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Designing a New Model to Improve Productivity Factors Implementing the Fuzzy Goal Programming Method

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Abstract

In this paper, the fuzzy goal programming method is used in order to improve productivity. Using this method, productivity factors including factors such as data, process, output, business cycles, competitors and government policies are modeled and a systematic model to improve factors in the field of three productivity areas: materials, capital and human resource is provided. By measuring the current status of productivity in three areas listed and changing the yields obtained from output of goal programming and re-measuring the productivity of three areas, productivity enhancement is shown. Output obtained from the solution of planning models shows that with output weights by AHP and LINGO8, α value is 0.61 and 61 percent of the amount of the increase or decrease in the constraints with fuzzy variable, there can be change. Material Productivity has been increased about 18 percent. Capital Productivity has been increased about 23 percent. Human resource productivity has been increased about 24 percent. By applying goal programming, with fuzzy logic, results in better picture of the real systems of production and sales, and as was seen results in improvements in productivity factors in three areas of material productivity, human resource productivity and capital productivity.

Keywords: Capital Productivity, Fuzzy Goal Programming Method, Human Resource Productivity, Material Productivity

1. Introduction

During the last two decades, the need to promote productivity in organizations has been of great importance. Productivity management, using science and knowledge in administration, and improving product quality tries to establish a system for measuring, evaluating, planning, and improving productivity in the organization through the use of management systems, and attempts to solve complex issues of organizations by the necessary information. Thus, standards are often set and organization performance is compared with these standards[1,2]. The main research problem is stated as follows: Developing a structured model to improve productivity of manufacturing industries that we know as productivity improvement. It can be said that development of all organization factors can result from development and enhancement of productivity and interaction of resources with each other. Regarding to Peter Drucker's study, the biggest challenge in developing countries in front of the managers is the knowledge-based productivity improvement[3–6]. By careful investigation of the research, it can be understood that human's economic efforts, were always impelled toward getting maximum results from minimum effort and resources. These desires may be called, the desire to attain more "productivity", that is the fundamental issue of the research. Discussing about productivity is one of the issues that today, all over the world are followed with great intensity. It seems that this word is being used as a slogan, and its importance is being understood more and more every day, however, there is no structured model in its improvement[7].

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Given the above, the main issue of research is the lack of a structured model in order to improve the productivity in industrial companies and inappropriate use of available resources that exist in the three areas: 1. Material productivity, 2. Human resource productivity and 3. Capital productivity[8–11].In this research, we seek to develop goal programming model with fuzzy approach to increase productivity in three abovementioned areas through it. According to the variables defined, mathematical programming problem as standard in finding optimal solutions, is a hierarchical structure decision that is even contradictory with desired goals[12]. In this regard, development variables of each of the production factors have been considered as input factors, process factors, output factors, business structure, competitor factors and government policy.In the study problem, to obtain maximum productivity, the plan must ensure that all resources are used effectively. Thus, production planning must be related to minimizing the time between operations and minimizing time spent on operations. In many other fields of production, the balance should appear[13–25]. In section 2, the methodology of this research is presented.

2. Methodology

This research is a cross-sectional descriptive analytical research and is quantitative, that according to the case study in the detergent industry, is of survey type.

According to the definition of the dependent variables, the main objective of developing and improving the productivity model of the production factors of organization, is in three desired goals[26].

- First Goal: Material productivity.
- Second Goal: Human resource productivity.
- Third Goal: Capital productivity.

First the dependent variables are considered as the basic goals of the model, and then based on all possible restrictions; limitations will be fuzzy in the goal model. Other confounding variables, such as product price and marginal parameters are also considered to take into account their impact on the model. The fuzzy goal programming method is used in order to improve productivity[27–35.]

Using this method, productivity factors including factors such as data, process, output, business cycles, competitors and government policies are modeled and a systematic model to improve factors in the field of three productivity areas: materials, capital and human resource is provided.

3. Developing Model

Given the above, fuzzy variables have been identified in the model based on defining parameters. Before creating the model by collecting data, model inputs will be developed. After developing three goals and constraints, by using a fuzzy goal planning method, model will be developed and by hierarchical analysis, the weight of goals will be ranked. The values of the weights will be entered in the objective function in the model and will be imported based on the fuzzy constraints and consequently fuzzy goal planning model will be solved by Analytic Hierarchy Process (AHP)® and Lingo 8.0® software[36].

Model inputs will be developed by collecting data before creating the model[37]. Therefore, by developing the questionnaire, the weight of each area of productivity can be determined through the process of hierarchical analysis[38].

Developing a fuzzy goal planning, each goal is considered each of the productivity areas, meaning that in the productivity improvement model, intended purpose is to increase productivity. Analytic hierarchical process has the following manner:

In analytic hierarchical process, each alternative is measured from each index dimension with other alternative, and its ratio is determined and then according to the ultimate goal, all alternatives are graded based on weight:

After getting weight values of the objective function, goal model according to the planning model will be as follows:

Minimizing deviations related to three productivity factors.

