Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2016/02/jls.htm
2016 Vol. 6 (S2), pp. 565-580/Nazari and Kohansal
Research Article

AN INTEGRATIVE APPROACH TO PRIORITIZING THE STRATEGIES FOR ACHIEVING WORLD-CLASS MANUFACTURING USING FUZZY MULTI-CRITERIA DECISION-MAKING TECHNIQUES (THE CASE OF JAHADDANESHGAHI ELM VASANAT (JDEVS))

***Nazari S.[1] and Kohansal B.[2]**
[1]*Department of Industrial Management, Central Branch of Azad University, Industrial Management Group, Tehran, Iran*
[2]*Department of Industrial Engineering, North Pardis University, Engineering-Technical Group, Amol, Iran*
**Author for Correspondence*

ABSTRACT
Without doubt, globalization is one of the significant developments in the trade and production fields in the 20th century. In the current circumstances, production is not a matter of local decisions and is beyond the national boundaries and involves global strategic decisions. This study aims to evaluate the strategies for world-class manufacturing in the "Jihad Daneshgahi Elm vaSan'at" (JDEVS) corporation using an integrative approach to the FVIKOR and FAHP techniques. Therefore, besides a comprehensive review on the literature, 10 experts of the concrete industry in the "Jihad …. "were asked to give their opinions on this matter. Given the three determined strategies (product design according to customers requirements, adopting new technology, improving the after-sale services, the findings of this study indicate the high priority of the "adopting new technology" strategy to achieve the world-class manufacturing.

Keywords: *Fuzzy Multi-Criteria Decision-Making, Strategy, World-Class Manufacturing, Concrete Industry, Tehran Province*

INTRODUCTION
A crucial problem in achieving the world-class manufacturing is developing consistent organizational strategies. Thus, managers should understand the nature and significance of strategy in the organization and by developing appropriate strategies help their organization to achieve world-class manufacturing and use appropriate production methods according to such strategies (Farsijani, 2010). Having an appropriate strategy allows organizations to act in creative and innovative ways (Wu *et al.*, 2010). Furthermore, the strategies related to production have an essential role in making organizations more competitive and close to the criteria for world-class manufacturing (Farsijani, 2010). The importance of competition on a global scale has made some issues in different levels of organizations more crucial (Smith, 2011).
Iranian concrete industry, with its emphasis on the environmental protection, Improving the quality and efficiency and meeting the requirements, is an active and productive participant in domestic and global trade contributing to national interests. Currently Iran has many relative advantages in concrete production, such as sufficient and low-cost energy resources, good experiment in concrete production, a young and professional labor force. By acquiring the new production technologies, it can be a competitive participant in the concrete global market (Afshar-kazemi *et al.*, 2009). Considering the aforementioned factors, a strategy to act globally is essential. Though there have been numerous studies on world-class manufacturing, few of them addressed the issue of strategy selection with the purpose of achieving a superior and global production level. Furthermore, given the fact that the validity of the strategy selection and application is based on empirical studies we will use the conceptual comprehensive model of Yuksel & Dagdeviren (2010) to bridge the gap between theory and practice. We aim to determine an appropriate strategy in order to achieve the superior and global level of production regarding the concrete industry in Tehran province considering the circumstances in this industry. Therefore, we take advantage of the FAHP technique to weigh the four perspectives of balanced scorecard and each of its indexes. Moreover,

for prioritizing the strategies and selecting the most appropriate one for the world-class manufacturing we used FVIKOR technique.

The results show the high priority of the adopting of new technology as a strategy for development and constant improvement of the products' quality in order to achieve world-class manufacturing.

World-Class Manufacturing

Without doubt, globalization is one of the significant developments in the trade and production fields in the 20th century. In the current circumstances, production is not a matter of local decisions and is beyond the national boundaries and involves global strategic decisions. Since in today's marketing market equals the customers and since today's market is a global one, the customer is a global customer as well and less defined on a national scale.

The basis of competition and production has also changed in this area and the emergence of the new conditions has forced to think of their production operations in a global context and revise their attitudes towards global competition.

Considering the rapid changes in production technology and the fierce competition in the 70's , most firms in different industries have examined their production strategies and adopted new approaches to production strategies.

Based on the earlier studies, the successful approaches to production up to 1989 include workers' participation programs, Total Quality Management (TQM), competitive production, incorporating production into the firm's strategy, decreasing the lead time, Total Preventive Maintenance (PM), Statistical Process Control (SPC), Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), and Computer Numerical Control machines (CNC) (Goudarzi, 2004).

By the studies conducted in 1995 it is found that those approaches which stressed the strategic and human aspects had prevailed over the computerized and algorithmic approaches. In 1995, the successful approaches, beside those already mentioned in the previous list include lean production, forming task groups and empowering the employees.

In the past two decades, many production firms have revised their strategic goals, values and priorities due to the fierce competition and eventually found it necessary to determine a production solution on a global scale.

One of the outcomes of the new insights is the shift of focus from production volume to production flexibility in order to enhance the quality of the products and the extent of the firm's responsiveness (Safaie-qadikolaie, 1999).

Since Schonberger (1986) introduced the term world-class manufacturing, It has been used by many others. World-class manufacturing could be defined as follows:

"A consensus on continuous improvement of quality, cost, lead time and service providing to customers with the primary goal of rendering production, as a component of this system, flexible".

