International Journal of Information Technology and Business Management

29th November 2012. Vol.7 No.1

ISSN 2304-0777 www.jitbm.com

A TAXONOMY AND REVIEW ON SUPPLIER SELECTION METHODS UNDER UNCERTAINTY

Atefeh Amindoust [a], Shamsuddin Ahmed [a], Ali Saghafinia [b]

[a] Faculty of Engineering, University of Malaya, Malaysia

[b] Faculty of Engineering, University of Malaya, Malaysia

Email: atefeh_amindoust@yahoo.com

ABSTRACT

Assessment of potentially competent **s**uppliers and selection of the right one(s) is a vital component of supply chain management which has received wide attention in recent years. An extensive range of decision making methods have been suggested to handle the supplier selection problem by a large number of authors in this area. The supplier selection problem is often faced by ambiguity and vagueness in practice and very often decision makers express their preferences in linguistic terms instead of numerical values. So, this paper intends to review the literatures on multi-criteria decision making methods in uncertain environment. Thirty-eight international journal articles published between 2008 and 2011 have been surveyed for this purpose. The articles are analysed to summarize the existing methods and the most popular method is identified and presented in this paper. Finally, suggestions for future researches are proposed for academics and decision makers.

Keywords: Supplier Selection, Multi- Criteria Decision Making, Uncertainty

1. INTRODUCTION

Due to the recent agile improvement of network technology and economic globalization, purchasing management has come to play a critical role as a key to business success in supply chain management. One of the crucial challenges confronted by purchasing managers is the evaluation and selection of suppliers. Existing researches in the field of supplier selection have been applied multi-criteria decision making methods, such as analytic hierarchy process (AHP), analytic network process (ANP), artificial neural network(ANN), data envelopment analysis(DEA), fuzzy set theory, mathematical programming, technique for order preference by similarity to ideal solution(TOPSIS), and their hybrids. The supplier selection problem is often faced by ambiguity and vagueness in practice and very often decision makers express their preferences in linguistic terms instead of numerical values.

There are at least five journal articles reviewing the literature regarding supplier evaluation and selection models (Weber et al. 1991; Holt 1998; Degraeve et al. 2000; de Boer et al. 2001; Ho et al. 2010). Since these articles review the literature up to 2008, this paper extends them through a literature review and taxonomy of the 38 international journal articles which have been focused on uncertainty in supplier selection between 2008 and 2011. This paper presents a comprehensive review of literature to identify the existing supplier selection methods in uncertain environments and determine the most popular ones.

2. RESEARCH METHODOLOGY

For a review article that is prepared basically to locate the further research needs authentic sources of knowledge is considered important. A comprehensive reference of the academic literature on supplier evaluation and selection was

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

obtained through the following four online journal databases:

- Web of science
- Science direct
- Emerald
- Springer

The literature search was conducted based on the key words "supplier selection", and "vendor selection". First the full text of each article was read to omit the articles that were not related to evaluation methods and evaluation criteria for supplier selection. Conference papers, master's and doctoral dissertations, textbooks and unpublished working papers were not included.

3. METHODS OF SUPPLIER SELECTION

Quite a few significant qualitative and quantitative methods are being applied in the area of interest. These can be broadly classified under single and hybrid categories. Some of the important methods under uncertainty are briefed in the following sections.

3.1 Single Method

Three out of thirty eight articles (7.89%) were written based on the application of one single method under uncertainty to evaluate the performance of suppliers and select the most suitable ones.

3.1.1 Fuzzy set theory

Wang (2010) proposed a fuzzy linguistic multi-agent model to cope with heterogeneous information and to prevent information loss problems in the supplier evaluation issue. The model was based on 2-tuple fuzzy linguistic information which composed of a linguistic term and a number (W. P. Wang 2010).

3.1.2 Fuzzy inference system

Carrera and Mayorga (2008) provided an application of fuzzy set theory to handle uncertainty in the supplier selection process. Fuzzy Inference System approach was applied to convert the multi-objective problem into a single one along four modules (Carrera and Mayorga 2008).

3.1.3 Vague sets

Zhang et al. (2009) implemented vague sets group decisions to handle the problem of supplier selection in uncertain environments. The model not only considered the relative importance of different decision-makers, but also included the accordance and difference in the decision group. To rank the suppliers, the judgments of all the decision-makers were integrated into a decision matrix (D. Zhang et al. 2009).

