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AHP MULTICRITERIA DECISION-MAKING METHODIN GREEN PROCUREMENT

Abstract

The aim of this article is to research and demonstrates effectiveness of the proposed a multicriteria decision-making methodology, applied for a case of themeat processing industry for cans as a packaging material supplier selection supported by an environmental approach. There are 7 criteria of supplier selection with green dimensions identified, examined and ranked by evaluation factors, the financial, qualitative and environmental management system criteria. The results of this study will support the introduction of the environmental management system and a quality of the suppliers. Sustainable packaging in a food industry is a relatively new addition to the environmental considerations for packaging and could have a pivotal role in a green supply chain of food production, in sustainable partnerships development and a buyer's corporate green image and competencies.

Keywords:*a green supply chain image, green performance, green procurement, a multicriteria decision-making, AHP.*

JEL classification: *Q01, Q11, Q56, Q57, C44*

МУЛТИКРИТЕРИУМСКИ МЕТОД ОДЛУЧИВАЊА-АХП У ЗЕЛЕНИМ НАБАВКАМА

Abstrakt

Циљ овог чланка је да се истражи и покаже ефикасност предложене АХП, више критеријумске методе доношења одлука, примењене у избору добављача амбалажног материјала, конзерви у индустрије прераде меса подржаног еколошким приступом у избору. За потребе избора добављача дефинисано је 7 критеријума избора са еколошким/зеленим димензијама

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у: идентификацији, испитивању и рангирају по факторима евалуације, финансијским, квалитативним и критеријумима система управљања животном средином. Резултати ове студије доприносе увођењу зелених набавки у систему управљања животном средином и квалитету добављача. Одрживо паковање у прехрамбеној индустрији је релативно нов приступ еколошким аспектима за паковање и могло би да има кључну улогу у зеленом ланцу снабдевања производње хране, у партнерству за одрживи развој и корпоративном зеленом и мицу добаљача и компетенцијама купаца.

***Кључне речи**: зелени и мици ланца снабдевања, зелене перформансе, више критеријумско одлучивање, АХП.*

Introduction

Supplier selection is the process in which companies identify, evaluate and contract with suppliers and is growing to be an important but complex issue, as it involves many factors and decisions (Mitic et al, 2021; 2021a). Some researchers agreed that a combination of factors should fit not only the technical requirements, but also the company's strategy (Miškić et al, 2017; Kvrgic et al, 2020), and even more, demand that suppliers would have to ---reduce environmental impacts (Jevtic et al, 2020).

A food manufacturer must evaluate potential packaging suppliers according to some of the following delicate characteristics when selecting a PMS (Popovic et al, 2020): availability of the technological base necessary to produce the packaging material; skilled labor force availability for the packaging material production; a requisite standard of quality program; technical support for maintaining the components; volume flexibility to manufacture different lot sizes; product flexibility to efficiently manufacture many products; effectiveness in protecting the manufacturer's proprietary information. In this regard, they are usually asked to pass an independent audit to check good manufacturing, hygiene and environmental practice (Srebro et al, 2020; Jevtic et al, 2020a; 2018; 2014; Radovic et al, 2013; 2013a; Turanjanin et al, 2020).

All these developments motivated the authors to propose a supplier selection model for a meat processing company from Serbia using analytic hierarchy process (AHP) approach respecting the green environmental standards and criteria in the selection process.

The article is structured so, that after the abstract, introduction and literature review are presented key findings and discussion in the process of decision-making integrating it in multicriteria approach helped by AHP method. At the end are given conclusions and references.