"A reasonable combination of JIT manufacturing, and employees' engagement with the goal of turning production into a strong competitive weapon for the firm".

"A new wave which began with forming multitask teams and include production design, Continuous Process Improvement (CPI), TQM, and expanding the quality-oriented activities in order to offer new products successfully and rapidly with the lowest costs and best quality of design, development, production and delivery".

"A set integrating customer orientedness, TQM, JIT manufacturing, continuous improvement, and engaging the employees in the production procedures and decision-makings and other activities" (Safaie-qadikolaie, 1999).

Globalization of trade and information technology has helped overcoming the time and space obstacles and narrowing the gap between small and big firms. Consequently, small agile organizations can effectively compete with industrial conglomerates. This leads to new conditions in which the strict boundaries between domestic and global markets are effaced. The managements of many organizations are still unaware of the strategic advantages which result from implementing world-class manufacturing

and have not stepped in yet. Table 1 presents some information on financial and strategic benefits of WCM tools (Farsijani, 2010).

Table 1: Financial and Strategic Benefits of WCM

Factors	**Manufacturing Costs**	**Lag Times**	**Raw Material Inventory and in Progress**	**Quality Costs**	**Manufacturing Space**	**Labor Costs**	**Time Needed for Developing New Product**	**Purchasing Costs**
Decrease by Percent	30-60	60-85	40-60	More than 50	30-65	30-65	30-60	30-50

Review of Similar Studies

In any experimental study, the researcher's close attention to similar past studies indicates the depth and inclusiveness of his work. The more he/she examines similar studies he got stronger in the field and this adds to the validity of his study and indicates of his accurate and comprehensive understanding of different aspects of the study. In the following, we present a summary of the findings of the relevant studies. Considering the fact that multi-criteria decision-making techniques have been applied in various fields and studies (Dargahi *et al.*, 2011; Safaie-qadikolaie *et al.*, 2011; Aqajani and Dargahi, 2011; Aghajani *et al.*, 2012; Goranourimi *et al.*, 2012), in the following we will review some of the recent studies on world-class manufacturing:

Safaaie-qadikolaie *et al.*, (2011) evaluated the world-class manufacturing systems in Iran Khodro and three Indian automotive companies and by using performance value analysis found that Iran Khodro's performance in comparison to it's Indian counterparts was better with two factors of production planning and control, and flexibility but lower with the two factors of top management commitment and customer services. It's performance with respect to other was average. They finally suggested that Iran Khordro co. pay more attention to all critical factors, and in particular to two hypercritical factors of top management commitment and customer services.

Eid (2009), in a paper titled "Factors affecting the success of world class manufacturing implementation in less developed countries, The case of Egypt" argues that manufacturing plants need to understand the critical factors of WCM techniques application. He mentions seven critical factors in two categories. The first category is the strategic enablers of WCM including management commitment, quality department, continuous improvement and customer engagement the second is the tactical enablers of WCM including the supply chain management, technical capacity management and production equipment management. By evaluating a sample of 96 Egyptian manufacturing companies it is found that strategic factors of WCM and tactical success factors have a significant impact on WCM success as well as on some of the strategic enablers and tactical enablers.

Sangwan & Digalwar (2008) in a paper titled "Evaluation of world-class manufacturing systems: a case of Indian automotive industries" reviewed the literature and identified 172 performance variables for the evaluation of WCM systems. They then selected 72 performance variables among them and categorized them into 12 critical factors. By data gathered from three operating companies in the Indian automotive industry and winners of quality reward of MalcomBaldrig (MBNQA), national quality award of Gandhi and using Performance Value Analysis algorithm, the aforementioned companies were compared with respect to their success in implementing world-class manufacturing systems. The writers argued for the validity and reliability of the suggested model and algorithm and thus they could be used for the evaluation of the automotive industry worldwide.

Salahedin & Eid (2007) conducted a study in order to implement world-class manufacturing techniques in Egyptian manufacturing firms and provide a guideline for this purpose. They found that reducing the

operational costs (marketing and manufacturing costs) and global issues (environmental market) are among the important variables for implementing WCM. Moreover, they found that a weak plan and lack of knowledge are among the most important obstacles in the way of implementing WCM in Egyptian plants.

They finally suggested that Implementing WCM requires a growth in knowledge and called for those interested in implementing WCM to realize this fact and persist in achieving it in order to gain the expected benefits.

Farsijani & Teymourian (2009) used the path analysis method for Hepco company in order to examine the success factors in the technology transfer with the aim of achieving world class status. They found that there is a positive correlation between successful technology transfer and achieving the world class status. Finally they suggested analyzing company's distance from world class status, implementing the world-class manufacturing system and etc. as ways to achieve the world class status.

Questions and Goals of the Study

The research questions are as follows:

- What are the weights of the four BSC perspectives according to the Yuksel and Dagdeviren model?
- What are the weights of the performance indexes in each of the four BSC perspectives according to the Yuksel and Dagdevirenmodel?
- According to Yuksel and Dagdeviren model, What is the most appropriate strategy to achieve the superior global level of production?

