

# Evaluating Performance of Companies by New Management Tools

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## Abstract

In this article, we want to design a model for evaluating the performance of companies in the stock market by using TOPSIS and sensitivity analysis. We use financial ratios as criteria in TOPSIS algorithm. In this methodology, first we try to rank companies and then use sensitivity analysis for determining positive and negative points of the company and suggest improving performance of the company.

**Keywords:** Performance, TOPSIS, Sensitivity analysis

## Introduction

NEED of investors to financial information and a variety of alternatives for investing, shows the importance of new financial analysis methods. In previous years, a shortage of the required financial information was the reason of traditional financial analysis. Those methods had a high error rate in financial analysis.

Efficient planning and management of investments have become not only an important but also a complicated problem in the dynamically changing environment. In this regard, analysts attend to the multi-criteria decision making methods (MCDM). MCDM is broadly classified into two categories: Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM).

MADM methods are used for selection, while MODM methods are used for designing a problem involving an infinite number of alternatives implicitly defined by mathematical constraints. Marie(2012) claimed that MADM methodology tries to obtain a meaningful index from multidimensional data to evaluate competing alternatives. Pioneering surveys on MADM methods were carried out by MacCrimmon. Since then, many methods have been developed by researchers in disciplines as diverse as management science, econom-

ics, psychometrics, marketing research, applied statistics, and decision theory. All MADM methods can be classified compensatory or noncompensatory, ordinal or cardinal, quantitative or qualitative. Chang(2009) believed that decision Makers (DMs) may want to see if the ranking order will change if some attribute value changes. Sensitivity analysis is concerned with how outcomes change when inputs change. However, we want to use sensitivity analysis in another way.

## Review of related literature

### *Sensitivity Analysis*

Sensitivity analysis is concerned with how outcomes change when inputs change. In other words, sensitivity analysis is a general way for calculating risk and reliability of the algorithm. A technique was used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. This technique is used within specific boundaries that depends on one or more input variables(Hekimoglu, 2010) .

In essence, sensitivity analysis answers the question, what makes a difference in this decision? The aim of modelling in decision making is to produce a request decision model - one, whose form and content are just sufficient, to solve a particular problem. Alternatives can be screened on the basis of deterministic and stochastic dominance, and inferior alternatives can be eliminated. Identifying dominant alternatives can be viewed as a version of sensitivity analysis, for use early in an analysis. In sensitivity analysis terms, analyzing alternatives for dominance amounts to ask whether there is any way that one alternative could end up being better than a second (Simanaviciene, 2011).

### *One-way & Multi-way Sensitivity Analysis*

The simplest form of sensitivity analysis to simply vary one value in the model by a given amount, and the impact of the change has on the model's results. For ex-

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ample, it might be shown that by changing the effectiveness of an intervention by 10%. This is known as one-way sensitivity analysis, since only one parameter is changed at one time. The analysis could be repeated on different parameters at different times. One-way sensitivity analysis can be undertaken using various different approaches, each of which is useful for different purposes. For each parameter change, the researcher might record the percentage impact on the model's main outcome, which can be shown graphically in the form of a tornado diagram. While a tornado diagram is useful in demonstrating the impact that a fixture change in each parameter has on the main outcomes, it is not useful in representing the confidence that a decision-maker (DM) might have in the model's inputs. Therefore, one form of one-way sensitivity analysis is to vary each parameter to the highest and lowest possible values. The definition of possible might vary from model to model, but it is usually reasonable to vary the parameters according to the confidence intervals of data (Taylor, 2009). While one-way sensitivity analysis is useful in demonstrating the impact of one parameter variables in the model, it may be necessary to examine the relationship of two or more different parameters changing simultaneously. This approach involves the changing, say, two key parameters; show the results for each potential combination of values within a given range. This is known as multi-way sensitivity analysis. It should be noted, however, that the presentation and interpretation of multi-way sensitivity analysis becomes increasingly difficult and complex as the number of parameters involved increases. One method that sometimes is to assess the confidence around all parameters is to undertake extreme sensitivity analysis, by varying all of the parameters in a model to their best and worst case. The best and worst case values should be chosen from the perspective of the intervention that is being assessed.

In most models, each parameter is assigned a point estimate value. In probabilistic sensitivity analysis, rather than assigning a single value to each parameter, computer software is used to assign a distribution to all parameters in the model. The ranges are determined by Average Value, Standard deviation, Shape of the Spread of data. Each time the model is run, the software will be able to select one value for each parameter and record the model's results randomly.

### TOPSIS

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the useful Multi Attribute Decision Making techniques. TOPSIS method was firstly proposed by Hwang and Yoon. According to this technique, the best alternative would be the one that

is nearest to the positive ideal solution and far from the negative ideal solution. The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria. In other words, the positive ideal solution is composed of all the good values attainable of criteria, whereas the negative ideal solution consists of all worst values attainable of criteria (Jiang, 2012).