Methodology

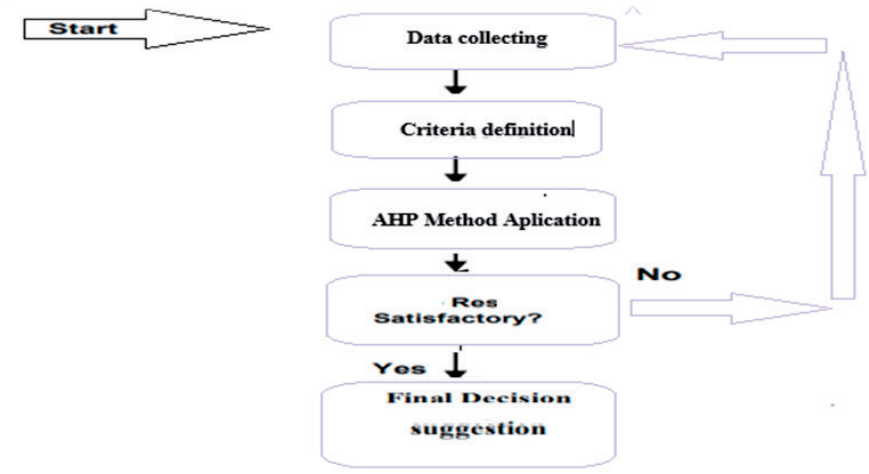
The objective of the research is the selection of suppliers introducing the criteria of green economy, image and performance as required environmental standards in the supplier evaluation system and encouraging the very competitiveness of the meat industry

and suppliers in the supply chain. The company selected for the case study considers the analytic hierarchy process (AHP) and techniques suitable decision framework for evaluating and prioritization of green suppliers, Figure 1.

In the research the analytic hierarchy process (AHP) is used for the elaboration of the results as the multi criteria decision-making (MCDM) modeling and methodological tool for dealing with the suppliers' selection problem.

The method has been developed by Thomas Saaty (2001; 2002; 2004). It includes a weighted method (Muralidharan et al, 2002; Cupic & Sukonovic, 1995; Thanaraksakul & Phruksaphanrat, 2009). The method supportsthe potential suppliers rating with respect to weighted factors determined by the procurement department. Weber & Current (1993), Partovi et al. (1990), Degraeve et al. (2000), and De Boer et al. (2001). The application of this method is further based on the theoretical works (Humpreys et al, 2003) on the: Evaluation of the environmental performance of a company's existing operating system, Environmental efficiency, Green image, and Environmental flexibility In the model application the decision-maker (DM) performs pair-wise comparisons, and, the pair-wise comparison matrix and the eigenvector are derived to specify the weights of each parameter in the problem.

Figure 1. Proposed research model



Source: Authors

The whole process is according to the figure 1 consists of further steps:

1. Constructing AHP decision model. AHP decision model was constructed and based on opinions of directors of the relative departments working in the company. Food Company's team defined 7 criteria for the evaluation of three suppliers, mostly based on a green approach. According to company's preferences there are: factors concerning the quality of cans as a product, including an eco-design, easily understanding and an easy measurement. The production technology, EMS and organization, green image, and cost, delivery, and financial conditions (Table 1).

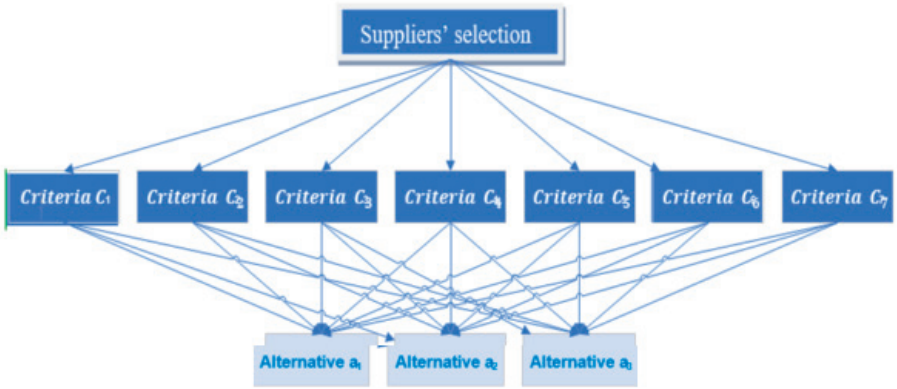
Table 1. Evaluation criteria.

C No.	Criteria	Definition
C_1	Quality	Quality Includes the material terms of use suitability of a green product, use time and the duration, a suitability innovation, an eco-design, easily understand, measured
C_2	Production technology	Clean, green origin, DE
C_3	EMS & organization	Environmental management system and organization, ISO 14001 certification inclusion
C_4	Green image & competencies	Includes a supplier's: green image, environmental performance environmental efficiency, green competencies
C_5	Delivery	Important especially for time based companies. Defined a of time required for the necessary materials and how many days or hours it takes to supply these materials
C_6	Cost	Defined as the summation of a net price after discount (if any) for purchased materials by the manager of department
C_7	Payment flexibility	The company attaches the importance to the payment in terms of delay or an installment. Possible trade credit inclusion. These are preferred more if available

Source: Saaty (1980)

A hierarchy problem decomposition in the suppliers' selection is presented in Figure 2.