The main goal of the study is to compare different strategies of achieving world-class manufacturing and prioritize them. Other goals of the study are as follows:

* The domestication of the suggested model by Yuksel and Dagdevirenin JahadDaneshgahi Elm VaSanat (JDEVS) of Tehran province.
* More appropriate allocation of the resources and facilities in the cement industry, considering the findings of the study.
* Clarifying the solutions available to the cement industry considering the relevant conditions in the study.

MATERIALS AND METHODS

Methodology and the Research Model

Considering the goal of this research which is the comparative evaluation of the strategies for achieving world-class manufacturing, the statistical population of this research consists of all authorities and managers who are influential in the macro decision makings of their companies. The sample consists of 10 male persons from JDVES company. 83% of them are older than 30 years old, 92% with bachelor's degree and higher and 59% with more than 10 years of work experience.

The data were collected through desk method and field method. Journals and scientific websites were among the resources.

The main data of the study were collected with field method and through questionnaires and interviews. Two questionnaires were used in the study; after designing the questionnaires, the experts in the company under study were asked to give their opinions on the questionnaires in different stages and after the corrections, the final questionnaires were handed to them in person.

The first questionnaire concerns the domestication of the model under study and it was distributed among the experts according to the Delphi method.

This questionnaire has two sections. The first section is about the demographical data of the experts and the second section is for assigning scores (degrees of importance) to the indexes and strategies. The experts were asked to score the indexes and strategies of the model on a scale of 1 (slightly important) to 10 (extremely important).

The n they were ask if they know any other indexes and strategies missing in the current model and if positive, score them on a scale of 1 (slightly important) to 10 (extremely important) as well. All indexes and strategies with an average score of 7 were chosen.