Then the following limitations are considered:

- Limitations related to the material productivity (6 factors of productivity areas are considered). Objective function - minimizing the amount of deviation in each area of goal productivity would be so that by hierarchical analysis for each of them, by using the designed and extracted questionnaire, the weight of each area of productivity also is extracted.

In the model, if both increasing and decreasing of variable is considered, both positive and negative variable values will be considered. If the increase is considered, the variable is considered with negative sign, and more is desirable. If the increase is considered, the variable is considered with positive sign, and less is desirable.

4. Final Model

$$\max z = \alpha$$

$$\sum_{k=1}^{3} w_k . d_k^- \le z_2 + (z_1 - z_2)(1-\alpha)$$

$$w_k \sum_{j=1}^{6} w_j^{'} F_{jl} - (d_k^+ - d_k^-) \ge 1$$

$$p^{'}_{j1} / \sum_{l=1}^{6} p^{'}_{jl} = F_{j1}, j = 1,2,3$$

$$p^{'}_{j2} / \sum_{l=1}^{6} p^{'}_{jl} = F_{j2}, j = 1,2,3$$

$$p^{'}_{j3} / \sum_{l=1}^{6} p^{'}_{jl} = F_{j3}, j = 1,2,3$$

$$p^{'}_{j4} / \sum_{l=1}^{6} p^{'}_{jl} = F_{j4}, j = 1,2,3$$

$$p^{'}_{j5} / \sum_{l=1}^{6} p^{'}_{jl} = F_{j5}, j = 1,2,3$$

$$p^{'}_{j6} / \sum_{l=1}^{6} p^{'}_{jl} = F_{j6}, j = 1,2,3$$

$$\sum_{i=1}^{n} p_{ijl} x_i = p^{'}_{jl}, j = 1,2,3, l = 1,2,..,6$$

5. Result

5.1 Population Introduction

Given the strategic nature of the detergent industry in current conditions and low productivity due to high capital requirements and large volume of material in the manufacturing process, in improving the productivity of this industry should be considered.

Target population will be extracted to determine the weight of each productivity index from five major detergents companies existing in detergents industrial clusters that was mentioned in the scope of the investigation.

5.2 Data Analysis

In this study, library studies are used to design the model and different models that are designed in creating productivity index are utilized. Also for case analysis in the detergent industry and determining the impact of each factor, the questionnaire is used. In this study, a questionnaire is used for collecting data in question, in order to formulate the weight of each question and ultimately weights of gain objective functions and the rate of powder and liquid production, are used in fuzzy goal planning. Other information required in input of optimal combination of production model (simplex), such as coefficients of objective functions, goal values, available resources, production, sale and capacities values is done through the information collection and field studies.

Data collection tool to the design the model is library studies. Also, in order to determine the productivity weight of each of the areas, questionnaires have been used. In the case study, the detergent industry has been selected and for sampling Tolypers company has been considered[39–44]. Data analysis is as follows:

- Measuring productivity by defined scales, without applying target model in the area of material productivity, human resource productivity, and capital productivity.
- Developing the model based on three mentioned goals and six areas of limitations.
- Re-measuring three productivity areas.

In order to determine the impact weight of each factor using AHP software and data collected from questionnaires and paired comparison of each of the 18 variables together, the data entered into the software, and the weights of the 6 indicators, and the paired comparison entered into the program that according to the final output rate, 0.03, is very desirable and weights are extracted (Table 1). In the output of the model of software, the degree of desirability 0.61 with the set goals, you can see the improvement of case study productivity model and represents the production rate of each product in the production plan to improve the productivity double in three areas.

By new combination achieved productivity values in retesting the model enhances double, which shows achieving the desired goals. According to the data provided in the questionnaires and entering those data to AHP software by comparing pairs, the weight of each alternative for each index is as follows:

Final ranking of the model, by incorporating alternative weights for each indicator has been as follows:

1. Material productivity weight: $w_1 = 0.312$
2. Human resource productivity weight: $w_2 = 0.222$
3. Capital productivity weight: $w_3 = 0.155$
4. Data factor weight: $w_4 = 0.074$
5. Process factor weight: $w_6 = 0.051$
6. Output factor weight: $w_7 = 0.035$
7. Structure factor weight: $w_8 = 0.108$

8. Competitors factor weight: $w_9 = 0.018$
9. Government factor weight: $w_{10} = 0.155$

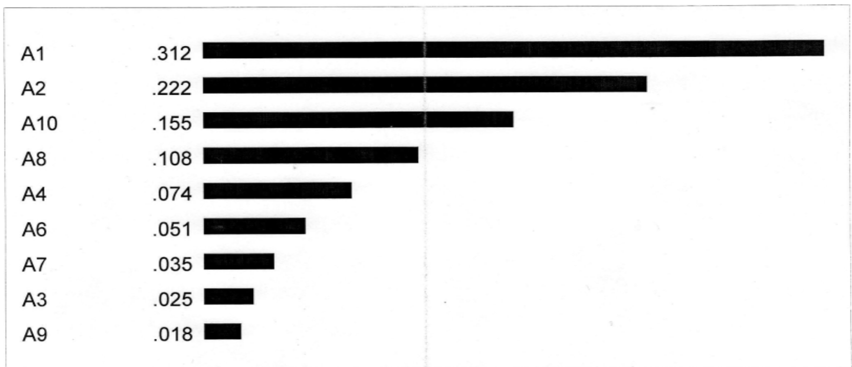
In this case, in the output of the model, according to the degree of desirability level achieved to improve the productivity, required amounts of each product