Figure 2.A hierarchy by AHP method problem decomposition



Source: Authors' calculations

1. ***Determining weights of criteria***. The decision-makers (DM) perform pair-wise comparisons, and, the pair-wise comparison matrix and the eigenvector are derived to specify the weights of each parameter in the problem in the process of choosing the superior alternative. Seven factors are taken into

the consideration simultaneously, allowing for dependence, a feedback and numerical trade-offs to arrive at a synthesis or the conclusion. The scale of the measurement for AHP is proposed in a table 2.

Table 2. The 1-9 scale for AHP

Definition	Explanation	Importance intensity
Equal importance	Two activities contribute equally to the objective	1
Moderate importance of one over another	Experience and a judgment strongly favor one over another	3
Very strong importance of one over another	Experience and a judgment slightly favors one over another	5
Very strong importance of one over another	Activity is strongly favored, and its dominance is demonstrated in a practice	7
Extreme importance of one over another Importance of one over another	Used to represent a compromise between the priorities listed above	9
Intermediate values	Used to represent a compromise between the priorities listed above	2,4,6,8

Source: Authors according to Saaty (1980).

2. ***Evaluating alternatives*** (suppliers) based on each criterion. It will assess each of the 3 alternatives based on 7 considered a decision-making criterion.
3. ***Evaluate alternatives*** based on all criteria. During this step, each alternative gains its value. The aim is to evaluate all performances, especially environmental performance and a green image of 3 suppliers of cans for the meat processing company end to calculate the mean values for each supplier.
4. ***In this step, the normalized a decision matrix is constructed***. The choice of alternatives. The highest degree of value determines the best solution to the supplier, and vice versa.

Results

As the results of the team discussion on the evaluation of 3 suppliers and 7 criteria and synthesized of previous steps of the multi criterion ranking of alternatives, the best supplier (labeled as an action -alternative) are selected, as the best overall. The synthesis procedure is presented in a table 3, in which values are obtained by multiplying the weight of the criteria with the participation of the action

in these criteria

Table 3. Decision-making problem Synthesis

Criteria	Weights of Criteria	Alternative	Weights of alternative	Weights of Criteria and Alternative
C_1	0.381	a_1	0.697	0.266
		a_2	0.232	0.088
		a_3	0.072	0.027
C_2	0.212	a_1	0.617	0.131
		a_2	0.302	0.064
		a_3	0.081	0.017
C_3	0.168	a_1	0.685	0.115
		a_2	0.247	0.042
		a_3	0.068	0.011
C_4	0.093	a_1	0.467	0.043
		a_2	0.376	0.035
		a_3	0.157	0.015
C_5	0.074	a_1	0.694	0.052
		a_2	0.231	0.017
		a_3	0.075	0.006
C_6	0.049	a_1	0.638	0.031
		a_2	0.281	0.014
		a_3	0.081	0.004
C_7	0.022	a_1	0.522	0.011
		a_2	0.382	0.008
		a_3	0.095	0.002

Source: Authors' calculations

By totaling the value for each *action* (supplier) according to each criteria from table 3, the total value of each share for all the criteria together is observed.

Alternative a_1

$T_{a1} = C_1 * C K_{1a1} + C_2 * C_{2a1} + C_3 * C_{3a1} + C_4 * C_{4a1} + C_5 * C_{5a1} + C_6 * C_{6a1} + C_7 * C_{7a1}$=0.381*0.697+0.212*0.617+0.168*0.685+0.093*0.467+0.074*0.694+0.049*0.638+0.022*0.522=0.266+0.131+0.115+0.042+0.052+0.031+0.011=0.650

Alternative a_2

$T_{a2} = C_1 * C_{1a2} + C_2 * C_{2a2} + C_3 * C_{3a2} + C_4 * C_{4a2} + C_5 * C_{5a2} + C_6 * C_{6a2} + K_7 * C_{7a2}$=0.381*0.232+0.212*0.302+0.168*0.247+0.093*0.376+0.074*0.231+0.049*0.281+0.022*0.382=0.088+0.064+0.042+0.035+0.017+0.014+0.011=0.268