Suppose that there is an MCDM problem with  $m$  alternatives and  $n$  criteria, and the decision matrix is  $[x_{ij}]_{m \times n}$ . The procedure of TOPSIS consists of the following steps:

- 1) Calculating the normalized decision matrix.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^m x_{ij}^2}}, \quad i = 1, \dots, m; \quad j = 1, \dots, n$$

- 2) Calculating the weighted normalized decision matrix.

$$V_{ij} = w_j n_{ij} \quad i = 1, \dots, m; \quad j = 1, \dots, n$$

Where  $w_j$  is the weight of the  $j$ -th criterion, and

$$\sum_{j=1}^n w_j = 1$$

- 3) Determining the positive and negative ideal solution.

$$A^+ = \{v_1^+, \dots, v_n^+\} = \{\max_i v_j, j = 1, \dots, n\}$$

$$A^- = \{v_1^-, \dots, v_n^-\} = \{\min_i v_j, j = 1, \dots, n\}$$

- 4) Calculating the separation measures, using the  $m$ -dimensional Euclidean distance. The separation of each alternative from PIS is given by

$$d_i^+ = \left\{ \sum_{j=1}^n (v_j - v_j^+)^2 \right\}^{\frac{1}{2}}, \quad i = 1, \dots, m$$

Similarly, the separation from NIS is given by

$$d_i^- = \left\{ \sum_{j=1}^n (v_j - v_j^-)^2 \right\}^{\frac{1}{2}}, \quad i = 1, \dots, m$$

- 5) Calculating the relative closeness to the ideal solution.

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-}, \quad i = 1, \dots, m$$

- 6) Ranking the preference, according to  $C_i$ .

## Methodology

Proposed methodology has four steps: in step1, rank alternatives by TOPSIS. In step 2, measure sensitivity of obtaining results to weights of criteria. In step 3, compare the criteria of each alternative and determine positive and negative points of alternatives. In step 4, measure sensitivity of alternatives to negative points.

### Ranking alternatives by TOPSIS

In this step, we rank alternatives by TOPSIS that Financial Ratios are criteria of the model. List of Financial Ratios is as follows (Table 1).

**Table 1. Financial Ratio List**

| Symbol | FR Group      | Financial Ratio              |
|--------|---------------|------------------------------|
| $F_1$  | Liquidity     | Current Ratio                |
| $F_2$  |               | Quick Ratio                  |
| $F_3$  | Activity      | Accounts Receivable Turnover |
| $F_4$  |               | Inventory Turnover           |
| $F_5$  | Profitability | Return On Sales              |
| $F_6$  |               | Total Asset Turnover         |
| $F_7$  |               | Return On Total Assets       |
| $F_8$  |               | Return On Common Equity      |
| $F_9$  | Leverage      | Debt Ratio                   |

### Weights of Criteria Sensitivity Analysis

In this step, we measure the sensitivity of the ranking list of weights of criteria. For this purpose, select two criteria and change their weight by 0.05 and record the model's results, which can be shown graphically in the form of a diagram. However, we must pay attention that:

$$\sum_{j=1}^n w_j = 1$$

Therefore, this reason, the sum of two FRs weight must be fixed.

### Positive and Negative Points of Alternatives

In this step, we compare financial ratio of two alternatives for determining positive and negative points. For this reason, we choose one alternative as  $A'$ . Also, there is a comparison between financial ratios of  $A'$  and its next rank as  $A^*$ . Positive points and negative points of  $A'$  are given by the following:

$$PP : FR_i^{A'} > FR_i^{A^*} \quad i=1, \dots, m$$

$$NP : FR_i^{A'} < FR_i^{A^*} \quad i=1, \dots, m$$

### Sensitivity analysis of NP

In the final step, we measure sensitivity of the alternative to change of Negative points. For this purpose, we change NP off  $A'$  by 0.05 and observation outcomes change.

### Numerical example

To illustrate the method proposed in the previous section, a numerical example is given hereunder.

**Step 1:** In this step, we rank twelve Investment Companies of Securities and Exchange Organization of Iran by using financial ratios (Table 2) as criteria. Decision Matrix for TOPSIS model is as follows:

**Table 2. Decision Matrix for TOPSIS model.**

|          | $F_1$ | $F_2$ | $F_3$ | $F_5$ | $F_6$ | $F_7$ | $F_8$ | $F_9$ |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|
| $A_1$    | 2.67  | 2.48  | 1.30  | 0.89  | 0.11  | 0.07  | 0.11  | 0.30  |
| $A_2$    | 14.15 | 13.71 | 1.62  | 1.24  | 0.13  | 0.13  | 0.14  | 0.09  |
| $A_3$    | 3.66  | 3.40  | 1.96  | 0.86  | 0.16  | 0.14  | 0.20  | 0.26  |
| $A_4$    | 4.48  | 4.36  | 4.95  | 0.74  | 0.21  | 0.15  | 0.22  | 0.30  |
| $A_5$    | 2.28  | 2.12  | 0.99  | 0.77  | 0.13  | 0.11  | 0.17  | 0.36  |
| $A_6$    | 6.51  | 6.31  | 0.83  | 0.79  | 0.07  | 0.06  | 0.07  | 0.20  |
| $A_7$    | 2.67  | 2.37  | 0.20  | 1.24  | 0.07  | 0.06  | 0.11  | 0.35  |
| $A_8$    | 1.09  | 0.94  | 1.29  | 0.87  | 0.16  | 0.14  | 0.17  | 0.20  |
| $A_9$    | 6.70  | 6.46  | 0.20  | -5.36 | 0.05  | 0.03  | 0.03  | 0.11  |
| $A_{10}$ | 3.36  | 3.33  | 0.97  | 1.67  | 0.07  | 0.06  | 0.08  | 0.19  |
| $A_{11}$ | 1.95  | 1.80  | 0.68  | 0.70  | 0.08  | 0.07  | 0.09  | 0.37  |
| $A_{12}$ | 2.03  | 1.91  | 0.24  | 1.01  | 0.06  | 0.06  | 0.17  | 0.56  |

