Maedeh SEDAGHAT, M.Sc.
Young Research Club
Sari Branch Azad University,
Sari, Iran
E-mail:sedaghat.maedeh@yahoo.com

A PRODUCTIVITY IMPROVEMENT EVALUATION MODEL BY INTEGRATING AHP, TOPSIS AND VIKOR METHODS UNDER FUZZY ENVIRONMENT (CASE STUDY: STATE-OWNED, PARTIALLY PRIVATE AND PRIVATE BANKS IN IRAN)

Abstract. *Productivity is one of the most significant factors in an organization's general performance. Regarding to the key role of banking industry in economic, social and political development, productivity improvement on each of its branches will be an effective factor for society productivity improvement. Productivity improvement in organizations is as one of executive managers and decision makers' main challenges in each country. Multiple criteria decision-making (MCDM) research has developed rapidly and has become a main area of research for dealing with complex decision problems. FAHP, TOPSIS, VIKOR and SAW are used as MCDM techniques in the present study. The proposed method enables decision analysts to better understand the complete evaluation process and provide a more accurate, effective and systematic decision support. In this paper, we study the importance degree of three effective dimensions (human resource, financial and management performance) on productivity improvement and also their sub criteria in state-owned, partially private and private banks in Iran. Fuzzy Analytic Hierarchy Process (FAHP) is applied for evaluating productivity improvement. TOPSIS, VIKOR and SAW are utilized for ranking the three mentioned banks. Our results indicate that among three mentioned productivity dimensions, management performance productivity is of the greater importance than human resource and financial productivity and private banks have gained the highest priority of all.*

Keywords*: Banking industry, Productivity, FAHP, FTOPSIS, FVIKOR.*

JEL Classification: C44-D24-L33

1. Introduction

The financial sector plays a crucial role in the effective allocation of resources, in economic growth and in job creation. In advanced economies, this sector has shown relatively high rates of growth during the last decades. The reliable and unbiased estimation of basic aggregates of banks such as

output, inputs and productivity is essential for the performance evaluation of any banking sector. Banks, just like any other firm, need to transform inputs into outputs at an efficient rate in order to maximize profitability and to survive under competitive conditions. Therefore, if a bank is using more resources in the production process than is technically required, it will be operating below the 'frontier' of efficiency and stakeholders, policy makers and academics alike take a keen interest when these relative levels of inefficiency are displayed.

Banking is one of the most complex industries in the world—and a major contributor to a country's wealth. In an environment in which financial markets are entering into an integration process and speedy and radical changes take place due to technological developments, it is important to ensure and maintain performance efficiency so that banks can contribute in sustainable development and fulfill the role they have assumed for the allocation of resources.

This paper proposes a Fuzzy MCDM methodology to study the most important area of productivity improvement using the most suitable criteria and sub-criteria in state-owned, partially private and private banks. The remainder of this paper is organized as follows. Section 2 reviews the related works pertinent to this research. The research conceptual model and the related references of criteria and sub-criteria are presented in section 3. The details of the proposed methodology are presented in Section 4. Section 5 provides a real-life example to demonstrate the efficiency of our proposed model. Conclusions are presented in Section 6.

2. Review of literature

Productivity is one of the most significant factors on an organization's general performance. In micro level, productivity improvement is always a useful tool for confronting with inflation effects and salary and wages policies. In a short, productivity results can be explained in: 1-reducing total cost and production continuation, 2- quality improvement, 3- products' market share growth, 4- raising employees' salary without any inflation pressure and 5- improvement on employees, employers and customers purchasing ability (Kazaz, 2007).

Our real income and living standards critically depend upon our ability to raise productivity, and as a nation, our objective should be to maximize increases in living standards. Therefore, productivity should always be something that we want to increase as much as possible (O'Neill, Egelton, and Hogue, 1999).

Success in any productivity enhancement program depends on the leadership, participation and the ongoing support of every manager. So the first activity is a top-level evaluation of management structure and style (Eppolito, 2002). Increases in productivity represent one of the key competitive advantages of a company. Unfortunately, companies seldom manage their productivity.

In this section, we present some recent studies about productivity in banks as presented in table1.

Table 1: Summary of the Recent Studies

No.	Authors' name	Place & year of the Study	Research Findings
1	Sanyal & Shankar	United States, 2011	This paper investigates the effect of ownership and competition on Indian bank productivity since the 1991 reforms. The results showed that Indian private banks dominate the public and foreign banks both in terms of productivity levels and productivity growth, with the new Indian private banks leading the charge. Competition has a positive impact on productivity for the old Indian private banks, and all the other banks are hurt by competition.
2	Epure, Kerstens, and Prior	Spain, 2011	This paper analyzes changes in productivity and efficiency of Spanish private and savings banks over an eight-year period (1998–2006). Empirical results demonstrate that productivity improvements are partially due to technological innovation and private banks enjoy better efficiency change.
3	Margono, Sharma, and Melvin II	United States, 2010	This study estimates cost efficiency, economies of scale, technological progress, and productivity growth among Indonesian banks from 1993 to 2000. The results indicate that private-owned banks and joint venture foreign banks were more efficient than public-owned banks.
4	Wu, Tzeng, and Chen	Taiwan, 2009	This paper applied FMCDM to evaluate bank performance based on BSC. In this research the evaluating performance index are prioritized based on the four perspectives of a Balanced Scorecard (BSC), then the three MCDM analytical tools of SAW, TOPSIS, and VIKOR were respectively adopted to rank the banking performance and improve the gaps with three banks as an empirical example. Applying the three mentioned MCDM tools among three banks, bank C has gotten the first rank. It indicates that all the ranking results are identical. However, the VIKOR method is found to be a better method of assessment to clearly discriminate the banking performance.
5	Jaffry, Ghulam, and Cox	United Kingdom, 2008	The focus of this paper is the estimation of productivity and efficiency of labor use in the banking sectors of the Indian sub-continent. The results show that the efficiency of labor use across the Indian sub-continent is improving over time and that foreign banks are more efficient compared to domestically owned banks in their usage of labor.

3. Research Theoretical Framework

The conceptual model of the present study is illustrated in figure 1.