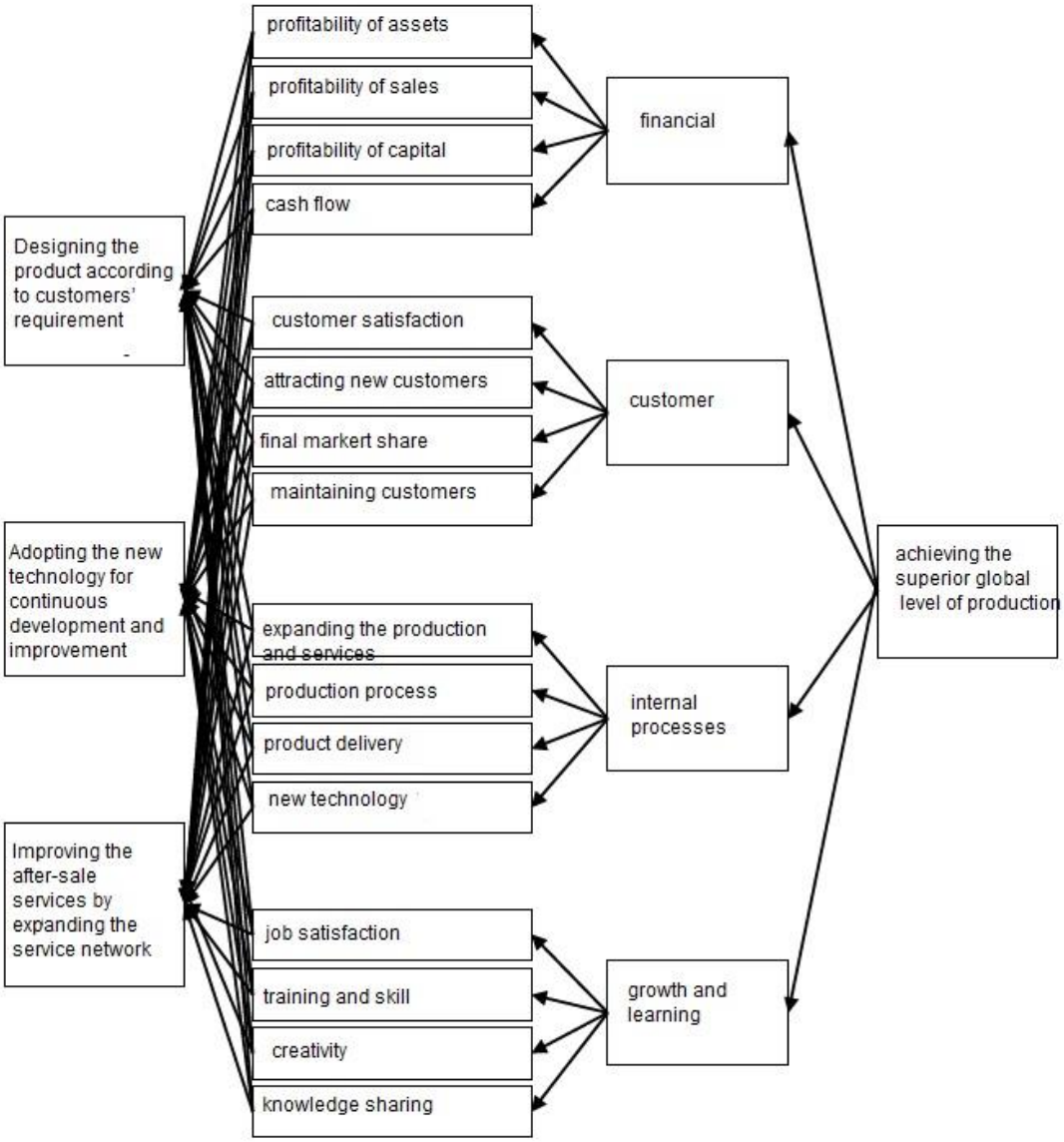

Figure 1: The Hierarchical Structure of Perspectives, Indexes and Strategies

The first section of the second questionnaires consists of questions regarding the degree of importance of the four perspectives of the balanced scorecard and the degree of importance of the indexes of these perspectives. This section consists of two parts; pairwise comparisons are performed in the first part to determine the degree of priority of the four perspectives of the balanced scorecard relative to each other (a pairwise comparison matrix); the second part comprises of pairwise comparisons to determine the degree of importance of the indexes of these perspectives in relation to each other. An Instruction paper was presented to the respondents to help them fill in the questionnaire, but the researcher himself was present while the respondents were filling in the questionnaires to help them with any problem.

A total of 10 questionnaires were distributed and gathered upon which the analysis of the results of the present study is based.

After distributing the first stage questionnaire and modifying it , or in other words, domesticating the conceptual model of Yuksel and Dagdeviren, eventually a hierarchical structure to evaluate and prioritize the strategies for achieving world-class manufacturing was developed, as seen in figure 1.

In what follows we will describe the FAHP and FVIKOR methods used for analyzing the data in the present study.

Fuzzy Multi-Criteria Decision-Making Techniques

FAHP

The Idea of AHP is to gather experts' knowledge concerning the object of study. Nonetheless, the classic AHP might not be capable to reflect the cognitive process of the human mind in a proper way (in particular when the problem is not defined thoroughly or the data to solve the problem is not reliable) (Haghighi *et al.*, 2010). Therefore, the Chang's fuzzy analytic hierarchy process (FAHP) was adopted (Chang, 1996).

In FAHP, after drawing the hierarchy decision tree, a pair wise comparison of the elements in each level of the model should be done. In the calculation stage, the coefficients for each of the pairwise comparison matrices is calculated (Azar and Faraji, 2002). Therefore, for each row of the pairwise comparison matrix, the S_k value, which itself is a triangular fuzzy number, is calculated from eq. (1). To calculate each of the terms of this equation, the equations (2-2), (2-3) and (2-4) are used:

$$S_K = \sum_{j=1}^{n} M_{ki}^{j} \otimes \left[\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij}\right]^{-1} \qquad (1)$$

$$\sum_{j=1}^{m} M_{ij} = \left(\sum_{i=1}^{m} l_j, \sum_{i=1}^{m} m_j, \sum_{i=1}^{m} u_j\right) \quad i = 1,2,\dots,m \qquad (2)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij} = \left(\sum_{i}^{n} l_i, \sum_{i}^{n} m_i, \sum_{i}^{n} u_i\right) \qquad (3)$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{ki}^{j}\right]^{-1} = \left[\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right] \qquad (4)$$

After calculating all S_ks, in the next stage, the magnitude of each of the elements of a specific level in relation to other elements of that level, should be calculated separately according to the equations below:

$$\begin{cases} V(M_1 \geq M_2) = 1 & if\ m_1 \geq m_2 \\ V(M_1 \geq M_2) = 0 & if\ I_2 \geq u_1 \\ V(M_1 \geq M_2) = hgt(M_1 \cap M_2) & otherwise \end{cases} \qquad (5)$$

$$hgt(M_1 \cap M_2) = \frac{I_2 - u_1}{(m_1 - u_1) - (m_2 - I_2)} \qquad (6)$$

The magnitude of a triangular fuzzy number from K other triangular fuzzy numbers is obtained by the equation below:

$$V(M_1 \geq M_2, \dots, M_K) = V(M_1 \geq M_2) and \dots and\ V(M_1 \geq M_K) \qquad (7)$$

The calculation of the weights of the indexes in the pairwise comparison matrix is as below:

$$\acute{w}(x_i) = min\{V(S_i \geq S_k)\} \quad k = 1,2,\dots,n, k \neq i \qquad (8)$$

So, the weight vector of the indexes is as below, which is the abnormal fuzzy coefficient vector of HAP:

$$\acute{w} = [\acute{w}(x_1), \acute{w}(x_2), \dots, \acute{w}(x_n)]^t \qquad (9)$$

FVIKOR Method

VIKOR is a compromise MADM method Developed by Opricovic & Tzeng (2007) and is based on LP-metric method.

$$L_{pi} = \left\{\sum_{j=1}^{n}\left[w_i\left(f_j^* - f_{ij}\right)/\left(f^* - f_j^-\right)\right]^p\right\}^{1/p} \qquad (10)$$

$$1 \le p \le +\infty; i = 1,2,\dots,I.$$

This method can provide a maximum value of group utility for the majority and a minimum value of individual regret of the opponent. The stages of this method are as follows (Opricovic & Tzeng, 2007).

Calculation of the normalized values

Assume that there are m alternatives and n criteria. Different alternatives are denoted as X_i .for the X_j alternative the rank is denoted as X_{ij} as well as for other alternatives. X_{ij} is the value of the J-th criterion. To descale the decision matrix, linear normalization is applied. This will be done in the calculation formula of the method.

