

## Application of TOPSIS, VIKOR and COPRAS for ideal investment decisions

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### ABSTRACT

An increase in investment is required to support the growth and expansion of the industrial sector in a given country. But the planning and ranking of investments must consider financial resource constraints, high investment risk, the frequency of needs and goals, as well as an unfavorable pattern of investments in the production sectors and industries. To ascertain ranking and economic viability for the investment sectors, this study used optimization techniques called TOPSIS, VIKOR, and COPRAS. From 2020 to 2022, this study was conducted for the Debre Berhan City Administration. The study's findings include investment criteria and outline the importance of certain investment areas. The final findings of this study show that, according to TOPSIS, VIKOR, and COPRAS, the current industrial investment pattern is not ideal investment priorities need to be changed. As a result of the above three optimization techniques; spinning, weaving, and finishing of textile fabric's sector have been ranked first.

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## 1. Introduction

Analytical models have been suggested in numerous studies as tools for managing conflicts. Multicriteria decision making (MCDM) is one of the most popular conflict management strategies out of the many that are available. One managerial level and one engineering level can be found in the MCDM process, which is dynamic and complicated (Tecele et al., 1998; Duckstein et al., 1982). The goal-setting and final ideal alternative are done at the managerial level. At this managerial level, where decision-makers are public authorities with the authority to approve or disapprove the solution put forth by the technical level, the multicriteria nature of decisions is highlighted. The optimization process carried out at the engineering level is offline from these decision-makers, who give the preference structure. The organization of preferences frequently incorporates political factors as well as technical ones. When this occurs, a system analyst can help with decision-making by conducting an extensive analysis and summarizing the key characteristics of noninferior and/or compromise options (Yu, 1973). The engineering level of the MCDM process defines options and outlines the effects of selecting any one of them considering numerous criteria. At this level, options are also ranked using multiple criteria. The following are the main steps in a MCDM process:

- (1) Establishing system evaluation criteria that relate system capabilities to goals.
- (2) Generating alternative systems for attaining the goals.
- (3) Evaluating alternatives in terms of criteria.
- (4) Applying a normative multicriteria analysis method.
- (5) Accepting one alternative as “ideal”.

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(6) If the final solution is not accepted, gather new information and go into the next iteration of multicriteria optimization.

Numerous MCDM techniques have been developed from earlier investigations, including AHP, ANP, VIKOR, PROMETHEE, ELECTRE, GRA, TOPSIS, COPRAS, etc. (Oguztimur, 2011). In this study, the city of Debre Berhan's best industrial investment was chosen and given top priority using the three MCDM methodologies TOPSIS, VIKOR, and COPRAS. We anticipate that the findings of this paper will be useful in helping policymakers to determine and assess how much funding is being allocated to active projects in relation to regional development plans.

In the literature review, most studies on MCDM were conducted using the single method for decision making process. However, a few studies were conducted using the combination of two MCDM methods, leading to the conclusion that the results were better for a variety of real-world issues. Particularly for emerging nations like Ethiopia, the research done on the MCDM in the manufacturing and service sectors were insufficient. Because the application of MCDM methodologies were still in its infancy in Ethiopia, which is a developing nation, it is essential to employ the combination of different methodologies in the decision-making process to get an ideal solution prior to the allocation of an investment. As a result, the research will have a considerable impact on how new entrepreneurs choose which sector to invest in to boost sales and maintain their competitive edge. In this sense, the literature reviews about the key subjects and applications of MCDM techniques have been presented in section 2. The remaining paper components are arranged as follows: Research material and methods have been presented in Section 3, in Section 4 results, and discussion, in Section 5 conclusions.

## 2. Literature review

Today's economy is a crucial and critical issue, therefore from a macroeconomic standpoint, several things can affect a country's industrial growth and, ultimately, its ability to prosper economically. The first consideration is how well the government's macro policy would affect the attractiveness of investments in various sectors. Small industries have been one of these cases, especially in these instances after the growth and transformation plan in our country provided a favorable environment for growth and the achievement of self-sufficiency, along about industry's infrastructure and main such as industry of mining, steel, leather and textiles, energy, beverages, and food etc. is being considered by officials. By evaluating and determining the relative advantages of each region in Ethiopia, it is possible to determine the second consideration, which has been called the internal factor. It refers to the facilities and capabilities of the region. As a result, to comprehend the facilities and capabilities of the region, it is necessary to establish and keep track of important indicators that may be used to gauge the quantity of facilities and capabilities in the region's numerous industrial fields.