3.2 Hybrid and innovative Methods

Thirty five out of thirty eight articles (92.1%) applied hybrid methods under uncertainty to evaluate the performance of suppliers and select the best ones. Since, decision makers express their preferences in linguistic terms instead of numerical values; the supplier selection problem is often faced by ambiguity and vagueness in practice. In such circumstance fuzzy logic and fuzzy set theory are used to handle these uncertainties.

3.2.1 Hybrid fuzzy-mathematical programming

Ten out of thirty five hybrid fuzzy methods (28.6%) used hybrid fuzzy- mathematical programming method for the supplier selection problem. In this group, hybrid fuzzy-mathematical programming was integrated with other models such as AHP and SWOT (Strengths, Weaknesses, Opportunities and Threats) in some articles.

Ozgen et al. (2008) used AHP to calculate the weights of the alternative suppliers for selecting the best ones. Then fuzzy theory was implemented to handle the imprecision data and consequently a multi-objective probabilistic linear programming approach was suggested to allocate order quantities to selected suppliers (Özgen 2008).

Sevkli et al. (2008) integrated fuzzy linear programming model with AHP to address

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

fuzziness issue and to take in to account of resource constraints in the supplier selection problem. The weights of the various criteria were calculated using AHP, were considered as the weights of the fuzzy multi-objective linear programming model (Sevkli et al. 2008).

Amid et al. (2009) developed a fuzzy multi objective model to handle simultaneously the imprecision of data and determine the order quantities based on price breaks for each supplier. In this model, the weighted additive rule was applied to cope with the unequal importance of fuzzy goals and fuzzy constraints (Amid et al. 2009).

Chen (2009) suggested a decision support model for supplier selection and order allocation problems. An interactive procedure based on past problem solving experiences was applied through a fuzzy-based mathematical programming approach to incorporate multiple uncertain criteria under the demand constraint of multiple items with varied importance to the purchasing firm (C. M. Chen 2009).

Guneri et al. (2009) proposed fuzzy linear programming model to solve multiple sourcing supplier selection problems. Linguistic variables in the form of trapezoidal fuzzy numbers were used to assess the importance weight of each criterion and the ratings of suppliers with respect to each criterion. The distances between alternative suppliers and fuzzy positive and negative ideal solutions were calculated to obtain closeness coefficients for using as coefficients of each supplier in linear programming model (Guneri et al. 2009).

Wang and Yang (2009) applied a multi objective linear programming model for allocating order quantities to each supplier in quantity discount environments. In this model, AHP was applied to calculate the weights of the objective functions for each criterion. Then the multi-objective model was reformulated into a fuzzy compromise programming approach to have a more reasonable compromise solution (T. Y. Wang and Yang 2009).

Amid et al. (2010) developed a weighted max–min fuzzy multi-objective model to complete the Amid et al.'s work in 2009 for supplier selection and order allocation problems. The current model considered imprecision of data and varying importance of quantitative/qualitative criteria. AHP was used to determine the weights of criteria in the model (Amid et al. 2010) .

Amin et al. (2010) suggested a strategic model for supplier selection which included two stages. In the first stage, fuzzy logic was integrated with quantified SWOT algorithm. In the second stage, the output of SWOT algorithm was implemented as an input in a fuzzy linear programming model to determine the order quantity (Amin et al. 2010) .

Diaz-Madronero et al. (2010) applied fuzzy multi objective linear model for vendor selection problem. A non-linear membership function called *S*-curve was utilized in this model. To find a preferred compromise solution for the model, an interactive solution methodology was suggested (Díaz-Madroñero et al. 2010).

Yucel and Guneri (2010) proposed a weighted additive fuzzy programming approach for supplier selection and order allocation problems. Linguistic variables were used to assess weights of the factors as trapezoidal fuzzy numbers. The weights were obtained by applying a procedure to calculate fuzzy positive ideal rating and fuzzy negative ideal rating for applying in a fuzzy multi-objective linear model (Yucel and Guneri 2010).

3.2.2 Hybrid fuzzy- AHP

Nine out of thirty five fuzzy hybrid methods (25.7%) used hybrid fuzzy –AHP methods for the supplier selection. In this group, hybrid fuzzy-AHP was integrated with other models such as interpretive structural modelling (ISM), goal programming, TOPSIS, structural equation modelling (SEM), and DEA.