Determining the best and the worst value

The best and the worst values in each criteria are identified and namedf_j^* and f_j^- respectively.

$$f_j^* = Max\ f_{ij} \quad ,i = 1,2,\dots,m \qquad (11)$$

$$f_j^- = Min\ f_{ij} \quad ,j = 1,2,\dots,n \qquad (12)$$

Where, f_j^* is the best positive ideal solution for the j-th criterion and f_j^- is the worst negative ideal solution for the j-th criterion.

An optimal combination of all f_j^* will provide the highest score.

Determining the weights of the criteria

The weights of the criteria should be calculated to indicate the degree of importance of their relation. FAHP will be used for this purpose.

Calculating the distance of the alternatives from the ideal solution

In this stage, the distance of each alternative from the ideal solution is calculated and the resulting values are added to give the total value:

$$S_j = \sum_{j=1}^{n} w_i\left(f_j^* - f_{ij}\right)/\left(f^* - f_j^-\right) \qquad (13)$$

$$R_j = Max\left[w_i\left(f_j^* - f_{ij}\right)/\left(f^* - f_j^-\right)\right] \qquad (14)$$

Where, S_i denotes the distance of the i-th alternative from the positive ideal solution (best combination) and R_i denotes the distance of the i-th alternative from the negative ideal solution (worst combination). The best and the worst rank are obtained based on the S_i and R_i values respectively. In other words, S_i and R_i are identical with L_{ij} and L_i in LP-metric, respectively.

Calculating Q_i

This value is calculated for each i as follows:

$$Q_i = v\left[\frac{S_i - S^*}{S^- - S^*}\right] + (1 - v)\left[\frac{R_i - R^*}{R^- - R^*}\right] \qquad (15)$$

Where $R^* = \min_i R_i$ ، $R^- = \max_i R_i$ ، $S^* = \min_i S_i$ ، $S^- = \max_i S_i$ and v is the weight for the strategy of the majority in favor of that criterion (or the weight for the strategy of maximum group utility):

$\left[\frac{S_i - S^*}{S^- - S^*}\right]$ denotes the ratio of the distance of i-th alternative from the negative ideal solution and implies the utility of the majority for the i-th ratio.

$\left[\frac{R_i - R^*}{R^- - R^*}\right]$ denotes the ration of the distance of the i-th alternative from the ideal solution and implies the regret of opponent to the ratio of the i-th alternative.

Therefore, when v>0.5, Q_i leads to the "voting by majority rule" and when v<0.5, Q_i implies "with veto". V=0.5 imlplies "by consensus".

Ranking the alternatives

In this stage, R, S and Q are ranked in the descending order.

Analyzing the Findings

There are different ways for converting the verbal comments of the respondents on the perspectives, indexes and strategies into triangular fuzzy numbers (Lee, 2010; Yang and Hsieh, 2009; Sun, 2010). Linguistics scale for determining the weight of the four perspectives of the balanced scorecard and indexes of these perspectives are shown in table 2.

Table 2: Fuzzy Numbers and Linguistic Scale for Determining the Weight of the Perspectives and Indexes

Linguistic Scale	**Very Less Importance (VL)**	**Less Importance (L)**	**Moderately Higher Importance (MH)**	**Higher Importance (H)**	**Very Higher Importance (VH)**
Triangular Fuzzy Numbers	(1,1,1)	(1,3,5)	(3,5,7)	(5,7,9)	(7,9,11)

Table 3 shows the linguistic scale for prioritizing the strategies to achieve world-class manufacturing.

Table 3: Fuzzy Numbers and Linguistic Scale for Prioritizing the Strategies

Linguistic Scale	**Worst (W)**	**Poor (P)**	**Fair (F)**	**Good (G)**	**Best (B)**
Triangular fuzzy numbers	(0,0,2.5)	(0,2.5,5)	(2.5,5,7.5)	(5,7.5,10)	(7.5,10,10)

As mentioned in the previous section, assigning weights to the four perspectives of the balanced scorecard and the related indexes is based on group FAHP and accomplished using Chang's extent analysis methods.

From the geometric mean of the opinions of the experts (the 10 questionnaires, the pairwise comparison matrix of the fuzzy numbers for the four perspectives of the balanced scorecard, the aggregation matrix of the exerts' opinions were resulted as shown in table 4.

Table 4: The Aggregation Matrix of Experts' Opinions Regarding the Four Perspective

Achieving the Superior Global Level of Production	**Financial**	**Customer**	**Internal Processes**	**Growth and Learning**
Financial	(1,1,1)	(0.74,0.965,1.265)	(0.812,1.106,1.456)	(0.87,1.183,1.527
Customer	(0.79,1.035,1.349)	(1,1,1)	(0.615,0.901,1.353)	(0.841,1.224,1.674)
Internal Processes	(0.686,1.903,1.32)	(0.738,1.109,1.623)	(1,1,1)	(0.784,1.034,1.342)
Growth and Learning	(0.654,0.844,1.148)	(0.597,0.816,1.188)	(0.745,0.966,1.274))	(1,1,1)

Then, the fuzzy compound expansion for each perspective is calculated:
In the next step, the degree of possibility for each pair is calculated as seen in table (5) and the least degree of possibility of each perspective in relation to other perspectives is obtained in order to create the weight vector of the four perspectives as depicted in table (6).