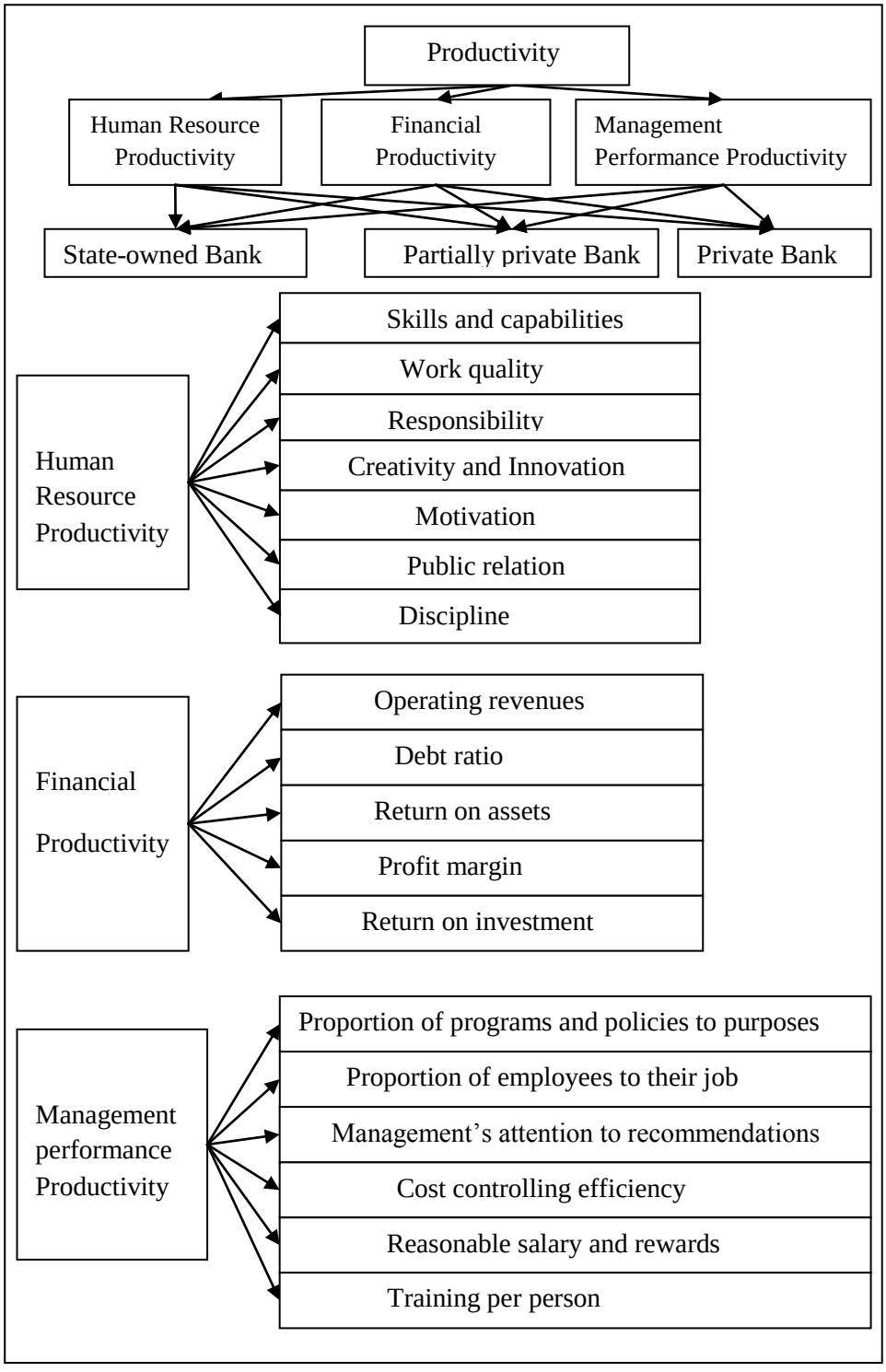

Figure 1: The conceptual model of the present study

In this conceptual model, the three productivity dimensions (human resource, financial and management performance) are extracted from Gill's paper (2011) and Eshraghniae Jahromi *et al.* paper (2010), human resource indexes from Azadeh et al. paper (2011), Financial indexes from Hung Yi Wu paper et al. (2009), management performance indexes from Eshraghniae Jahromi et al. paper (2010). The references of the three mentioned dimensions of productivity's sub-criteria in the research conceptual model are presented in table 2.

Table 2: Sub-criteria's References

Workers' skills & capabilities	Azadeh *et al*.(2011), Liu *et al*. (2007), Kopelman *et al.(*1986)
Work quality	Azadeh *et al*.(2011), Jensen & Alting (2006)
Responsibility	Azadeh *et al*.(2011), Jensen & Alting (2006), Tubbs & Moss (2000), Huczynski, & Bachnan D (2001)
Creativity & innovation	Azadeh *et al*.(2011), Masso *et al*. (2011), Cassiman (2010)
Motivation	Azadeh *et al*.(2011), Kopelman *et al.* (1986), Akhavan Tabasi *et al*. (2009), Jenseng & Alting (2006), Islam *et al.* (2008)
Public relation	Azadeh *et al*.(2011), Jensen & Alting (2006)
Discipline	Azadeh *et al*.(2011)
Operating revenues	Wu *et al*.(2009), Neveu (1989)
Debt ratio	Wu *et al*.(2009),. Neveu (1989), Secme *et al*. (2009)
Return on assets	Garcia *et al*. (2010), Wu *et al.(*2009), Ray & Das (2010), Secme *et al*. (2009)
Profit margin	Wynder (2011), Wu et al.(2009), Secme *et al*. (2009), Barth *et al.* (2004), Doliente (2003)
Return on investment	Garcia *et al.* (2010), Wu *et al*.(2009), Ray & Das (2010), Secme *et al.* (2009)
Management's attention to recommendations	Eshraghnia Jahromi (2009)
Cost controlling efficiency	Eshraghnia Jahromi (2009), Kauko (2009)
Reasonable salary and rewards	Eshraghnia Jahromi (2009). Broadbent & Laghlin (2009), Ferreria & Otley (2005), Kopelman *et al.* (1986)
Training per person	Eshraghnia Jahromi (2009), Kauko (2009), Jabbor *et al*. (2008), Cue *et al*. (2001), Kopelman *et al*. (1986)

The fuzzy analytic hierarchy process using Chang's extent analysis technique is employed as the main statistical method of the study [3]. Regarding to our

subject essence of research model and the experts' viewpoint in Iran's central bank, Melli bank, Saderat bank and Parsian bank are selected as the representatives of state-owned bank, partially private bank and private bank, respectively due to their high market share among other Iranian banks, hence the three mentioned banks constituted our case study. The experts are the head masters or high rank managers with at least 10 year service and Bachelor degree in the three mentioned banks.

4. Research Methodology

4.1. Fuzzy AHP Method

In the proposed methodology, AHP with its fuzzy extension, namely fuzzy AHP, is applied to obtain more decisive judgments by prioritizing the market segment selection criteria and weighting them in the presence of vagueness. There are numerous fuzzy AHP applications in the literature that propose systematic approaches for selection of alternatives and justification of problem by using fuzzy set theory and hierarchical structure analysis (Efendigil *et al.*, 2008) (Önüt *et al.*, 2010). DMs usually find it more convenient to express interval judgments than fixed value judgments due to the fuzzy nature of the comparison process (Bozdag *et al.* 2003). This study concentrates on a fuzzy AHP approach introduced by Chang (1992), in which triangular fuzzy numbers are preferred for pairwise comparison scale. Extent analysis method is selected for the synthetic extent values of the pairwise comparisons. Some papers published used the fuzzy AHP procedure based on extent analysis method and showed how it can be applied to selection problems (Cebeci and Ruan, 2007; Kahraman *et al.* 2003, 2004). The outlines of the fuzzy sets and extent analysis method for fuzzy AHP are given below.