Table 1. The output of AHP software

A2		2.0	3.0	4.0	5.0	6.0	7.0	8.0
A10			2.0	3.0	4.0	5.0	6.0	7.0
A8				2.0	3.0	4.0	5.0	6.0
A4					2.0	3.0	4.0	5.0
A6						2.0	3.0	4.0
A7							2.0	3.0
A3								2.0

Row element is __ times more than column element unless enclosed in ()

Abbreviation	Definition
Goal	
A1	a1
A2	a2
A10	a10
A8	a8
A4	a4
A6	a6
A7	a7
A3	a3
A9	a9



Inconsistency Ratio =0.03

According to amounts presented in the tables, data have been entered based on the final model of problem. By solving the model, the value of desirability level is estimated to be 0.61 that in case that all goal values are allowed to maximum acceptability, the accuracy of a value is confirmed. Other values of production in solving model are attached.

6. Conclusion

Output obtained from the solution of planning models shows that with output weights by AHP and LINGO8, σ value is 0.61 and 61 percent of the amount of the increase or decrease in the constraints with fuzzy variable, there can be change.

is determined, and in this case, the productivity level will increase double in each of the three areas.

In the goal decision-making, a move that provides the most expected effect is chosen from among a variety of managerial decisions. If in the real decision-making, circumstances and activities are represented by fuzzy sets, is called fuzzy statistical decision, that in this kind of decision, as was observed, real data, are incorporated in the model and consist the final improve.

1. The use of fuzzy logic in optimal combination model and producing to improve efficiency of the model.
2. Collecting data with 0.85 validity.
3. Using AHP to weight each of the goals with 0.03 rates.
4. Agreeing levels of productivity goals with minimal deviation from the fuzzy goal planning.

Table 2. Existing productivity

Year/productivity	1385	1386	1387	1388	1389
material	0.62	0.66	0.59	0.65	0.63
capital	0.43	0.46	0.48	0.45	0.48
Human resource	0.76	0.77	0.72	0.78	0.75

Table 3. Productivity values

Year/productivity	1390	1391	1392	1393	1394
material	0.74	0.79	0.69	0.78	0.75
capital	0.54	0.57	0.61	0.56	0.62
Human resource	0.93	0.94	0.88	0.96	0.97

5. Providing productivity model by considering all the constraints.
6. Solving the model by lingo software.

6.1 Productivity Values

Productivity values extracted in the three areas according to the past 5 years from the population has been extracted as the following Table 2 and Table 3.

- Material Productivity has been increased about 18 percent.
- Capital Productivity has been increased about 23 percent.
- Human resource productivity has been increased about 24 percent.

6.2 Recommendation

- Applying goal programming, with fuzzy logic, results in better picture of the real systems of production and sales, and as was seen results in improvements in Productivity factors in three areas of material productivity, human resource productivity and capital productivity.
- Using fuzzy logic is recommended in all approaches that approximate parameters exist, and in different conditions various variables affect it, because it converts the conceptual values to numerical values.
- Due to the fact that, using this logic has resulted in organization's productivity, the hypothesis of productivity improvement by using this presented model in the organization has been proved and for this purpose, the model created can be used.

6.3 Limitations

- AHP model only use for factors that is independent with together.
- In order to determine the productivity weight of each of the areas, questionnaires have been used.
- To determine the weight of each productivity index from five major detergents companies existing in detergents industrial clusters that was mentioned in the scope of the investigation.
- Factors are three fields of productivity areas: materials, capital and human resource.

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Appendix

d_i^- : Negative variable of ith goal.

d_i^+ : Positive variable of ith goal.

w_i : weight variable of each goal (non-fuzzy) (from hierarchical analysis and questionnaire data).

p_{ij} : Productivity of ith product related to jth area in lth factor.

s_i : Sales value (fuzzy variable).

c_i : Amount of profit per product (non-fuzzy variable).

Δ_i : fuzzy deviation.

b_i : Maximum time available (fuzzy variable).

z_1 : Optimal value of model for $\alpha = 1$.

z_2 : Optimal value of model for $\alpha = 0$.

$p_{lj}^{'}$: Value added for Productivity j^{th} area in l^{th} factor.

F_{ij} : Productivity percent for i^{th} product and j^{th} area.

α : Degree of desirability.

x_i : Decision variables (type of product) and Production quantities of each product.