Table 5: Degrees of Possibility for each Pair of the Four Perspectives

SC1> SC2 = 1	SC2> SC1 = 0.976	SC3> SC1 =0.947	SC4> SC1 = 0.829
SC1> SC3 = 1	SC2> SC3 = 1	SC3> SC2 = 0.971	SC4> SC2 = 0.857
SC1> SC4 = 1	1 SC1> SC4 = 1	SC3> SC4 = 1	SC4> SC3 = 0.885

Table 6: The Final Weight for the Four Perspectives

The Four Perspectives	**Financial**	**Customer**	**Internal Processes**	**Growth and Learning**
The Minimum Degree of Possibility	1	0.976	0.947	0.829
The Final Weight	0.266	0.26	0.252	0.221

In order to prioritize each of the four perspectives, the above stages are repeated. Due to high amount of calculations, we only present the results for the final weights of each of the 16 indexes in table (7).

Table 7: The Final Weight for the Indexes of Balanced Scorecard Calculated Using FAHP Method

Weights of the Perspectives		**Indexes for each of the Four Perspectives**		**The Final Weight of each Index**
Perspectives	**Weights**	**Indexes**	**Weights**	
Financial	0.226	Profitability of the Assets	0.197	0.052
		Profitability of Sales	0.185	0.049
		Profitability of Capital	0.205	0.054
		Cash Flow	0.211	0.056
Customer	0.252	Customer Satisfaction	0.284	0.073
		Attracting New Customers	0.234	0.061
		Final Market Share	0.233	0.058
		Maintaining the Customers	.0257	0.066
Internal Processes	0.252	Expanding the Production	0.237	0.059
		Production Process	0.255	0.064
		Product Delivery	0.249	0.062
		New Technology	0.258	0.065
Growth and Learning	0.221	Job Satisfaction	0.277	0.061
		Training and Skill	0.23	0.021
		Creativity	0.263	0.058
		Knowledge Sharing	0.227	0.05

The Comparative Evaluation of the Strategies Using FVIKOR

To prioritize the strategies for achieving world-class manufacturing, we will use FVIKOR and the fuzzy numbers in table 3-2. The matrix for experts' opinions is presented in table 4-38.

Considering the information in table (4-38), the normalized aggregation matrix of experts' opinions is as shown in table 9.

	Profitability of the Assets					**Profitability of the Sales**					**…**	**Creativity**					**Knowledge Sharing**				
	Expert 1	**Expert 2**	**…**	**Expert 9**	**Expert 10**	**Expert 1**	**Expert 2**	**…**	**Expert 9**	**Expert 10**		**Expert 1**	**Expert 2**	**…**	**Expert 9**	**Expert 10**	**Expert 1**	**Expert 2**	**…**	**Expert 9**	**Expert 10**
Designing the Product According to Customers' Requirement	G	B	…	F	F	F	F	…	F	G	…	G	G	…	F	G	G	G	…	G	F
Adopting the new Technology for Continuous Development and	F	F	…	G	G	P	W	…	`F	P	…	G	G	…	B	B	G	B	…	B	B
Improving the after-Sale Services by Expanding the Service Network	F	G	…	B	G	B	G	…	G	G	…	P	P	…	F	W	P	F	…	P	F

Table 9: The Aggregation Normalized Fuzzy Matrix for the Experts' Opinions

	Profitability of Assets	**Profitability of Sales**	**…**	**Creativity**	**Knowledge Sharing**
Designing the product according to customers' requirement	(0.34,0.591,0.804)	(0.42,0.697,0.93)		(0.402,0.68,0.953)	(0.396,0.664,0.908)
Adopting the new technology for continuous development and improvement	(0.369,0.1,1.622)	(0,0,0.535)		(0.517,0.801,1)	(0.572,0.837,1)
Improving the after-sale services by expanding the service network	(0.362,0.615,0.83)	(0.535,0.809,1)		(0,0,0.586)	(0,0,0.558)

The remaining steps of FVIKOR technique is as shown in tables 10-13

Table 10: The Best and the Worst Fuzzy Values

The Worst Fuzzy Value (f)				**The Best Fuzzy Value (f^*)**			
Knowledge Sharing	**Creativity**	**…**	**Profitability of Sales**	**Profitability of Assets**	**Knowledge Sharing**	**Creativity**	**…**	**Profitability of Sales**	**Profitability of Assets**
(0,0,0.558)	(0,0,0.586)		(0,0,0.493)	(0.302,0.548,0.791)	(0.573,0.837,1)	(0.0517,0.801,1)		(0.535,0.809,1)	(0.0369,0.622,1)

Table 11: Values of S_i and R_i

	S_i	**Ri**
Designing the product according to customers' requirement	(0.295,0.324,0.401)	(0.06,0.064,0.064)
Adopting the new technology for continuous development and improvement	(0.255,0.31,0.365)	(0.048,0.054,0.054)
Improving the after-sale services by expanding the service network	(0.64,0.647,0.736)	(0.065,0.065,0.065)

Table 12: The Best and the Worst Values of S_i and R_i

$\widetilde{s^+}$	(0.255, 0.31, 0.365)
$\widetilde{s^-}$	(0.579, 0.654, 0.832)
$\widetilde{R^+}$	(0.64, 0.647, 0.736)
$\widetilde{R^-}$	(0.065, 0.065, 0.065)