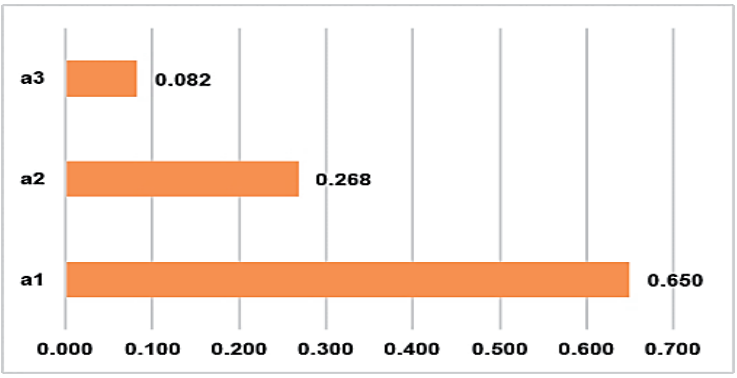
Alternative a_3

$T_{a3} = C_1 * C_{1a3} + C_2 * C_{2a3} + C_3 * C_{3a3} + C_4 * C_{4a3} + C_5 * C_{5a3} + C_6 * C_{6a3} + C_7 * C_{7a3}$=0.381*0.072+0.212*0.081+0.168*0.068+0.093*0.157+0.074*0.075+0.049*0.081+0.022*0.095=0.2027-+0.017+0.011+0.015+0.006+0.004+0.002=0.082

The supplier's total rank relative to the target (composite normalized vector) is: a_1 (0.650); a_2 (0.268); a_3 (0.082). The resulting values represent the final results, are shown in Figure 3.

$T_{a1>}T_{a2>}T_{a3}$

Figure 3. Comprehensive Supplier Ranking Synthesizes



Source: Authors' calculations

Discussions

According to the results of the conducted a process of a multi-criteria decision-making on the selection of suppliers of cans for the meat industry as selected case, it can be seen that the selection was performed according to the defined criteria by the team of the production company. The criteria successfully referred to aspects of an environmental protection, a green economy and standards, a technology, prices and a delivery, as well as finance. The best action – a1 is the supplier who has met the individual criteria, as well as all criteria with the highest rank, then the supplier a2. The worst grades for individual criteria and group criteria were given to the supplier a3.

Conclusion

These conclusions support the justification of introducing the criteria of a green economy, an image and performance as required environmental standards in the supplier evaluation system and encourage the very competitiveness of the meat industry and suppliers in the supply chain. Environmentally-friendly (sustainable) packaging's cans in which meat products (ready meals, cold cuts, meat cuts) are packed, reduce the warming, a carbon footprint and greenhouse gases. They divert tons of metal and plastic and other non-degradable materials from landfills (Mihajlovic et al.2013).

Specific criteria for PMS selection as a risk of a disruption, a volume and product flexibility and an innovation are not included, what could be found as the limitation of this approach

References

Awasthi, A., Chauhan, S. S., & Goyal, S. K. (2010.). A fuzzy multicriteria approach for evaluating environmental performance of suppliers, *International Journal of Production Economics*, 126(2), 370–378. https://doi.org/10.1016/j.ijpe.2010.04.029

Bai, C., & Sarkis, J. (2010). Green supplier development: analytical evaluation using rough set theory, *Journal of Cleaner Production*, 18(12), 1200–1210. https://doi.org/10.1016/j.jclepro.2010.01.016

Baskaran, V., Nachiappan, S., & Rahman, S. (2012). Indian textile suppliers' sustainability evaluation using the grey approach, *International Journal of Production Economics*, 135 (2), 647–658.https://doi.org/10.1016/j.ijpe.2011.06.012

Brans, J. P.(1984). A New Family of Outranking Methods in Multicriteria Analysis, *Operational Research '84*, North Holland.

Cupic, M. (1987). Introduction to Decision Theory, *Science Book.*

Cupic, M., & Suknovic, M.(1995). Multicriteria decision making - methods and examples, *University of Braca Karic.*

Cupic, M., Novakovic, T. & Svilar, M. (1992). Generators and applications of decision support systems, *Scientific book*.