A fuzzy number is a special fuzzy set F = {(x,μ_F (x), x ∈R}, where x takes its values on the real line, R: $-\infty \leq x \leq \infty$ and μ_F (x) is a continuous mapping from R to the closed interval$[0, 1]$.A triangular fuzzy number (TFN) expresses the relativestrength of each pair of elements in the same hierarchyand can be denoted as M = (l, m, u), where $l \leq m \leq u$. The parameters l; m; u; indicate the smallest possible value, the most promising value, and the largest possible value respectively in a fuzzy event. The recent applications of fuzzy AHP method in shortly are listed below:

- Fouladgar *et al* (2011) used fuzzy AHP and fuzzy TOPSIS for prioritizing strategies of the Iranian mining sector.
- Lin *et al* (2011) used fuzzy Delphi method, fuzzy AHP and fuzzy theory to develop an evaluation system of knowledge management performance.
- Heo *et al.* (2010) used fuzzy AHP for analysis of the assessment factors for renewable energy dissemination program evaluation.
- Che *et al.* (2010) utilized a fuzzy AHP and DEA approach for making bank loan decisions for small and medium enterprises in Taiwan.
- Wu *et al.* (2009) applied a fuzzy MCDM approach for evaluating banking performance based on Balanced Scorecard.

This paper applies Chang's extent analysis method (Chang, 1996). According to Chang's extent analysis method, the value of fuzzy synthetic extent is defined, using the standard fuzzy arithmetic, as below:

$$S_i = \sum_{j=1}^{m} M_i^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_i^j \right]^{-1} \tag{2}$$

where M_i^j is a triangular fuzzy number representing theextent analysis value for decision element i with respect to goal j.$M_i^j$is the generic element of a fuzzy pair-wise comparison matrix like the one used in the AHP method.

The degree of possibility of $M_1 \geq M_2$ is defined as:

$$V(M_1 \geq M_2) = Sup_{x \geq y} \left[\min(\mu_{M_1}(x), \mu_{M_2}(y)) \right] \tag{3}$$

And can be equivalently expressed as follows:

$$V\ M_1 \geq M_2\ = hgt\ M_2 \cap M_1\ = \begin{cases} 1, if\ \ b_1 \geq b_2\ , \\ 0, if\ \ a_2 \geq c_1\ , \\ \dfrac{c_1 - a_2}{c_1 - a_2\ -\ b_2 - b_1}, otherwise, \end{cases} \tag{4}$$

The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy number $M_i\ \ i = 1, 2, ..., k$ can be defined by

$$\begin{aligned} &V\ \ M \geq M_1, M_2, ..., M_K\ = V\ \ M \geq M_1\ \ and, V\ \ M \geq M_2\ \ and... \\ &and, V\ \ M \geq M_k\ = \min\ V\ \ M \geq M_i\ , i = 1, 2, ..., k \end{aligned} \tag{5}$$

Assume that:

$$d'\ \ A_i\ = \min V\ \ S_i \geq S_k \tag{6}$$

For $K = 1, 2, ..., n;\ \ K \neq i$ then the weight vector is given by

$$W' = \ \ d'\ \ A_1\ , d'\ \ A_2\ , \ldots , d'\ \ A_n\ \ ^T \tag{7}$$

Where $A_i (i = 1, 2, ..., n)$ are n decisions elements, via normalization, the normalized weight vectors are

$$W = \ \ d\ \ A_1\ , d\ \ A_2\ , \ldots , d\ \ A_n\ \ ^T \tag{8}$$

Where W is a non-fuzzy number, compared to conventional AHP, The fuzzy AHP approach allows a more accurate description of the decision making process.

Paired comparisons are done based on the information of table 3.

Table 3: Triangular fuzzy conversion (Önüt *et al,* 2008)

Linguistic scale for importance	Triangular fuzzy scale (a, b, c)
Just equal	(1.0,1.0,1.0)
Equal importance	(1.0,1.0,3.0)
Weak importance of one over another	(1.0,3.0,5.0)
Essential or strong importance	(3.0,5.0,7.0)
Very strong importance	(5.0,7.0,9.0)
Extremely preferred	(7.0,9.0,9.0)
If factor i has one of the above numbers assigned to it when compared to factor j, then j has the reciprocal value when compared whit i Reciprocals of above $M_1^{-1} \approx \left(\frac{1}{c_1}, \frac{1}{b_1}, \frac{1}{a_1}\right)$.	

4.2. Fuzzy TOPSIS

TOPSIS was proposed by Hwang and Yoon (1981) to determine the best alternative based on the concepts of the compromise solution. The compromise solution can be regarded as to choose a solution with the shortest Euclidean distance from the ideal solution and the farthest Euclidean distance from the negative-ideal solution.

Since the preferred ratings usually refer to the subjective uncertainty, it is natural to extend TOPSIS to consider the situation of fuzzy numbers. Fuzzy TOPSIS can be intuitively extended by using the fuzzy arithmetic operations as follows.

Given a set of alternatives, $A = \{A_i \mid i = 1, \cdots, n\}$, and a set of criteria, $C = \{C_j \mid j = 1, \cdots, m\}$, where $\tilde{X} = \{\tilde{x}_{ij} \mid i = 1, \cdots, n;\ j = 1, \cdots m\}$ denotes the set of fuzzy ratings and $\tilde{W} = \{\tilde{w}_j \mid j = 1, \cdots, m\}$ is the set of fuzzy weights.

The first step of TOPSIS is to calculate normalized ratings by

$$\tilde{r}_{ij}(\boldsymbol{x}) = \frac{\tilde{x}_{ij}}{\sqrt{\sum_{i=1}^{n} \tilde{x}_{ij}^2}}, \quad i = 1, \cdots, n; \quad j = 1, \cdots, m \tag{1}$$

and then to calculate the weighted normalized ratings by

$$\tilde{v}_{ij}(\boldsymbol{x}) = \tilde{w}_j \tilde{r}_{ij}(\boldsymbol{x}), \quad i = 1, \cdots, n; \quad j = 1, \cdots, m. \tag{2}$$

Next the positive ideal point (*PIS*) and the negative ideal point (*NIS*) are derived as

$$PIS = \tilde{\boldsymbol{A}}^+ = \{\tilde{v}_1^+(\boldsymbol{x}), \tilde{v}_2^+(\boldsymbol{x}), \cdots, \tilde{v}_j^+(\boldsymbol{x}), \cdots, \tilde{v}_m^+(\boldsymbol{x})\}$$
$$= \{(\max_i\ \tilde{v}_{ij}(\boldsymbol{x}) \mid j \in J_1), \quad (\min_i\ \tilde{v}_{ij}(\boldsymbol{x}) \mid j \in J_2) \mid i = 1, \cdots, n\}. \tag{3}$$

$$PIS = \tilde{\boldsymbol{A}}^{-} = \{\tilde{v}_1^{-}(\boldsymbol{x}), \tilde{v}_2^{-}(\boldsymbol{x}), \cdots, \tilde{v}_j^{-}(\boldsymbol{x}), \cdots, \tilde{v}_m^{-}(\boldsymbol{x})\}$$
$$= \{(\min_i \tilde{v}_{ij}(\boldsymbol{x}) \mid j \in J_1), \ (\max_i \tilde{v}_{ij}(\boldsymbol{x}) \mid j \in J_2) \mid i = 1, \cdots, n\}. \quad (4)$$

where J_1 and J_2 are the benefit and the cost attributes, respectively.