Investors and investment alike have experienced difficulties in making decisions pertaining to the commercial and personal domains in the current competitive business environment. When facing any decision challenges, they require a practical and trustworthy way to obtain superior decision help. In some previous studies, we use single MCDM methodology in a variety of contexts. For instance, extended TOPSIS model for solving multi-attribute decision making problems in engineering (Aikhuele & Turan, 2017), TOPSIS for selection of the all-time best World XI test cricket team (Chakraborty et al., 2019) as well as for identifying effective criteria in agile project management and ranking projects regarding the employer and the contractor's perception (Pourkhandani, & Iranban, 2014), FTOPSIS method for knowledge management processes to prioritize organizations (Shirouyehzad et al., 2015) as well as for in supporting supplier selection with focus on HSE criteria in the oil and gas industry (Haddad et al., 2021), TOPSIS method for the selection of a car by using hypothetical data (Abdal, 2020), FTOPSIS for evaluating project management standards based on EFQM Criteria (Golpîra, 2014), combined FAHP and TOPSIS decision model for selecting the best firewall alternative (Cubukcu & Cantekin, 2022), FAHP and TOPSIS methods for risk evaluation of gas transmission facility (Farokhi, 2019).

There also tends to use the combinations of two or more MCDM methodologies in a variety of contexts to get better solutions. For instance, selection of sustainable suppliers in the oil and gas industry using fuzzy MCDM methods (Jermisittiparsert et al., 2021). Sun (2010) developed an evaluation model based on the FAHP and the FTOPSIS to help the industrial practitioners for the performance evaluation in a fuzzy environment. The proposed method enables decision analysts to better understand the complete evaluation process and provide a more accurate, effective, and systematic decision support tool (Sun, 2010). An integrated FAHP and FTOPSIS approach for ranking and selecting the chief inspectors of bank (Esmaili-dooki et al., 2017) as well as for identification and ranking of affecting factors on sales and operations planning process implementation in dairy industry (Hassanzadeh & Asghari, 2020), suitable computerized maintenance management system selection using grey group TOPSIS and fuzzy group VIKOR (Zare et al., 2018), WSM, COPRAS and TOPSIS for minimizing environmental emissions in construction projects (Marzouk & Abdelakder, 2019), AHP and Extended TOPSIS for best player selection Based on Wefa framework in MAGDM problems (Nikjo et al., 2015), for ranking efficient DMUs based on TOPSIS and Virtual DMUs (F. H. Lotfi et al., 2012), hybrid FAHP and TOPSIS to determine recommendation for improving SMEs facing Covid-19 pandemic (Kustiyahningsih et al., 2022), A FAHP and VIKOR for the discrete time-cost-quality trade-off problem (Eydi et al., 2016).

In their research, Danaei et al. employed the TOPSIS pattern to rank investments in securities exchange-accepted sectors (Danaei & Moradi Haghighi, 2013). According to the study's findings, the telecoms industry group received priority funding in both 2009 and 2010, which means that investments made in this sector have a greater chance of success due to a partial

advantage. The industrial development goals for West Azerbaijan are selected and rated according to research conducted by Lotfi et al. in the field of FTOPSIS (A. Lotfi & Mansourabad, 2014). The findings of this study imply that the West Azerbaijan Province has a good potential for playing its proper part in national industrial development and regional planning, both of which are necessary for the country to realize its visionary goals.

The literature review section examines several research studies that are pertinent to this topic. Numerous academics have used the MCDM method in their studies to show how this strategy functions and how successful it is when choosing the best option from a list of options. Despite the large amount of research on MCDM approaches that has been done to date, these methods didn't sufficiently account for the selection of ideal industrial investment priorities. Therefore, MCDM process based on the use of the combination of different MCDM methodologies (TOPSIS, VIKOR and COPRAS) is recommended as the primary goal of this research to select the ideal industrial investment decision.

### 3. Materials and methods

This research is applied. The library technique is employed in this study in the examined industrial zone, Debre Berhan city administration, to rank the industrial investment sectors. As well as international standard industrial classification (ISIC) two-digit codes for the years 2020 to 2022, the studied population and all staff manufacturing factories in Debre Berhan City with their employees were used. Additionally, statistical yearbooks, Debre Berhan city statistics bureau data, census figures, and information from sizable industrial workshops maintained by the Ethiopian statistics center were also the considered authorities. Based on the criteria mentioned in Table 1 below, groups have been identified and ranked in terms of profitability indicators, employment, profitability, and employment as a combination of priority industrial investment and industries. Then further theoretical analysis of the research has been conducted using statistical techniques: TOPSIS, VIKOR, and COPRAS.