De Boer, L., Labro, E., & Morlacchi, P. (2001). A review of methods supporting supplier selection. *Eur. J. Purchasing. Supply. Manage*, 7(2), 75–89.https://doi.org/10.1016/s0969-7012(00)00028-9

Degraeve, Z., Labro, E., & Roodhooft, F. (2000). An evaluation of supplier selection methods from a total cost of ownership perspective. *Eur. J. Opera. Res.*, 125(1), 34–58. https://doi.org/10.1016/s0377-2217(99)00199-x

Droge, C., Germain, R., & Stock, J.R. (1991). Dimensions Underlying Retail Logistics and Their Relationship to Supplier Evaluation Criteria. I*nt. J. Logist. Manage,* 2, 19-25.https://doi.org/10.1108/09574099110804643

Fu, X., Zhu, Q., & Sarkis, J. (2012). Evaluating green supplier development programs at a telecommunications systems provider, *International Journal of Production Economics,* 140(1), 357–367.https://doi.org/10.1016/j.ijpe.2011.08.030

Fishburn, P.C. (1970). Utility Theory Predecision-Making, *Wiley*, New York.

Green, K., Morton, B., & New, S. (1996). Purchasing and environmental management: interaction, policies and opportunities, *Business Strategy and the Environment,* 5, 188–197. https://doi.org/10.1002/(sici)1099-0836(199609)5:3<188::aid-bse60>3.0.co;2-p

Grozdanic, R., Radovic, M., &Jevtic, B. (2013). New Technologies, Green Growth and Jobsin Rural Entrepreneurship: opportunities for entrepreneurs, *Faculty of Business Economics and Entrepreneurship*, *Monography,* 92-112.

Humphreys, P., McIvor, R., & Chan, F. (2003). Using case-based reasoning to evaluate supplier environmental management performance, *Expert Systems with Applications,* 25(2), 141–153. https://doi.org/10.1016/s0957-4174(03)00042-3

Handfield, R. S., Walton, V., Sroufe, R., & Melnyk, S. A.(2002). Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process, *European Journal of Operational Research*, 141(1), 70–87.https://doi.org/10.1016/s0377-2217(01)00261-2

Jevtic, B., Zakic, N., Popovic, J., Coric, G., & Kvrgic, G. (2020). Digital Challenges for SMEs Organizations in Human Capital Investments and Change, 62nd International Scientific Conference on Economic and Social Development - Lisbon, 19-20 November, 20-29.

Jevtic, B., Kvrgic, G., Coric, G., Beslac, M. (2020). Challenges of ICT Skills of SME Employees, *Limes plus*, 2020, 1, 121-142. doi: 10.5281/zenodo.4601507

Jevtić, B., Aleksić, N., Pantović, V. (2018) ICT Green Technology Sector opportunities, *Ecologica*, 25(90), 244-249.

Jevtic, B.,& Markovic, D. (2014). New information technologies and economic growth, *Institut of Economic Sciences, Monography,*565-638.

Kvrgic, G., Popovic, J., Milosevic, D., & Avakumovic, J. (2020). Showing the Impact of the Operational Risks Posed on the Tourism & Travel SMEs Sustainability, *Limes plus*, XVI, No.1-2, 131-151.

Linton, J. D., Klassen, R., & Jayaraman, V. (2007). Sustainable supply chains: an introduction, *Journal of Operations Management*, 25(1), 1075–1082.https://doi.org/10.1016/j.jom.2007.01.012

Mihajlovic D., Ilic, B., & Simonovic, Z. (2013), Development Economic of Natural Resources Compliance with Environmental Requirements. Ekonomika, 59(4), 10-21. https://doi.org/10.22004/ag.econ.289621

Mitić, N., Avakumovic, J., Miloševic, D., Kvrgic, G., & Popovic, J. (2021). Sustainability of the organization in times of crisis with an integral approach to strategic financial management, *Ecologica,* 1. https://doi.org/10.18485/ecologica.2021.28.101.14

Mitić, N., Popovic. , J. Kvrgić, G., Avakumovi, J.,& Milosevic, D. (2021). The impact of consumer satisfaction on the image of a modern organization, *Ecologica*, 2. https://doi.org/10.18485/ecologica.2021.28.101.14