Similar to the crisp situation, the following step is to calculate the separation from the *PIS* and the *NIS* between the alternatives. The separation values can also be measured using the Euclidean distance given as:

$$\tilde{S}_i^{+} = \sqrt{\sum_{j=1}^{m} [\tilde{v}_{ij}(\boldsymbol{x}) - \tilde{v}_j^{+}(\boldsymbol{x})]^2}, i = 1, \cdots, n \quad (5)$$

and

$$\tilde{S}_i^{-} = \sqrt{\sum_{j=1}^{m} [\tilde{v}_{ij}(\boldsymbol{x}) - \tilde{v}_j^{-}(\boldsymbol{x})]^2}, i = 1, \cdots, n \quad (6)$$

where

$$\max\{\tilde{v}_{ij}(\boldsymbol{x})\} - \tilde{v}_j^{+}(\boldsymbol{x}) = \min\{\tilde{v}_{ij}(\boldsymbol{x})\} - \tilde{v}_j^{-}(\boldsymbol{x}) = 0. \quad (7)$$

Then, the defuzzified separation values should be derived using one of defuzzified methods, such as CoA to calculate the similarities to the *PIS*.

Next, the similarities to the *PIS* is given as

$$C_i^{*} = D(S_i^{-}) \Big/ [D(S_i^{+}) + D(S_i^{-})] \ , i = 1, \cdots, n \quad (8)$$

where $C_i^{*} \in [0,1] \ \ \forall i = 1, \cdots, n$.

Finally, the preferred orders are ranked according to C_i^{*} in descending order to choose the best alternatives.

Fuzzy TOPSIS method was applied in many fields:

- Kutlu and Ekmekciog˘lu (2011) studied Fuzzy failure modes and effects analysis by using fuzzy TOPSIS-based fuzzy AHP.
- Sivapirakasam *et al.* (2011) paper aims to develop a combination of Taguchi and fuzzy TOPSIS methods to solve multi-response parameter optimization problems in green manufacturing.
- Kaya and Cengiz Kahraman (2011) studied Multicriteria decision making in energy planning using a modified fuzzy TOPSIS methodology.
- Sun (2010) applied a performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods.
- Saremi *et al.* (2009) applied Fuzzy TOPSIS for TQM consultant selection in SMEs.

° Secme *et al.* (2009) conducted Fuzzy performance evaluation in Turkish Banking Sector using Analytic Hierarchy Process and TOPSIS.

4.3. The Fuzzy VIKOR Method

The optimum in multi-criteria decision-making is the process to decide the compromise ranking in the ensured rules. In reality, there is no avoidance of the coexistence of qualitative and quantitative data, and they are often full of fuzziness and uncertainty. So, the optimum is often the not inferior solutions or compromise solutions depend on the decision-maker. The concepts of compromise solutions were first initiated by Yu *et al*. (1973). The compromise solutions will be presented by comparing the degree of closeness to the ideal alternative. The method of VIKOR initiated by Opricovic (1998), works on the principle that each alternative can be evaluated by each criterion function; the compromise ranking will be presented by comparing the degree of closeness to the ideal alternative. To solve fuzzy multi-criteria decision-making problems with a best solution and compromise solution in reality confirmed situation, Fuzzy VIKOR was described by Wang *et al*. (2005). The following was the stages in Fuzzy VIKOR.

Step1: Form a group of decision-makers (denoted in n), then determine the evaluation criteria (denoted in k) and feasible alternatives (denoted in m).

Step 2: Identify the appropriate linguistic variables for the importance weight of criteria, and the rating for alternatives with regard to each criterion (as shown in Table 4 and Table 5). The membership degree of fuzzy numbers in the weight of criteria and the rating of alternatives will be presented in Figure 2 and Figure 3.

Table 4: Linguistic Variables for the Weight of Criteria

Linguistic Variables	Fuzzy Numbers
VeryLow(VL)	(0.00,0.00,0.25)
Low(L)	(0.00,0.25,0.50)
Medium(M)	(0.25,0.50,0.75)
High(H)	(0.50,0.75,1.00)
VeryHigh(VH)	(0.75,1.00,1.00)

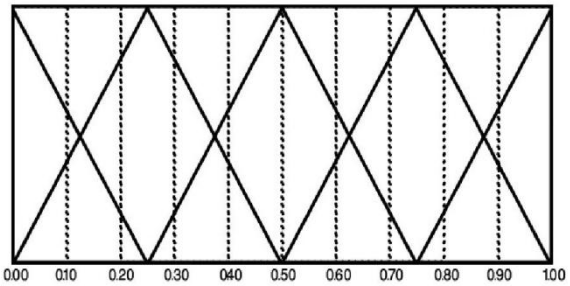

Figure 2.**The Membership Degree of Fuzzy Numbers in the Weight of Criteria**

Table 5: Linguistic Variables for the Rating of Alternative

Linguistic Variables	Fuzzy Number
Worst (W)	(0.0,0.0,2.5)
Poor(P)	(0.0,2.5,5.0)
Fair(F)	(2.5,5.0,7.5)
Good(G)	(5.0,7.5,10)
Best(B)	(7.5,10, 10)

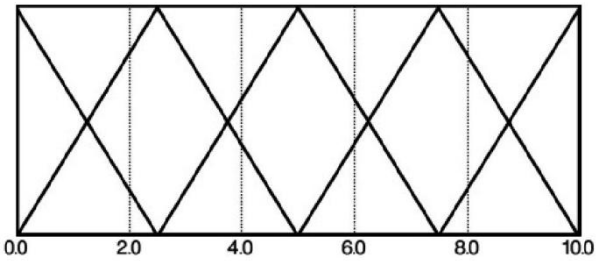

Figure 3.The Membership Degree of Fuzzy Numbers in the Rating of Alternative

Step 3: Pull the decision makers' opinions to get the aggregated fuzzy weight of criteria, and aggregated fuzzy rating of alternatives .If there are n persons in a decision committee, the importance weight of each criterion and rating of each alternative can be measured by:

$$\breve{w}_i - \frac{1}{k}\left[\breve{w}_i^1 + \breve{w}_i^2 + ... + \breve{w}_i^k\right] \quad (1)$$

$$\breve{X}_{ij} = \frac{1}{k}\left[\breve{X}_{ij}^{-1} + \breve{X}_{ij}^{-2} + ... + \breve{X}_{ij}^{-k}\right] \quad (2)$$

Step 4: Construct a fuzzy decision matrix. Formally, a typical fuzzy multi criteria decision making problem can be expressed in matrix format as:

$$\tilde{D} = \begin{pmatrix} \widetilde{X_{11}} & \wedge & \widetilde{X_{1n}} \\ M & M & M \\ \widetilde{X_{m1}} & \wedge & \widetilde{X_{mn}} \end{pmatrix} \quad i = 1,2,\ldots,m \quad j = 1,2,\ldots,n \quad (3)$$

$$\breve{w} = \breve{w}_1, \breve{w}_2, ...\breve{w}_n \ , j = 1,2,...,n \quad (4)$$

Where X_{ij} the rating of alternative A_i with respect to C_j, $\widetilde{W_j}$the importance weight of the j*th* criterion holds, X_{ij} and $\widetilde{W_j}$ are linguistic variables denoted by triangular fuzzy numbers.

Step5: Determine the fuzzy best value (FBV,f_i^+) and fuzzy worst value (FWV,f_i^-) of all criterion functions.

$$f_j^* = \quad Max\, f_{ij} \quad , i = 1,2,..., m$$
$$f_j^- = \quad Min\, f_{ij}\, , j = 1,2,..., n \qquad (5)$$

Step6: Compute the values S_i and R_i:

$$S_i = \sum_{j=1}^{n} w_i (f_j^* - f_{ij}) / (f^* - f_j^-) \qquad (6)$$

$$R_i = Max_j [w_i (f_j^* - f_{ij}) / (f^* - f_j^-)] \qquad (7)$$

where S_i refers to the separation measure of A_i from the fuzzy best value, similarly, R_i is the separation measure of A_i from the fuzzy worst value.