#### 3.1. Investment priority criteria

The combination of a few of the indexes in Table 1 yields the investment priority indicators. An investing index or combinations of top priorities are listed.

**Table 1**  
Investment priority indicators<sup>1</sup>

Index name	Index relation
C1: Productivity Indicator	$L_j = [(v_j/N_j)/(v_T/N_T)]$
C2: Share of value-added output	$VQ_i = V_i/Q_i$
C3: Independence on Foreign Resources	$IOF_i = \ln f_i / \ln e_i$
C4: Profitability Index	$I\pi = (Y_i - C_i)/L_i$
C5: Capital intensive index	$L_i = (V_i - W_i)/L_i$
C6: Export orientation	$XM = X_i/V_i$
C7: Revealed comparative advantage Balassa	$RCA_{ij} = \frac{X_{ij} / \sum_i X_{ij}}{\sum_j X_{ij} / \sum_i \sum_j X_{ij}}$
C8: Location quotient in terms of value-added	$LQV_{ij} = \frac{V_{ij} / \sum_i X_{ij}}{\sum_j V_{ij} / \sum_i \sum_j V_{ij}}$
C9: Location quotient in terms of employment	$LQL_{ij} = \frac{L_{ij} / \sum_i X_{ij}}{\sum_j L_{ij} / \sum_i \sum_j L_{ij}}$

#### 3.2 TOPSIS Method

The traditional TOPSIS method was proposed to be extended by (Alinezhad et al., 2009). This strategy can be explained as follows. Let  $[X_{ij}]$  be the  $j$ th criterion value for the  $i$ th alternative, and let  $W = (w_1, w_2, \dots, w_n)$  be the weight vector. The following steps make up the strategy suggested in (Alinezhad et al., 2009):

**Step one:** Using the (Opricovic & Tzeng, 2007) following equations to normalize the decision matrix:

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

**Step two:** The following equations are used to create the weighted normalized decision matrix while accounting for the significance of the criteria:

$$v_{ij} = w_j r_{ij}, i = 1, 2, \dots m; j = 1, 2, \dots n \quad (2)$$

<sup>1</sup> The criteria are employed to prioritize what the most important is regarding the goal of the investment. This is important to compare each investment alternative regarding each criterion. <https://www.diva-portal.org/smash/get/diva2:1331120/FULLTEXT01.pdf>.

**Step three:** The ideal solutions, both positive and negative, are obtained as follows:

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\} = \left\{ \left( \text{Max}_i v_{ij} \mid j \in J^+ \right), \left( \text{Min}_j v_{ij} \mid j \in J^- \right) \mid i = 1, 2, \dots, m \right\} \quad (3)$$

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} = \left\{ \left( \text{min}_i v_{ij} \mid j \in J^+ \right), \left( \text{max}_j v_{ij} \mid j \in J^- \right) \mid i = 1, 2, \dots, m \right\} \quad (4)$$

**Step four:** The n-dimensional Euclidean distance is used to calculate the distance between each alternative and the positive ideal solution as well as each alternative and negative ideal solution which have been shown in Eq. (5) and Eq. (6) respectively:

$$d_{j \in J}^+ = \left\{ \sum_{j \in J} (v_{ij} - v_j^+)^2 + \sum_{j \in J} (v_{ij} - v_j^+)^2 \right\}^{\frac{1}{2}}, i = 1, 2, \dots, m \quad (5)$$

**Step five:** Calculate how near an option is to the optimal alternatives:

$$d_{j \in J}^- = \left\{ \sum_{j \in J} (v_{ij} - v_j^-)^2 + \sum_{j \in J} (v_{ij} - v_j^-)^2 \right\}^{\frac{1}{2}}, i = 1, 2, \dots, m \quad (6)$$

$$\bar{R}_i = \frac{d_i^-}{d_i^- + d_i^+}, i = 1, 2, \dots, m \quad (7)$$

**Step six:** The better the alternative  $d_i$ , the closer it is to the ideal alternatives, the higher the rank of the alternatives.