Table 13: Prioritizing the Strategies

	Fuzzy Q_1	D-Fuzzy Q_1	Priority of the Strategies
Designing the product according to customers' requirement	(0.271,0.295,0.299)	0.288	2
Adopting the new technology for continuous development and improvement	(0,0,0)	0	1
Improving the after-sale services by expanding the service network	(0.67,0.763,0.925)	0.786	3

Now it is time to check the table and choose the optimum alternative. Therefore, the conditions for choosing the final alternative should be tested.
First test (acceptable advantage):

$(0.288 - 0) \geq \left[\frac{1}{3-1}\right]$ $\quad 0.288 \geq 0.5$

Obviously the first condition for the second strategy is not met.
Second test (acceptable stability in decision making):
???
From table 4-35 it is found that the second strategy has the least value for the S_i and R_i parameters which means the highest order in priority.
Note that the first condition is not met, so according to the solution for the special cases (Cf. section 3) the optimum alternative should be chosen as follows:

$(0.288 - 0) \geq \left[\frac{1}{3-1}\right]$ $\quad 0.288 \leq 0.5$

$(0.786 - 0.288) \geq \left[\frac{1}{3-1}\right]$ $\quad 0.498 \leq 0.5$

Which implies that the first and the second strategies are the most appropriate strategies for achieving the world-class manufacturing.

Conclusion and Suggestions

The aim of this study is the comparative evaluation, or in other words, prioritization of the strategies for achieving world-class manufacturing. The point is that most variables used in the present study are subjective, qualitative and of a linguistic nature and measuring them by deterministic methods and numbers seems difficult. The main contribution of the present study is an integration of two techniques, FAHP and FVIKOR in a fuzzy environment to tackle this problem. In other words, researchers use fuzzy concepts to give a mathematical expression of verbal comments and linguistic variables. By analyzing the results and findings of the study it is possible to give answers to the research questions:
1. - What are the weights of the four BSC perspectives according to the Yuksel and Dagdevirenmodel?
By using FAHP method and the results in table 6 it is found that experts in JDEVS in Tehran consider the financial perspective (with a weight of 0.266) to be the most important perspective among the four perspectives of the balanced scorecard in achieving the main goal of the study. Other perspectives' weights are as follows: customer (0.26), internal processes (0.252), growth and learning (0.221).

2- What are the weights of the performance indexes in each of the four BSC perspectives according to the Yuksel and Dagdevirenmodel?

Considering the weights obtained in the FAHP method and presented in table 7, the priority ranking of each index of the four perspectives of balanced scorecard is determined with the "customer satisfaction (0.073) and "maintaining the customers" (0.064) having the highest importance for achieving the world-class manufacturing. The ranking and weights of other indexes is as follows: new technology (0.065), production process (0.064), product delivery (0.062), job satisfaction (0.0614), attracting customers (0.06109), expanding the production (0.059), creativity (0.058296), final market share (0.058263), cash flow (0.056), Profitability of capital (0.054), decreasing the production costs (o.053), profitability of the assets (0.052), knowledge sharing (0.05), profitability of sales (0.049), training and skill (0.021).

3- According to Yuksel and Dagdeviren model, What is the most appropriate strategy to achieve the superior global level of production?

To prioritize the strategies for achieving world-class manufacturing, FVIKOR method and fuzzy numbers in table (3) were used. The results show the high priority of the "adopting new technology" strategy in comparison to the two other strategies.

Complexity of managerial decision making and the conflicts which naturally arise in the mutual communications in a collective decision making and problems caused by the hierarchical structure, leads to less appropriate decisions regarding strategy selection.

Using FVIKOR, FAHP and BSC together helps the managers to deal with such problems which arise from the traditional approaches to collective decision making.

Based on the findings of the research, we outline some practical suggestions for achieving a superior global level of production:

* Choosing an appropriate strategy is an essential step to end dispersed and inconsistent decisions of the managers. The authorities and managers of the cement industry can take advantage of the results of the present study by focusing on the strategy with the highest priority and align their efforts with the goal of achieving world-class manufacturing.

* Considering the very rapid changes in the world today, the strategy should be flexible. Therefore, we suggest the authorities and managers of the cement companies not to consider strategic management as some activity which is planned once and for all, but as parts of a chain which involves organizational learning, and thus, modifications in the strategies. The learning should be based on the key capabilities of the organizations and environmental changes.

* Since "adopting the new technology for continuous improvement of the product's quality" was identified as the most appropriate strategy for achieving the world-class manufacturing in cement industry and given the fact that advanced technologies are one of the key drivers of increasing efficiency in the companies, it is crucial for the companies under study to adopt the new technology and become competitive in the global market. So, we suggest the managers to adopt a technology consistent with the structure and environment of their organizations.

* Considering the high importance of financial perspective in achieving the aforementioned goal, we suggest the management to use financial ratios to evaluate the performances and identifying the advantages and disadvantages. Moreover, considering the importance of these financial ratios for the managers, customers and moneylenders it is necessary for the managers to evaluate and control these ratios and make decisions to improve them.

* Considering the high importance of the "customer's satisfaction" and "keeping customers" indexes, we suggest designing and implementing systems for managing communications with the customers and managing the knowledge of customer in order to gain knowledge of customer's priorities (through data-mining) and increasing their satisfaction and royalty.