Step7: Calculate the value S^+,S^- ,R^+ , R^- and Q_i:

$$S^- = Max_i S_i\,, \quad S^* = Min_i S_i\,, \quad R^- = Max_i R_i \quad , R* = Min_i R_i \qquad (8)$$

$$\tilde{Q}_i = \frac{v(\tilde{S}_i - \tilde{S}^*)}{\tilde{S}^- - \tilde{S}^*} + \frac{(1-v)(\tilde{R}_j - \tilde{R}^*)}{\tilde{R}^- - \tilde{R}^*} \qquad (9)$$

The index is with a maximum majority rule, and is with a minimum individual regret of an opponent strategy. As well, v is introduced as weight of the strategy of the maximum group utility, usually v =0.5.

Step 8: Defuzzify triangular fuzzy number Q_i and rank the alternatives by the index Q_i.

The process converting a fuzzy number into a crisp value is called defuzzify. Various defuzzification strategies were suggested, in this paper, Chen's (1985) method of maximizing set and minimizing set is applied. The maximizing set is defined as:

R={(x,f_R(x))x R},with the membership function Similarly, the minimizing set is defined as:

$R = (N, F_R(X) X \in R$ with membership function:

$$f_R(x) = \begin{cases} (x - x_2)/(x_1 - x_2), & x_1 \leq x \leq x_2 \\ 0 & \text{otherwise} \end{cases} \qquad (10)$$

Similarly, the minimizing set is defined as: $L = (X, F, X); X \in R$,with membership function

$$f_L(x) = \begin{cases} (x - x_2)/(x_1 - x_2), & x_1 \leq x \leq x_2 \\ 0, & Otherwise \end{cases}$$

Then the right utility $U_R(Q_i)$ and left utility $U_L(Q_i)$ can be denoted as:

$$U_{F_i}(F_i) = \underbrace{Sup}_{x} (f_{F_i}(x) \wedge f_M(x)) \qquad (11)$$

$$U_l(P_l) = (\sup(f_{p1(x)} \wedge f_{a(x)})$$

$$U_l(P_l) = \underset{x}{\sup}\left(f_{p1(x)} \wedge f_{a(x)}\right) \quad (12)$$

As a result, the crisp value can be obtained by combining the right and left utilities.

$$U_T(f_i) = U_R(f_i) + 1 - U_l(f_i) \ / 2 \quad (13)$$

The index Q_i implies the separation measure of A_i from the best alternative.

That is the smaller the value, the better the alternative.

Step9: To determine a compromise solution (a) by the index Q in double conditions .To fit in with below double conditions, we should point out is our compromise solution.

[Condition 1] acceptable advantage:

Q (a) –Q (a) ≥ DQ

DQ= (1/m-1) (DQ=0.33if m=3) (14)

[Condition 2] Acceptable stability in decision making: Q(a) must in S(a)or/and R(a), is the alternative with second position ranked by index Q. If condition 1 is not satisfied, and Q (a^m) –Q (a)<DQ, a, a¯,k, a¯¯ are compromise solution in the same. If condition 2 is not satisfied, and a are a' compromise solutions in the same.

Step 10: Determine the best alternative. The best alternative is Q (a), which is one with the minimum of Q_i.

Fuzzy VIKOR method was applied in many fields:

- Devi (2011) used extension of VIKOR method in intuitionistic fuzzy environment for robot selection.
- Shemshadi *et al*. (2011) applied a fuzzy VIKOR method for supplier selection based on entropy measure for objective weighting.
- Opricovic (2011) utilized Fuzzy VIKOR with an application to water resources planning.
- Kaya and Kahraman (2011) studied Fuzzy multiple criteria forestry decision making based on an integrated VIKOR and AHP approach.
- Sanayei *et al*. (2010) used Group decision making process for supplier selection with VIKOR under fuzzy environment.

4.4. Fuzzy simple additive weighting (FSAW)

In practice for fuzzy multi attribute decision making (FMADM) problems, if we assume that there exist mutually independent relationships among criteria, after calculating the relative weights and the performance score of each criterion with respect to each alternative, then we can use FSAW method to aggregate the fuzzy preferred ratings to rank the order of alternatives. The procedure of SAW for FMADM can be summarized as follows:

Step 1: Calculating the relative fuzzy weight $\tilde{w}_j$ of the *j*th attribute, the relative

weights also probably assign by subjective judgment of decision makers or evaluators.

Step 2: Obtaining the fuzzy decision matrix whose elements composed by a set of fuzzy comparable rating $\tilde{r}_{ij}(\boldsymbol{x})$ for the *j*th attribute with respect to the *i*th alternative. If the raw decision matrix comprised by $\tilde{x}_{ij}$ for the *j*th attribute with respect to the *i*th alternative, in order to reduce the influence of the dimension, we can extend Hwang and Yoon (1981) method to transfer the fuzzy raw data $\tilde{x}_{ij}$ to non-dimension data $\tilde{r}_{ij}(\boldsymbol{x})$ according to following principle:

Case 1: If the criteria are defined by benefit criteria (the larger $\tilde{x}_j$, the greater preference); then the transformed outcome $\tilde{x}_{ij}$ is $\tilde{r}_{ij}(\boldsymbol{x}) = \dfrac{\tilde{x}_{ij}}{\tilde{x}_j^*}$, where $\tilde{x}_j^* = \max_i \tilde{x}_{ij}$, and it is clear $0 \le \tilde{r}_{ij}(\boldsymbol{x}) \le 1$;

Case 2: If the criteria are defined by cost criteria (the smaller $\tilde{x}_j$, the greater preference); then the transformed outcome $\tilde{x}_{ij}$ is $\tilde{r}_{ij}(\boldsymbol{x}) = \dfrac{1/\tilde{x}_{ij}}{1/\tilde{x}_j^*} = \dfrac{\min_i \tilde{x}_{ij}}{\tilde{x}_{ij}}$.

Step 3: Synthesizing the fuzzy value $\tilde{u}_i(\boldsymbol{x})$ for the *i*th alternative, which is summation of multiplying by relative fuzzy weight $\tilde{w}_j$ and non-dimension comparable data $\tilde{r}_{ij}(\boldsymbol{x})$ as follows: $\tilde{u}_i(\boldsymbol{x}) = \sum_j \tilde{w}_j \tilde{r}_{ij}(\boldsymbol{x})$.

Step 4: Selecting the best alternative defined in this: $\tilde{A}^* = \{\tilde{u}_i(\boldsymbol{x}) \mid \max_i \tilde{u}_i(\boldsymbol{x})\}$

Furthermore, it can be seen that since the final rating of each alternative is also a fuzzy number, a defuzzified method, such as the CoA method, can be used for decision makers to determine the best non fuzzy performance (BNP) value of alternatives.

5. Research Findings

After processing the fuzzy data for the second level of conceptual model (the three productivity dimensions), according to table 6, each indicators weight shows that management performance productivity is the most important indicator based on 27 experts of all banks and also in each bank, separately. Hence, regarding to productivity improvement, management performance productivity is at first priority and human resource productivity and financial productivity are on the second and third priority level, respectively. In the next tables B1, B2 and B3 stand for State-owned bank, Partially private Bank and Private bank, respectively.