Yang et al. (2008) employed ISM approach to clarify the relationships among the sub-criteria in the vendor selection problem. The fuzzy AHP method was used to compute the relative weights for each criterion. Also, the non-additive fuzzy integral was applied to obtain the fuzzy synthetic

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

performance of each criterion. Finally, the best vendor was determined according to the overall aggregating score of each vendor using the fuzzy weights with fuzzy synthetic utilities (Yang et al. 2008).

Lee (2009) applied a fuzzy AHP model with the consideration of opportunities and risk besides benefits and costs for buyers to select the best suppliers (Lee 2009).

Lee et al. (2009) operated fuzzy AHP to analyze the importance weights of multiple factors in the supplier selection problem. These weights were used as the coefficient of goals in the goal programming model (Lee et al. 2009).

Wang et al. (2009) developed fuzzy hierarchical TOPSIS method to simplify the complicated metric distance method which had been applied by Chen et al. (2005) and to rectify Chen's fuzzy TOPSIS idea (2000) in the supplier selection problem. In the modified model, fuzzy AHP was used to calculate the fuzzy weight of each criterion. Also, the weights were inserted to TOPSIS method for ranking suppliers (J. W. Wang et al. 2009).

Chamodrakas et al. (2010) suggested an approach to modify Mikhailov's fuzzy preference programming method (2000) according to Liberatore's rating scale AHP method (1987) for the supplier selection problem in an electronic marketplace environment. A Simon's satisfying model was used for supplier pre-qualification and the modified rating-scale AHP version fuzzy preference programming method was applied for final supplier evaluation (Chamodrakas et al. 2010).

Ku et al. (2010) utilized fuzzy goal programming considering the manufacturer's supply chain strategies for the supplier selection problem. Fuzzy AHP was applied to calculate the relative weights of criteria and then the weight numbers were used as goals' coefficients in objective function of fuzzy goal programming to determine the optimal order allocation (Ku et al. 2010).

Jolai et al. (2010) employed fuzzy AHP to calculate the importance weights of criteria and a modified fuzzy TOPSIS approach to gain the scores of alternative suppliers in multi product environment. Also, the goal programming method was applied to construct a multi-objective mixed integer linear programming model to determine the quantity of order allocation to each selected supplier in each period (Jolai et al. 2010).

Punniyamoorthy et al. (2011) employed SEM approach to obtain the relative weights of the quantitative and qualitative criteria in the supplier selection problem. Fuzzy AHP was used to gain the relative weights of suppliers to achieve supplier selection score (Punniyamoorthy et al. 2010).

Zeydan et al. (2011) applied fuzzy AHP model to find criteria weights and also fuzzy TOPSIS model to rank the suppliers. In this model, qualitative variables were transformed into a quantitative variable for using in DEA approach as an output to determine the efficient and inefficient suppliers (Zeydan et al. 2011).

3.2.3 Hybrid fuzzy-TOPSIS

Five out of thirty five fuzzy hybrid methods (14.3%) used hybrid fuzzy -TOSIS method for the supplier selection problem. In this group, some methods such as mathematical programming, SWOT, DEA, and Decision-Making Trial and Evaluation Laboratory (DEMATEL) were integrated with hybrid fuzzy-TOPSIS in some articles.

Boran et al. (2009) applied fuzzy set to determine the importance of each criterion and the score of each supplier with respect to each criterion in the supplier selection problem. Also intuitionist fuzzy averaging operator was used for aggregation of expert opinions. The fuzzy numbers were passed to TOPSIS model for ranking suppliers (Boran et al. 2009).

Awasthi et al. (2010) applied fuzzy TOPSIS method to generate an overall performance score for each supplier in supply chain. The sensitivity analysis was performed to present the impact of criteria weights on decision making process (Awasthi et al. 2010).

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

Chen (2010) suggested a strategically method based on SWOT analysis to identify the criteria of the supplier selection process. First, potential suppliers through DEA approach were screened to efficient and inefficient groups. Then membership functions for the fuzzy weights of criteria were calculated and the efficient suppliers were ranked through TOPSIS model (Y. J. Chen 2010).

Dalalah et al. (2011) employed DEMATEL to determine the cause and effect relationship between criteria in the supplier selection problem. The DEMATEL model was modified to handle fuzzy rating and linguistic evaluations. Also, the overall importance weights of all criteria were shifted to modified TOPSIS model to find the best supplier (Dalalah et al. 2011).