The weights of criteria are specified as follow:

$$w_i = (0 / 2985,0 / 2153,0 / 1475,0 / 1201,0 / 1049,0 / 0416,0 / 0403,0 / 0318)$$

Ranking of alternative by TOPSIS is as follows:

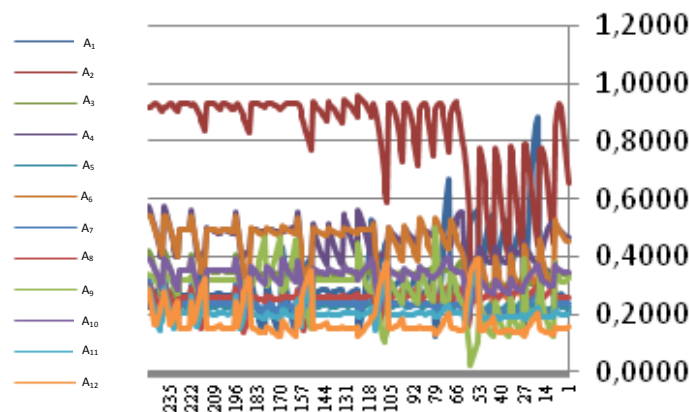
$$A_2 > A_4 > A_6 > A_{10} > A_3 > A_9 > A_1 > A_8 > A_7 > A_5 > A_{11} > A_{12}$$

**Step 2:** In this step, we measure sensitivity of the ranking list to weight of the criteria. For this reason, we change weight of two FRs and do ranking of alternatives. Figure 1 shows obtained results of 250 cases.

**Step 3:** In this step, we consider two alternatives for determining positive and negative points. For this reason, we choose  $A_4$  and  $A_6$ . Then, we compare financial ratio of two alternatives. The obtained results are shown in Table 3.

**Table 3. Financial Ratio Comparison of  $A_4, A_6$**

| Symbol | Financial Ratios             |
|--------|------------------------------|
| PP     | Current Ratio                |
|        | Quick Ratio                  |
|        | Return On Sales              |
|        | Debt Ratio                   |
| NP     | Accounts Receivable Turnover |
|        | Total Asset Turnover         |
|        | Return On Total Assets       |
|        | Return On Common Equity      |



**Figure 1. Sensitivity Analysis Results**

**Step 4:** In the final step, we measure sensitivity of the alternative to change of negative points. For this

reason, we change NP of  $A'$  by 0.05 and observation outcomes change. Table 4 show different cases.

**Table 4. Sensitivity Analysis Cases**

| FR    | Case I | Case II | Case III | Case IV | Case V |
|-------|--------|---------|----------|---------|--------|
| $F_3$ | 0.88   | 0.93    | 0.98     | 1.03    | 1.08   |
| $F_6$ | 0.12   | 0.17    | 0.22     | 0.27    | 0.32   |
| $F_7$ | 0.11   | 0.16    | 0.21     | 0.26    | 0.31   |
| $F_8$ | 0.12   | 0.17    | 0.22     | 0.27    | 0.32   |

Figure 2 shows obtained results of sensitivity analysis cases.

### Conclusions

The major finding of our paper is summarized as follows:

Obtained result of Weights Sensitivity Analysis (Fig1) shows that this model is reliable because results are maintained in 91.2% cases.

Obtained result of Alternative Sensitivity Analysis (Fig2) shows that  $A_6$  is sensitivity to  $F_8$  and  $F_3$ . In other words, this alternative can improve its rank by focusing on these Financial Ratios.

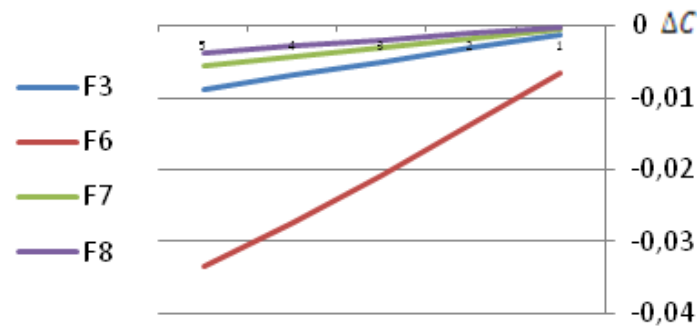


Figure 2. Sensitivity Analysis Results

Decision making models with sensitivity analysis have better results and can be used in Decision Supporting Systems (DSS) models.

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