Table 6: The final weights of effective factors on productivity improvement

	Human resource productivity	Financial productivity	Management performance productivity	
All banks	0.397	0.126	0.477	W
B1	0.386	0.169	0.444	
B2	0.427	0.124	0.449	
B3	0.363	0.071	0.567	

The considerable point is the decrease of financial productivity importance degree comparing state-owned bank with private bank. In the next step, human resource productivity indexes are compared. Their final weights are presented in table 7.

Table7: The final weights of effective factors on human resource productivity

	Skills & capabilities	Work quality	Responsibility	Creativity & innovation	motivation	Public relation	Discipline
All	0.070	0.081	0.219	0.112	0.236	0.100	0.182
B1	0.0949	0.116	0.1865	0.137	0.1861	0.0951	0.184
B2	0.041	0.074	0.266	0.082	0.314	0.084	0.140
B3	0.140	0.067	0.187	0.092	0.197	0.117	0.199

Comparing 7 sub criteria of human resource productivity, motivation has the first priority as has been specified in table 7.According to state-owned banks' experts view, responsibility has attained the first priority with a very minor weight variance comparing to motivation and in private bank, discipline has got the first priority with a very minor weight variance comparing to motivation. In partially private bank, motivation is at first priority with an obvious weight variance comparing to other indicators. It can be concluded that paying attention to indicators of human resource productivity is not balanced in this bank. In the next step, financial productivity indexes are compared. Their final weights are presented in table 8.

Table 8: The final weights of effective factors on financial productivity

	Operating revenues	Debt ratio	Return on assets	Profit margin	Return on investment	
All	0.1419	0.0847	0.2396	0.2666	0.2672	W
B1	0.123	0.118	0.263	0.239	0.252	
B2	0.161	0.006	0.315	0.245	0.273	
B3	0.132	0.059	0.122	0.368	0.319	

Comparing financial productivity sub criteria, return on investment has attained the first priority with a very minor weight variance comparing to profit margin as illustrated in table 8. According to state-owned bank and private bank experts' view, return on assets has the first priority, while in private Bank; profit margin is at the first priority.

In this step, management performance productivity indexes are compared in banking industry. Their final weights are illustrated in table 9.

Table 9: The final weights of effective factors on management performance productivity

	Proportion of programs and policies to purposes	Proportion of employees to their job	Management's attention to recommendations	Cost controlling efficiency	Reasonable salary and rewards	Training per person
All	0.165	0.190	0.112	0.137	0.199	0.197

B1	0.205	0.145	0.128	0.080	0.255	0.186
B2	0.069	0.303	0.164	0.074	0.186	0.204
B3	0.194	0.160	0.104	0.150	0.176	0.217

Comparing management performance productivity sub criteria, reasonable salary and rewards has attained the first priority with a very minor weight variance comparing to training per person as illustrated in table 9. According to state-owned bank experts' view, reasonable salary and rewards has the first priority, while in partially private bank, Proportion of employees to their job is at the first priority and in private bank, and training per person has gotten the first priority. The results shows that in private bank, training is the most significant factor for management performance productivity improvement while partially private bank experts believe that proportion of employees to their job is the most significant factor regarding to management performance productivity improvement.

In the next step, state-owned bank, partially private bank and private bank are compared regarding to human resource productivity, financial productivity and management performance productivity based on the experts' point of view. Their final weights are presented in tables 10, 11 and 12 respectively.

Table 10: The final weights of the banks importance order regarding to human resource productivity

State-owned bank	Partially private bank	Private bank	
0.001	0.333	0.665	W

Table 11: The final weights of the banks importance order regarding to financial productivity

State-owned bank	Partially private bank	Private bank	
0.001	0.324	0.674	W

Table 12: The final weights of the banks importance order regarding to management performance productivity

State-owned bank	Partially private bank	Private bank	
0.071	0.285	0.644	W

In three mentioned dimensions, private bank has the first priority with an obvious weight variance comparing to partially private and state-owned bank. The important point is that according experts' point of view, the state-owned bank has not been successful with the aim of productivity improvement in all three mentioned dimensions.

The elements' weights at two levels are combined together and final weights of productivity improvement dimensions are attained as indicated in table 13.

Table 13: Combining the weights of two levels and computing the final weight of the three banks with objective of productivity improvement based on FAHP

	Human resource productivity	Financial productivity	Management performance productivity	
	0.397	0.126	0.477	
B1	0.001	0.001	0.071	0.034
B2	0.333	0.324	0.285	0.309
B3	0.665	0.674	0.644	0.656

After computing the weights of criteria and sub-criteria based on Fuzzy AHP, the weights of criteria and sub-criteria of the research conceptual model are calculated based on Fuzzy TOPSIS, Fuzzy VIKOR and Fuzzy SAW, the results of which are illustrated in tables 14, 15 and 16, respectively

Table 14: Final Ranking of Banks based on Fuzzy TOPSIS

Effective factors on Productivity Improvement		Human Resource Productivity	Financial Productivity	Management performance productivity
State-owned bank		0.397	0.126	0.477
Banks	B2	0.001	0.001	0.11
	B3	0.5	0.48	0.442
	B1	1	1	1
f^*		1	1	1
f^-		0.001	0.001	0.11
Banks	Si	Ri	Vi	Qi
B1	1	0.477	0.5	1
B2	0.562	0.299	0.5	0.43
B3	0	0	0.5	0

Table 15: Final Ranking of Banks based on Fuzzy VIKOR

Effective factors on Productivity Improvement		Human Resource Productivity	Financial Productivity	anagement performance productivity
Factors' weight		0.397	0.126	0.477
Banks	B1	0	0	0.047
	B2	0.177	0.054	0.291
	B3	0.355	0.113	0.434
A^+		0.355	0.113	0.434
A^-		0	0	0.047
Banks	d_i^+	d_i^-	$d_i^- + d_i^+$	C_i
B1	0.288	0	0	0
B2	0.235	0.306	0.541	0.565
B3	0	0.537	0.537	1

Table 16: Final Ranking of Banks based on Fuzzy SAW

	Human resource productivity	Financial productivity	Management performance productivity		Rank
B1	0.11	0.001	0.001	0.049	3
B2	0.442	0.48	0.5	0.468	2
B3	1	1	1	1	1
Factor's weight	0.397	0.126	0.477		

As it can be seen and according to tables 14, 15 and 16, the results of Fuzzy TOPSIS, Fuzzy VIKOR and Fuzzy SAW confirmed the results of Fuzzy AHP. Hence, according to experts' point of view, private bank has accomplished better in gaining productivity improvement comparing with state-owned bank and partially private bank. The results also indicate that among three mentioned productivity dimensions, management performance productivity is of the greater importance than human resource and financial productivity.

6. Conclusion

Banking industries across the world are going through a series of rapid changes due in part to the pace of technological development. Use of automated teller machines (ATMs) and advanced statistical models for risk management has transformed the way traditional banking activity was performed.