Soner Kara (2011) applied fuzzy TOPSIS method to rank suppliers in unknown environment. Furthermore a group of ranked suppliers were shifted in to a two-stage stochastic programming model to determine order quantities under demand uncertainty. (Soner Kara 2011).

3.2.4 Hybrid fuzzy- ANP

Four out of thirty five fuzzy hybrid methods (11.4%) used hybrid fuzzy- ANP method for the supplier selection problem. In this group, hybrid fuzzy- ANP was integrated with another model such as TOPSIS. Also various kinds of fuzzy models were used in some articles.

Lin (2009) integrated the Fuzzy preference programming method with ANP to measure the weights of the suppliers. Then, the weights were used as coefficients in the objective function of the multi-objective linear programming model to obtain optimal allocation of orders (R. H. Lin 2009).

Onut et al. (2009) applied fuzzy ANP to calculate criteria weights in the supplier selection problem. Then these weights were shifted to the fuzzy TOPSIS methodology to rank the suppliers (Önüt et al. 2009).

Buyukozkan and Cifci (2010) utilized fuzzy ANP model in sustainable supplier selection problem. In this model, missing values were estimated through the preferences of evaluators applying incomplete preference relations and fuzzy linguistic terms were used to analyze criteria (Buyukozkan and Çifçi 2010).

Vindoh et al. (2010) implemented fuzzy ANP approach to find the most appropriate supplier on the basis of weighted index. Also a sensitivity analysis was performed on varying the relative importance of different criteria (Vinodh et al. 2010).

3.2.5 Hybrid fuzzy- neural network

Three out of thirty five hybrid fuzzy methods (8.6%) used hybrid fuzzy- neural network method for the supplier selection problem. Not only the various models of neural network were applied in two articles of this group but also one of them was integrated hybrid fuzzy- neural network method with genetic algorithm.

Sadeghi Moghadam et al. (2008) applied fuzzy neural network to control the inventory and select the optimal supplier. The results of the model were passed to a mixed integer programming and because of the complexity and non-linear nature of the model, a genetic algorithm was used to solve it (Sadeghi Moghadam et al. 2008).

Aydin Keskin et al. (2010) presented Fuzzy Adaptive Resonance Theory Neural Networks for supplier evaluation and selection. In this model, the most appropriate supplier(s) were selected and clustered (AydIn Keskin et al. 2010).

Kuo (2010) suggested a particle swarm optimization based fuzzy neural network for the supplier selection problem. The model derived the fuzzy relationship for qualitative factors. Then quantitative data and fuzzy knowledge decision were integrated to get the best decision (Kuo 2010).

3.2.6 Hybrid fuzzy-other

Four out of thirty five fuzzy hybrid methods (11.4%) used hybrid fuzzy-other method for the supplier selection problem.

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

Chou and Chang (2008) proposed fuzzy set theory into a simple multi-attribute rating technique (SMART) to select the appropriate supplier. A fuzzy SMART was implemented to cope with the ratings of both qualitative and quantitative criteria for evaluating of suppliers. Also, a sensitivity analysis was carried out to present the effect of variance in the risk coefficients in ranking order of suppliers (Chou and Chang 2008).

Amin and Razmi (2009) operated quality function deployment (QFD) to determine the best suppliers based on qualitative criteria. Also, a weighted linear programming model was adopted to consider quantitative metrics as a quantitative model. Finally these two models were composed and selected the best suppliers (Amin and Razmi 2009).

Azadeh and Alem (2010) suggested a model included DEA for deterministic data, Fuzzy DEA for fuzzy data and Chance Constraint DEA for probabilistic data under certainty, uncertainty and probabilistic conditions. The Monte Carlo simulation was applied to solve the three models (Azadeh and Alem 2010).

Sanayei et al. (2010) developed multi-criteria optimization and compromise solution approach (the Serbian name is VIKOR) for ranking suppliers. A hierarchy MCDM model based on fuzzy sets theory and VIKOR method was introduced to determine the closeness to the ideal solution. Also, the differences between this method and TOPSIS model were referred in the article (Sanayei et al. 2010).