Miskic, M., Coric, G., &Vukosavljevic, D. (2017). Building Financial and Insurance Resilience in the Context of Climate Change, *Economics of Agriculture, 3*, 1019-1035. https://doi.org/10.5937/ekopolj1703019m

Noci, G. (1997). Designing “green” vendor rating systems for the assessment of a supplier’s environmental performance, *European Journal of Purchasing and Supply Management,* 3(2),103–114.https://doi.org/10.1016/s0969-7012 (96)00021-4

Neralic, L. (2003). Introduction to mathematical programming 1, *Element.*

Nikolic, I., & Borović, S. (1996). Multicriteria optimization - methods, application in logistics, software, *Vojnoizdavački zavod*.

Partovic, F.Y., Burton, J., & Banerjee, A. (1990). Application of analytical hierarchy process in operations anagement. *Int. J. Oper. Prod. Manage*, 10(3), 5-19. https://doi.org/10.1108/01443579010134945

Popović, J., Kvrgić, G., Corić, G., Avakumović, J., & Milosevic, D. (2020). Uncertainity in SMEs Assessment of Coronavirus Pandemic Risk Impact on Agri-Food Sector in Western Balkans, *Economics of Agriculture*, 67(2), 445-460.https://doi.org/10.5937/ekopolj2002445p

Radović, M., Grozdanić, R., Jevtić, B., Cukanovic, M., &Vukosavljevic D. (2013). Challenges o Climate Change, *Ecologica*, 20 (70), 159-163.

Radović, M., Grozdanić, R., Jevtić, B., Jovancevic, D., &Vukosavljevic. D. (2013a). The Importance of the Environment Vulnerability Monitoring, *Ecologica*, 20 (70), 141-148.

Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations and Production Management*, 25(9), 898– 916.https://doi.org/10.1108/01443570510613956

Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review, *International Journal of Management Reviews*, 9(1), 53–80.

Shaw, K., Shankar, R., Yadav, S. S., & Thakur, L. S. (2012). Supplier selection using fuzzy AHP and fuzzy multi-objective linear programming for developing low carbon supply chain, *Expert Systems with Applications*, 39, 8182–8192.https://doi.org/10.1016/j.eswa.2012.01.149

Saaty, T.L. (1980). The Analytic Hierarchy Process. *McGraw-Hill*, New York.

Saaty, T. L. (2001). Decision Making with Dependence and Feedback: The Analytic Network Process, *RWS Publications, Pittsburgh, Pa, USA*, 2nd edition.

Saaty, T. L.(2004). Decision making—the analytic hierarchy and network processes (AHP/ANP), *Journal of Systems Science and Systems Engin*eering, 13(1), 1–34. https://doi.org/10.1007/s11518-006-0151-5

Srebro, B., Zakic, N., Jevtic, B., & Milosevic. D. (2020). Agile Organizations in the Digitial Strategy Imperatives Implementation,An Evidence from Serbia, *Limes plus*, 2. 79-99. doi: 10.5281/zenodo.4601550

Tabucanon, M. T. (1988). Multiple Criteria Decision Making in Industry, *Elsevier.*

Turanjanin, D., Cvetanović, S., & Popovic, J. (2020). Global environmental quality problems in economic development policy, *Ecologica*, 28(100), 714-722.

Tuzkaya, G., Ozgen, A., Ozgen, D., & Tuzkaya, U. R. (2009). Environmental performance evaluation of suppliers: a hybrid fuzzy multi-criteria decision approach, *International Journal of Environmental Science and Technology*, 6 (3),477–490.https://doi.org/10.1007/bf03326087

Thanaraksakul, W., & Phruksaphanrat, B. (2009). Supplier Evaluation Framework Based on Balanced Scorecard with Integrated Corporate Social Responsibility Perspective Proceedings. *Int. Multi Conference. Eng. Comput. Scientists,* March 18 – 20.

Vincke, Ph. (1992). Multicriteria Decision-Aid, *John Wiley & Sons, Chichester*.

Weber, C.A., & Current, J.R. (1993). A multi objective approach to vendor selection. *Eur. J. Oper. Res., 68*, 173-184.

Zeleny, M (1992). Multiple Criteria Decision Making, McGraw – *Hill*, New York.