In this paper, the importance degree of three effective dimensions (human resource, financial and management performance productivity) on productivity improvement and the dimensions' sub criteria are studied in state-owned bank,

partially private bank and private bank in Iran using FAHP, Fuzzy TOPSIS, Fuzzy VIKOR and Fuzzy SAW and based on experts' views. The results suggest that private bank has performed better than state-owned bank and partially private bank in three mentioned dimensions. In fact, according to experts' point of view, private bank has accomplished better in gaining productivity improvement comparing with state-owned bank and partially private bank. It indicates that all the ranking results are identical.

Comparing the three productivity dimensions, management performance productivity is at the first priority that implies in order of having better productivity circumstances, enjoying high performance managers has a great effect. The considerable point is the decrease of financial productivity importance degree comparing state-owned bank with private bank. In human resource productivity, motivation is of the greater importance along with responsibility and discipline. According to table 8 in financial productivity, return on investment has attained the first priority with a very minor weight variance comparing to profit margin. According to state-owned bank and private bank experts' view, return on assets has the first priority, while in private bank; profit margin is at the first priority. Comparing management performance productivity sub criteria, reasonable salary and rewards has attained the first priority with a very minor weight variance comparing to training per person as illustrated in table 9. According to state-owned bank experts' view, reasonable salary and rewards has the first priority, while in partially private bank, Proportion of employees to their job is at the first priority and in private bank, and training per person has gotten the first priority.

Comparing the results of present study with Azadeh *et al.* study (2011) in which work quality was announced as the first priority in human resource productivity while in this study motivation is of the greater importance along with responsibility and discipline.

Comparing the results of present study with Hung Yi Wu *et al.* paper (2009), In financial productivity, return on assets was announced as the first priority that is the same as private bank managers' point of view, but according to all three banks experts' view, return on investment has attained the first priority with a very minor weight variance comparing to profit margin.

Comparing the findings of present study with Sanyal *et al.* study (2011), Indian private banks dominate the public and foreign banks both in terms of productivity levels and productivity growth that the present study finding has proved the domination of private bank in terms of productivity improvement.

Comparing the findings of present study with Margono *et al.* paper (2010), the results indicate that private-owned banks and joint venture foreign banks were more efficient than Public-owned banks, hence our finding emphasizes theirs.

Comparing the results of present study with Jaffry *et al.* paper (2008), their results show that the efficiency of labor use across the Indian sub-continent is improving over time and that foreign banks are more efficient compared to domestically owned banks in their usage of labor. Their result has been verified by our result.

For future research, it is recommended that the same conceptual model apply in foreign countries and compare their findings with the present study. It is also suggested study the reasons of the gap between governmental and non-governmental banks. The criteria should be adjusted based on each organization's mission and objectives.

Acknowledgments

The authors would like to thank to acknowledge the contribution of the referees and Editor-in-Chief for their invaluable comments and suggestions which improved the quality of this paper.

REFERENCES

[1] **Akhavan Tabassi A, Abu Bakar A.H. (2009), Training, motivation, and performance:** ***The case of human resource management in construction projects in Mashhad*****, Iran**, *International Journal of Project Management 27, 471–480;*

[2] **Azadeh, A. Ghaderi, S.F, Mirjalali, M. Moghaddam, M. (2011),** ***Integration or hierarchy process and data envelopment analysis for assessment and optimization of personnel productivity in a large industrial bank****, Journal of Expert System with Applications 38, 5212-5225.*

[3] **Bozdag, C. E., Kahraman, C., Ruan, D. (2003*), Fuzzy group decision making for selection among computer integrated manufacturing systems,*** *Computers in Industry, 51(1), 13–29.*

[4] **Barth J. R, Caprio G, Levine R. (2004),** ***Bank regulation and supervision: What works best?*** *Journal of Financial Intermediation, 13, 205–248.*

[5] **Broadbent J. & Laughlin R (2009)** ***Performance management systems: A conceptual model****, Management Accounting Research, 20, 283–295.*

[6] **Cassiman B, Golovko E, Martinez-Ros E (2010),** ***Innovation, exports and productivity****, International Journal of Industrial Organization, 28, 372-376.*

[7] **Cebeci, U., Ruan, D., (2007*), A Multi-Attribute comparison of Turkish quality consultants by Fuzzy AHP****, International Journal of Information Technology and Decision Making, 6 (1), 191-207.*

[8] **Chang, D. Y. (1996),** ***Applications of extent analysis method on fuzzy AHP;*** *European Journal of Operational Research 95, 649–655.*

[9] **Chang, D.Y. (1992),** ***Extent analysis and synthetic decision****, Optimization Techniques and Applications, 1, 352.*

[10] **Che, Z.H., Wang, H.S. Chuang C.L. (2010),** ***A fuzzy AHP and DEA approach for making bank loan decisions for small and medium enterprises in Taiwan****, Expert Systems with Applications 37, 7189–7199.*

[11] **Chen SH (1985),** ***Ranking fuzzy numbers with maximizing set and minimizing set,*** *Fuzzy Sets and System, 17 (2), 1113-129.*

[12] **Cua, K.O., McKone, K.E., Schroeder, R.G. (2001),** ***Relationships between implementation of TQM, JIT, and TPM and manufacturing performance*****;** *Journal of Operations Management, 19 (6), 675–694.*

[13] **Devi K (2011),** ***Extension of VIKOR method in intuitionistic fuzzy environment for robot selection*****;** *Expert Systems with Applications 38: 14163–14168.*

[14] **Doliente J. S. (2005),** ***Determinants of bank net interest margins of Southeast Asia****, Applied Financial Economics Letters, 1(1), 53-57.*

[15] **Efendigil, T., Önüt, S., Kongar, E., (2008),** ***A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness;*** *Computers and Industrial Engineering, 54 (2), 269-287.*

[16] **Eppolito, L. (2002),** ***Productivity Guidelines for Community Bankers. BankTalk****: BISYS Online Magazine. [https://www.bank.bisys.com/banktalk_leppolito01.asp] and[https://www.bank.bisys.com/banktalk_leppolito02.asp].*

[17] **Epure Mircea, Kerstens Kristiaan, Prior Diego (2011),** ***Bank productivity and performance groups: A decomposition approach based upon the Luenberger productivity indicator****; European Journal of Operational Research,* 211, 630–641.

[18] **Eshraghniae Jahromi A. and Borjalilu, N. (2010),** ***Presenting a model for productivity measurement and improvement in Plastiran,*** 8th *International Management Conference in Iran, Tehran.*

[19] **Ferreira, A and Otley, D. (2009),** ***The Design and Use of Performance Management Systems: An Extended Framework for Analysis****, Management Accounting Research, 20, 263–282.*

[20] **Fouladgar, M. M., Yazdani-Chamzini, A., Zavadskas, E. K. (2011),** ***An integrated model for prioritizing strategies of the Iranian mining sector,*** *Technological and Economic Development of Economy 17(3): 459-483.*

[21] **García F, Guijarro F, Moya I (2010),** ***Ranking Spanish savings banks: A multi criteria approach****, Mathematical and Computer Modeling 52, 1058_1065.*

[22] **Gill Avninder (2011),** ***Measurement and Comparison of Productivity Performance Under Fuzzy Imprecise Data,*** *International Journal of Business Research and Management (IJBRM0): 2(1), 19-32.*

[23] **Heo, E., Kim, J., Boo, K. J. (2010),** ***Analysis of the assessment factors for renewable energy dissemination program evaluation using fuzzy AHP,*** *Renewable and Sustainable Energy Reviews 14, 2214–2220.*