4. THE MOST POPULAR SUPPLIER SELECTION METHODS

From the previous section, this is observed that hybrid methods (92.1%) are obviously more practical than single methods (7.9%). Because every single method has some drawbacks and the integration of methods is implemented to overcome the drawbacks. Among the existing hybrid methods, the hybrid fuzzy-mathematical programming models are more prevalent. Supplier selection is a multi criteria decision making and this issue can be modelled as a multi-objective programming technique. Usually one or more than one criterion is considered in objective functions and other criteria are considered as constraints. Besides evaluation and selection criteria, companies are exposed to various constraints in the supplier selection problem which can be formulated as mathematical programming models. Moreover, in multiple sourcing environments mathematical programming methods are famous because these assist not only to select the appropriate suppliers but also determine the amount of order allocation to selected supplier simultaneously. That is why; the hybrid mathematical programming is the most popular method. However, mathematical programming method has some drawbacks as follows. Mathematical Programming models often neglect to consider scaling and subjective weighting issues and have no possibility for the decision makers to apply his or her preference.

The weight determination is a challenging task for implementing these models. Moreover, mathematical programming models have no ability to cope with the qualitative criteria. So, to overcome the weightless characteristic of mathematical programming models, all of the studies in fuzzy- mathematical programming group suggested a kind of solution methods. AHP provides the most functional solution methods in this group. AHP is a common approach for calculating the relative importance weightings of criteria and sub-criteria owing to its simplicity and flexibility. Based on the above analysis, it is obvious that the integrated fuzzy mathematical programming and AHP method is the most popular hybrid methods in supplier selection in uncertain environment.

5. CONCLUSION , SUGGESTION, RESEARCH LIMITATIONS

This literature review on the multiple criteria decision making methods for supplier evaluation and selection in uncertain environment from 2008 to 2011 provides valuable insights and a complete classification on this issue. The number of articles on the supplier selection problem is on the rise as shown in **Error! Reference source not found.**. The numerous proposed single and hybrid methods to deal with supplier selection problem were discussed. The

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

most popular hybrid method for supplier selection in uncertain environments is fuzzy AHP-Mathematical Programming. But AHP has a strong shortcoming and there is a limitation about the amount of criteria and suppliers in AHP method. So, focusing on the mentioned issue and working on new methods which have no limitations on the number of criteria and suppliers would be a fertile area for future research.

This paper might have some limitations. First, only English publications were considered and may be some outstanding studies exist in non-English languages. Second, the review paper was only based on a sample of 38 articles were limited to 4 online databases.

REFERENCES

Amid, A., Ghodsypour, S., & O'Brien, C. (2009). A weighted additive fuzzy multiobjective model for the supplier selection problem under price breaks in a supply Chain. *International Journal of Production Economics, 121*(2), 323-332.

Amid, A., Ghodsypour, S., & O'Brien, C. (2010). A Weighted max-min model for fuzzy multi-objective supplier selection in a supply chain. *International Journal of Production Economics*.

Amin, S. H., & Razmi, J. (2009). An integrated fuzzy model for supplier management: A case study of ISP selection and evaluation. *Expert Systems with Applications, 36*(4), 8639-8648.

Amin, S. H., Razmi, J., & Zhang, G. (2010). Supplier selection and order allocation based on fuzzy SWOT analysis and fuzzy linear programming. *Expert Systems with Applications*.

Awasthi, A., Chauhan, S. S., & Goyal, S. (2010). A fuzzy multicriteria approach for evaluating environmental performance of suppliers. *International Journal of Production Economics*.

AydIn Keskin, G., lhan, S., & Özkan, C. (2010). The Fuzzy ART algorithm: A categorization method for supplier evaluation and selection. *Expert Systems with Applications, 37*(2), 1235-1240.

Azadeh, A., & Alem, S. (2010). A flexible deterministic, stochastic and fuzzy Data Envelopment Analysis approach for supply chain risk and vendor selection problem: Simulation analysis. *Expert Systems with Applications*.

Boran, F. E., Kurt, M., & Akay, D. (2009). A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method. *Expert Systems with Applications, 36*(8), 11363-11368.

Buyukozkan, G., & Çifçi, G. (2010). A novel fuzzy multi-criteria decision framework for sustainable supplier selection with incomplete information. *Computers in Industry*.

Carrera, D. A., & Mayorga, R. V. (2008). Supply chain management: a modular Fuzzy Inference System approach in supplier selection for new product development. *Journal of Intelligent Manufacturing, 19*(1), 1-12.

