Sycara, 1998). The ability of agents to learn from their previous interactions with other agents or their environment is very important to achieve better negotiation results (Rau, Tsai, Chen, & Shiang, 2006). Inspired by biological systems, particularly by research into the human brain, artificial neural network (ANN) is an information processing system that mimics the brain's ability to classify patterns, to learn or to make forecasts based on past experience (Choy, Lee, Lau, Lu, & Lo, 2004; Cooper, 1999; Lee, Jung, Eum, Park, & Nam, 2006; Zhang, Patuwo, & Hu, 1998). As opposed to the traditional model-based methods, ANNs are data-driven self-adaptive methods in that there are few a priori assumptions about the model for problems. They learn from examples and capture subtle functional relationships among the data even if the underlying relationships are unknown or hard to describe. Thus, ANNs are well suited for problems whose solutions require knowledge that is difficult to specify but for which there are enough data or observations (Zhang et al., 1998).

With the excellent features, ANNs are being applied for a wide variety of fields. Wei et al. used the determinant factors: performance, quality, geography and price of supplier selection as inputs to a neural network model to select supplier (Wei, Zhang, & Li, 1997). Boussabaine and Kaka introduce neural networks as an alternative approach for cost flow forecasting to those mathematical and statistical methods (Boussabaine & Kaka, 1998). Szkuta et al. use ANNs computing technique to forecast the system marginal electricity price (Szkuta, Sanabria, & Dillon, 1999). Cooper applies the back-propagation algorithm to a problem from the field of international economics (Cooper, 1999). In early phases of product design, Bode uses the data classification and function approximation properties of neural networks to estimate product cost (Bode, 2000). Chiu and Lin propose the application of the agent concept and ANN approach to formulate a paradigm of collaborative supply chain planning (Chiu & Lin, 2004). Choy et al. present an intelligent supplier relationship management system using hybrid case based reasoning and ANNs techtiques to select and benchmark potential suppliers (Choy et al., 2004). Lee et al. apply neural network theory to develop an effective allocation policy in supply chain for recognizing actual demands from the previous buyers' orders (Lee et al., 2006). In the ANNs-based negotiation research area, Rau et al. develop a learning model to learn the opponent's preference, concession tactic and issues' weights in negotiation process (Rau et al., 2006). Carbonneau et al., present an approach using ANN to modeling the negotiation process in a time-series fashion. The network uses information about past offers and the current proposed offer to simulate expected counter-offers (Carbonneau et al., 2008).

From the above literature reviews, it can be found that the issues related to supplier selection negotiation process and improve its negotiation efficiency are little addressed. Basically, the outcomes of bilateral negotiation process are influenced by reservation prices, power, times pressure and concession tactics of both-side negotiators (Balakrishnan & Eliashberg, 1995). However, in supplier selection negotiation process, in addition to the factors above, order quantity, due date, quality and production relevant costs, scheduling plans and capacity of suppliers further affect the supplier selection negotiation results and efficiency (Cakravastia & Nakamura, 2002; Cakravastia & Takahashi, 2004; Cakravastia et al., 2002; Lee & Ou-Yang, in press; Murthy et al., 2004; Sadeh & Sun, 2003). Therefore, the environment of supplier selection negotiation process is interactive, dynamic and many variables involved. This makes the negotiation process outcomes are hard to describe, analyze and forecast by traditional statistical model. In this regard and following (Lee & Ou-Yang, in press), an artificial neural network-based (ANN) predictive model with application for forecasting the supplier's bid price of each round in supplier selection negotiation process is proposed in this paper. The purpose of this paper is applying the model's forecast ability to provide negotiation supports or recommendations for demander in deciding the better current bid price. That is the demander can foresee the supplier's next offer in advance to decrease meaningless negotiation times, reduce procurement cost, improve negotiation efficiency or shorten supplier selection lead-time.

The rest of this paper is organized as follows. Section 2 describes the research background of the supplier selection negotiation process and interactive bidding strategy in it. The artificial neural network-based predictive model is developed in Section 3. Section 4 presents the training and test procedures of model. The training and test results are provided in Section 5. Section 6 describes the applications and advantages of the ANN predictive model. Section 7 addresses the conclusions.

2. Supplier selection negotiation process framework

In the section, the supplier selection negotiation process (SSNP) and interactive bidding strategies for both-side parties presented in Lee and Ou-Yang (in press) are reviewed. After that, an approach to establish a better bidding strategy for demander to obtain more efficient negotiation is proposed. The framework of supplier selection negotiation process is depicted in Fig. 1. It contains of four entities: a set of suppliers, a supplier selection auction market