REFERENCES

Afshar-kazemi MA, Makouie A and Darman Z (2009). Developing the supply chain strategy of Iran steel industry using systems dynamics analysis, *Quarterly of Trade Research* **50** 201-224.

Aghajani H, Sedaghat M, Dargahi H and Pourhossein M (2012). Applying VIKOR, TOPSIS and SAW in fuzzy Environment for Ranking Suppliers in Supply Chain: A Case study. *American Journal of Scientific Research* **48** 10-19.

Anbari M, Bagheri R & Davodi H (2013). Survey of Social factors Effective on discontinuation of innovation in rural areas (Case Study: Drip irrigation Technology in Lorestan). *Journal of Science and Today's World* **2**(5) 451-464.

Aqajani H and Dargahi H (2011). Applying FVIKOR technique to solve the problems of the suppliers in a supply chain: the case of Iran Khodro co. *2'nd International Conference of Problem Solving Strategies and Techniques*, Tehran.

Azar A and Faraji H (2002). *The Science of Fuzzy Management*, (Ministry of Culture and Islamic Guidance, Tehran).

Chang DY (1996). Application of the extent analysis method on fuzzy AHP. *European Journal of Operational Research* **95** 649-65.

Dargahi H, Fallah Y and Esmaeili F (2011). Application of multi-criteria decision making techniques in ranking the obstacles of electronic commerce with mobile phones (the case of Ghaem-shahr city), *The 2nd International Conference of E-Citizen and Cellphone*, Tehran.

Eid R (2009). Factors affecting the success of world class manufacturing implementation in less developed countries: The case of Egypt. *Journal of Manufacturing Technology Management* **20**(7).

Farsijani H (2010). World-class Manufacturing and operational methods. *The Organization for Researching and Composing University Textbooks in the Humanities* (SAMT Publications, Tehran).

Farsijani H and Teymourian M (2009). Success factors of technology transfer for achieving the world class status (the case of Hepco Company). *Journal of Management Outlook* **32** 158-168.

Goranourimi F, Dargahi H, Sedaghat M and Moakher AK (2012). Ranking Suppliers in Supply Chain Using Fuzzy Multi-Attribute Decision Making Model: A Case Study in Iran Automobile Compant. *American Journal of Scientific Research* **42** 5-11.

Goudarzi QR (2004). Designing the strategic decision making model of a parts and accessories supply chain for world-class manufacturing, PHD dissertation, Tarbiat Modares University.

Haghighi M, Divandari A and Keimasi M (2010). The impact of 3D e-readiness on e-banking development in Iran: A fuzzy AHP analysis. *Expert Systems with Applications* **37** 4084–4093.

Lee SH (2010). Using fuzzy AHP to develop intellectual capital evaluation model for assessing their performance contribution in a university. *Expert Systems with Application* **37** 4941-4947.

Maghsoudi T, Hekmat M & Davodi H (2012). Supporting the entrepreneurship development in the agriculture production cooperatives. *African Journal of Business Management* **6**(10) 3639.

Opricovic S and Tzeng GH (2007). Extended VIKOR method in Compromise with outranking method. *European Journal of Operational Research* **178** 178-514.

SafaeiGhadikolaei A, Baboli AM, Elyasi Z and Akbarzadeh Z (2011). Comparison of Comparitive World-Class Manufacturing in the Iranian and Indian Automotive industries With PVA Algorithm (Case Study: Irankhodro company). *European Journal of Scientific Research* **61** 273 -281.

Safaie-qadikolaie A (1999). Principals of implementing world-class manufacturing in automotive companies, PHD dissertation, Tarbiat Modares University.

Safaie-qadikolaie A, Dargahi H and Mousavi SF (2011). Developing a fuzzy approach for determining the competitive status of the media tools. *2'nd National Conference of Applications of Fuzzy Logic in Media Studies*, Tehran.

Salahedin SI and Eid R (2007). The implementation of world class manufacturing techniques in Egyptian manufacturing firms: An empirical study. *Industrial Management & Data Systems* **107**(4) 551-566.

Sangwan KS and Digalwar AK (2008). Evaluation of world-class manufacturing systems: a case of Indian automotive industries. *International Journal of Services and Operations Management* **4**(6).

Schonberger R (1986). *World Class Manufacturing: The Lesson of Simplicity Applied*, (The Free Press, New York, USA).

Smith AD (2011). Component part quality assurance concerns and standards Comparison of world – class manufacturing. *Benchmarking: An International Journal* **18** 128-148.
Sun CC (2010). A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods. *Expert Systems with Application* **37** 7745-7754.
Wu CS, Lin CT and Lee C (2010). Optimal marketing strategy: A decision- making with ANP and TOPSIS. *International Journal of Production Economics* **127** 190-196.
Yang T and Hsieh CH (2009). Six- sigma project selection using national quality award criteria and Delphi fuzzy multiple criteria decision- making method. *Expert Systems with Application* **36** 7594-7603.
Yuksel I and Dagdeviren M (2010). Using the fuzzy analytic process (ANP) for Balanced Scorecard (BSC): A case study for manufacturing firm, *Expert Systems with Applications* **37** 1270-1278.