Chamodrakas, I., Batis, D., & Martakos, D. (2010). Supplier selection in electronic marketplaces using satisficing and fuzzy AHP. *Expert Systems with Applications, 37*(1), 490-498.

Chen, C. M. (2009). A fuzzy-based decision-support model for rebuy procurement. *International Journal of Production Economics, 122*(2), 714-724.

Chen, Y. J. (2010). Structured methodology for supplier selection and evaluation in a supply chain. *Information Sciences*.

Chou, S. Y., & Chang, Y. H. (2008). A decision support system for supplier selection based on a strategy-aligned fuzzy SMART approach. *Expert Systems with Applications, 34*(4), 2241-2253.

Dalalah, D., Hayajneh, M., & Batieha, F. (2011). A Fuzzy Multi-Criteria Decision Making Model for Supplier Selection. *Expert Systems with Applications*.

de Boer, L., Labro, E., & Morlacchi, P. (2001). A review of methods supporting supplier selection. *European Journal of Purchasing & Supply Management, 7*(2), 75-89.

Degraeve, Z., Labro, E., & Roodhooft, F. (2000). An evaluation of vendor selection models from a total cost of ownership perspective. [doi:

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

DOI: 10.1016/S0377-2217(99)00199-X]. *European Journal of Operational Research, 125*(1), 34-58.

Díaz-Madroñero, M., Peidro, D., Mula, J., & Ferriols, F. J. (2010). Fuzzy Multiobjective Mathematical Programming Approaches for Operational Transport Planning. *Revista de métodos cuantitativos para la economía y la empresa*(9), 44.

Ebrahim, R. M., Razmi, J., & Haleh, H. (2009). Scatter search algorithm for supplier selection and order lot sizing under multiple price discount environment. *Advances in Engineering Software, 40*(9), 766-776.

Guneri, A. F., Yucel, A., & Ayyildiz, G. (2009). An integrated fuzzy-lp approach for a supplier selection problem in supply chain management. *Expert Systems with Applications, 36*(5), 9223-9228.

Ho, W., Xu, X., & Dey, P. K. (2010). Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. *European Journal of Operational Research, 202*(1), 16-24.

Holt, G. D. (1998). Which contractor selection methodology? *International Journal of Project Management, 16*(3), 153-164.

Jolai, F., Yazdian, S., Shahanaghi, K., & Azari Khojasteh, M. (2010). Integrating fuzzy TOPSIS and multi-period goal programming for purchasing multiple products from multiple suppliers. *Journal of Purchasing and Supply Management*.

Ku, C. Y., Chang, C. T., & Ho, H. P. (2010). Global supplier selection using fuzzy analytic hierarchy process and fuzzy goal programming. *Quality and Quantity, 44*(4), 623-640.

Kuo, R. (2010). Integration of Particle Swarm Optimization-Based Fuzzy Neural Network and Artificial Neural Network for Supplier Selection. *Applied Mathematical Modelling*.

Lee, A. H. I. (2009). A fuzzy supplier selection model with the consideration of benefits, opportunities, costs and risks. *Expert Systems with Applications, 36*(2), 2879-2893.

Lee, A. H. I., Kang, H. Y., & Chang, C. T. (2009). Fuzzy multiple goal programming applied to TFT-LCD supplier selection by downstream manufacturers. *Expert Systems with Applications, 36*(3), 6318-6325.

Lin, R. H. (2009). An integrated FANP-MOLP for supplier evaluation and order allocation. *Applied Mathematical Modelling, 33*(6), 2730-2736.

Önüt, S., Kara, S. S., & Isik, E. (2009). Long term supplier selection using a combined fuzzy MCDM approach: A case study for a telecommunication company. *Expert Systems with Applications, 36*(2), 3887-3895.

Özgen, D. (2008). A two-phase possibilistic linear programming methodology for multi-objective supplier evaluation and order allocation problems. *Information Sciences, 178*(2), 485-500.

Punniyamoorthy, M., Mathiyalagan, P., & Vasishta, G. (2010). A strategic model using structural equation modeling and fuzzy logic in supplier selection. *Expert Systems with Applications*.

Sadeghi Moghadam, M. R., Afsar, A., & Sohrabi, B. (2008). Inventory lot-sizing with supplier selection using hybrid intelligent algorithm. *Applied Soft Computing, 8*(4), 1523-1529.