[24] **Huczynski A, Bachnan D (2001),** ***Organizational Behavior,*** *Fourth Edition, Prentice Hall.*

[25] **Hwang, C.L., and Yoon, K., (1981),** ***Multiple Attribute Decision Making: Methods and Applications****, New York: Springer-Verlag.*

[26] **Islam R and Ismail A Z (2008),** ***Employee Motivation: a Malaysian Perspective****, International Journal of Commerce and Management, 344 – 362.*

[27] **Jabbour C, Charbel J, Ce´sar Almada Santos, F. (2008),** ***Relationships between human resource dimensions and environmental management in companies: proposal of a model****, Journal of Cleaner Production, 16, 51-58.*

[28] **Jaffry S, Ghulam Y and Cox J (2008),** ***Labour use efficiency in the Indian and Pakistani commercial bank****, Journal of Asian Economics*, 19: *259–293.*

[29] **Jensen, P.L., and Alting, L. (2006),** ***Human Factors in the Management of Production, Department of Manufacturing Engineering and Management Building 424,*** *Technical Annals of the CIRP, 5(1), 457-460.*

[30] **Kahraman, C., Ruan, D., DÖgan, ˙I. (2003),** ***Fuzzy group decision making for facility location selection****, Information Sciences 157, 135–153.*

[31] **Kahraman, C., Cebeci, U., Ruan, D. (2004),** ***Multi-attribute comparison of catering service companies using fuzzy AHP: The case of Turkey.*** *International Journal of Production Economics, 87, 171–184.*

[32] **Kauko, K. (2009),** ***Managers and Efficiency in Banking****, Journal of Banking & Finance, 33, 546–556.*

[33] **Kaya T., Kahraman C. (2011),** ***Multicriteria Decision making in energy planning using a modified fuzzy TOPSIS methodology,*** *Expert Systems with Applications 38: 6577–6585.*

[34] **Kaya T., Kahraman C. (2011),** ***Fuzzy multiple criteria forestry decision making based on an integrated VIKOR and AHP approach,*** *Expert Systems with Applications 38: 7326–7333.*

[35] **Kazaz A, Ulubeyli S, (2007),** ***Drivers of productivity among Construction workers: A study in a developing country.*** *.Building and Environment 42(5): 2132-2140.*

[36] **Kopelman R.E (1986),** ***Alternative work schedules and productivity: A review of the evidence National Productivity Review,*** *Managing Productivity in Organization, 5(2), 150–165.*

[37] **Kutlu A.C., Ekmekciog˘lu M. (2012),** ***Fuzzy failure modes and effects analysis by using fuzzy TOPSIS-based fuzzy AHP****, Expert Systems with Applications, 39(1), 61-67.*

[38] **Lin, E.-K., Chang, C.-C., Lin, Y.-C. (2011),** ***Structure development and performance evaluation of construction knowledge management system,*** *Journal of Civil Engineering and Management 17(2): 184-196.*

[39] **Liu Y., Combs JG., Ketchen Jr DJ, Ireland R. D. (2007*****), The value of human resource management for organizational performance****, Business Horizons, 50 (6), 50, 503–511.*

[40] **Margono H, Sharma S, Melvin II D.P (2010),** ***Cost efficiency, economies of scale, technological progress and productivity in Indonesian banks****, Journal of Asian Economics* 21: 53–65.

[41] **Masso J., and Vahter P (2011),** ***The Link between Innovation and Productivity in Estonia's Service Sectors by William Davidson Institute***

Working Paper Number 1012. *The Service Industries Journal*. *DOI:10.1080/02642069.2011.600444.*

[42] **O'Neill, T., Egelton, R., Hogue, R. (1999),** ***Canadian Productivity – The sky is not Falling;*** *Bank of Montreal Economics, Economic analysis: Special report*. [http: //www.bmo.com/economic/regular/canprod.pdf].

[43] **Önüt, S., Efendigil, T., Karar, S. S., (2010),** ***A combined fuzzy MCDM approach for selecting shopping center site: An example from Istanbul, Turkey;****Expert Systems with Applications, 37: 1973–1980.*

[44] **Önüt, S., Kara, S. S., Efendigil, T. (2008),** ***A hybrid fuzzy MCDM approach to machine tool selection,*** *Journal of Intelligent Manufacturing 19, 443–453.*

[45] **Opricovic S (1998),** ***Multicriteria optimization of civil engineering systems,*** Faculty of Civil Engineering, Belgrade.

[46] **Opricovic S. (2011),** ***Fuzzy VIKOR with an application to water resources planning,*** *Expert Systems with Applications 38: 12983–12990.*

[47] **Neveu, R.P. (1989). Fundamentals of Managerial Finance**, *3rd ed., Cincinnati, Ohio: Siuth Western Publication Co.*

[48] **Ray, S.C., Das, A. (2010),** ***Distribution of cost and profit efficiency: Evidence from Indian Banking***, *European Journal of Operational Research, 201(1), 297–307.*

[49] **Sanayei A., Mousavi S.F., Yazdankhah A. (2010),** ***Group decision making process for supplier selection with VIKOR under fuzzy environment,*** *Expert Systems with Applications 37: 24–30.*

[50] **Sanyal P, Shankar R (2011),** ***Ownership, competition, and bank productivity: An analysis of Indian banking in the post-reform period,*** *International Review of Economics and Finance 20: 225–247.*

[51] **Saremi M., Mousavi S.F., Sanayei A. (2009),** ***TQM consultant selection in SMEs with TOPSIS under fuzzy environment,*** *Expert Systems with Applications 36: 2742–2749.*

[52] **Secme N.Y., Bayrakdarog˘lu A., Kahraman C. (2009),** ***Fuzzy performance evaluation in Turkish Banking Sector using Analytic Hierarchy Process and TOPSIS,*** *Expert Systems with Applications 36, 11699–11709.*

[53] **Shemshadi A, Shirazi H., Toreihi M., Tarokh M.J. (2011),** ***A fuzzy VIKOR method for supplier selection based on entropy measure for objective weighting,*** *Expert Systems with Applications 38: 12160–12167.*

[54] **Sivapirakasam S.P., Mathew J., Surianarayanan M. (2011),** ***Multi-attribute decision making for green electrical discharge machining,*** *Expert Systems with Applications 38: 8370–8374.*

[55] **Sun C.C., (2010),** ***A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods,*** *Expert Systems with Applications 37: 7745–7754.*

[56] **Tubbs S, and Moss S, (2000),** ***Human communication***, *Eighth Edition, McGraw-Hill.*

[57] **Wu H.Y., Tzeng G.H. and Chen Y.H (2009),** ***A fuzzy MCDM approach for evaluating banking performance based on Balanced Scorecard,*** *Expert Systems with Applications 36: 10135–10147.*

[58] **Wynder J. M. (2011),** ***Chemico: Evaluating performance based on the Balanced Scorecard****, Journal of Accounting Education, 28 (3-4), 221-236.*

[59] **Wang TC and Chang TH (2005),** ***Fuzzy VIKOR as a resolution for multicriteria group decision making,*** *The 11th International Conference on Industrial Engineering and Engineering Management, 352-356.*

[60] **Yu PL. (1973),** ***A class of solutions for group decision problems,*** *Management Science, 19 (8), 936-946.*