Sanayei, A., Farid Mousavi, S., & Yazdankhah, A. (2010). Group decision making process for supplier selection with VIKOR under fuzzy environment. *Expert Systems with Applications, 37*(1), 24-30.

Sevkli, M., Koh, S. C. L., Zaim, S., Demirbag, M., & Tatoglu, E. (2008). Hybrid analytical hierarchy process model for supplier selection. *Industrial Management & Data Systems, 108*(1), 122-142.

Soner Kara, S. (2011). Supplier selection with an integrated methodology in unknown environment. [doi: DOI: 10.1016/j.eswa.2010.07.154]. *Expert Systems with Applications, 38*(3), 2133-2139.

Vinodh, S., Ramiya, R. A., & Gautham, S. (2010). Application of fuzzy analytic network process for supplier selection in a manufacturing organisation. *Expert Systems with Applications*.

29th November 2012. Vol.7 No.1

ISSN 2304-0777
www.jitbm.com

Wang, T. Y., & Yang, Y. H. (2009). A fuzzy model for supplier selection in quantity discount environments. *Expert Systems with Applications*, *36*(10), 12179-12187.

Wang, W. P. (2010). A fuzzy linguistic computing approach to supplier evaluation. *Applied Mathematical Modelling*, *34*(10), 3130-3141.

Weber, C. A., Current, J. R., & Benton, W. (1991). Vendor selection criteria and methods. *European Journal of Operational Research*, *50*(1), 2-18.

Yang, J. L., Chiu, H. N., Tzeng, G. H., & Yeh, R. H. (2008). Vendor selection by integrated fuzzy MCDM techniques with independent and interdependent relationships. *Information Sciences*, *178*(21), 4166-4183.

Yucel, A., & Guneri, A. F. (2010). A weighted additive fuzzy programming approach for multi-criteria supplier selection. *Expert Systems with Applications*.

Zeydan, M., Çolpan, C., & Çobanoglu, C. (2011). A combined methodology for supplier selection and performance evaluation. [doi: DOI: 10.1016/j.eswa.2010.08.064]. *Expert Systems with Applications*, *38*(3), 2741-2751.

Zhang, D., Zhang, J., Lai, K. K., & Lu, Y. (2009). An novel approach to supplier selection based on vague sets group decision. *Expert Systems with Applications*, *36*(5), 9557-9563.

29th November 2012. Vol.7 No.1

ISSN 2304-0777 www.jitbm.com

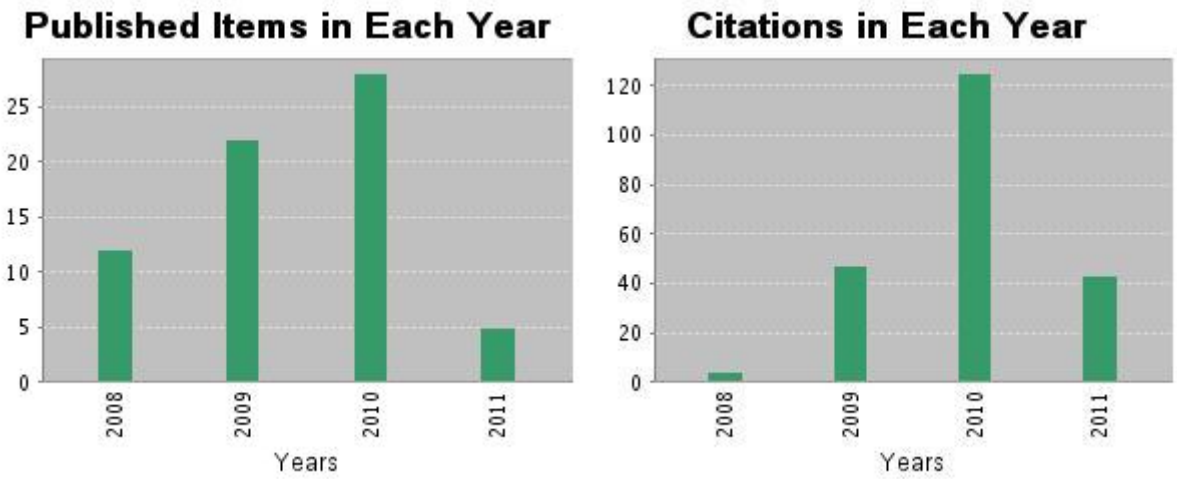

Figure 1. Distribution of articles by year of publication