### 3.3 VIKOR Method

To solve discrete decision-making problems with competing and incommensurable criteria, VIKOR employs a multi-criteria approach. This strategy, which was invented by (Opricovic & Tzeng, 2007), was centered on rating and choosing from a list of alternatives to find compromise solutions to a problem with competing criteria. The workable alternative that comes closest to the ideal solution is called the compromise solution. A compromise solution is one that is based on shared acceptance of the requirements. The VIKOR technique was created using  $L_p$ -metric (Eydi et al., 2016):

$$L_{p,i} = \left\{ \sum_{j=1}^n [\mu_j (f_i^* - f_{ij}) / (f_i^* - f_i^-)]^p \right\}^{\frac{1}{p}}, i = 1, 2, \dots, m; 1 \leq p \leq \infty \quad (8)$$

The best (positive ideal) and the worst (negative ideal) values of the scores are denoted by  $f_i^*$  and  $f_i^-$ , respectively. Where  $\mu_j$  is the weight of the  $j$ th criterion,  $f_{ij}$  is the rating of the  $j^{\text{th}}$  criterion for  $i^{\text{th}}$  choice. The majority can benefit the most from this strategy, while the opponent can have the least amount of personal regret. When  $p$  is low, the collective utility is taken into consideration, and when  $p$  is high, the individual regrets are given greater weight. The fact that VIKOR uses linear normalization gives it an edge over other approaches, most notably TOPSIS. So, the normalized values in VIKOR are not reliant on the unit of measurement for the criteria. The best solution in TOPSIS is therefore not necessarily the closest alternative to the best solution in VIKOR method because TOPSIS does not consider the distance relative importance from positive and negative ideal solutions. On the other hand, compromise solution is always the closest alternative to ideal solution in VIKOR method. The stages in using this technique are as follows:

**Step one:** Build a comparison matrix: This matrix is built with the intention of evaluating all options considering various factors. Assume that you are faced with a multi-criteria decision-making situation that has  $m$  alternatives and  $n$  criteria. The performance of the  $i^{\text{th}}$  alternative based on the  $j^{\text{th}}$  criteria is represented by the string " $X_{ij}$ ."

**Step two:** Determine the criteria weight vector using one of several ways, considering the weight and importance of each criterion in the decision-making process. The weight of the criteria has been determined in this case using Shannon's Entropy technique.

$$x = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (9)$$

**Step three:** Finding the optimum values at their highest and lowest points: The best (positive ideal) and worst (negative ideal) choices for each criterion were identified and designated  $f_i^*$  and  $f_i^-$ , respectively. Considering the profit kind as the criterion, then:

$$f_i^- = \min_j f_{ij}; f_i^* = \max_j f_{ij}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (10)$$

We would achieve the best possible combination with the highest score if all our associates were  $f_i^*$   $f_i$  (positive ideal solution). The optimum solution is negative for  $f_i^-$  as well.

**Step four:** Calculating how far the alternatives are from the optimal solution:

$$S_i = \sum_{j=1}^n w_j \frac{(f_i^* - f_{ij})}{(f_i^* - f_i^-)} \quad (11)$$

$$R_i = \text{Max}[w_j \frac{(f_i^* - f_{ij})}{(f_i^* - f_i^-)}] \quad (12)$$

where  $S_i$  is the distance in terms of the  $i$ th alternative from the positive ideal solution, and  $R_i$  is the distance in terms of the  $i$ th alternative from the negative ideal solution.

**Step five:** Calculating the VIKOR index:

$$Q_i = v \left( \frac{S_i - S^*}{S^- - S^*} \right) + (1 - v) \left( \frac{R_i - R^*}{R^- - R^*} \right); v \in [0, 1] \quad (13)$$

When the  $v$  value is greater than 0.5, the  $Q_i$  index will result in majority agreement, and when the  $v$  value is less than 0.5, the  $Q_i$  index will suggest a majority negative attitude. Typically, when the  $v$  value is equal to 0.5, this demonstrates the compromise attitude of evaluation specialists.

**Step six:** Putting each  $S$ ,  $R$ , and  $Q$  value in decreasing order will help you rank the possibilities. If alternative  $a'$  receives first place based on  $Q$  value and both of the following two criteria are met, it will be suggested as a compromise solution:

**Condition one:** acceptable advantage

$$Q(a^i) - Q(a^j) \geq \frac{1}{i - 1} \quad (14)$$

Where  $a^j$  is the option that is ranked second by  $Q$ , and  $i$  is the total number of alternatives.

**Condition two:** Acceptable decision-making stability:

The best ranking for alternative  $a'$  must come from either the  $S$  value, the  $R$  value, or all of them.

A set of compromise alternatives are provided if one of the above conditions is not met:

- ✚  $a^j$ , and  $a^i$  are provided as alternatives if only requirement-two is not met.
- ✚ Alternatives  $a^j$ ,  $a^k, \dots, a^m$  are proposed if requirement-one is not met. And for the largest value of  $m$ , the following relation yields  $a^m$ :

$$Q(a^m) - Q(a^j) < \frac{1}{i - 1} \quad (15)$$

### 3.4 COPRAS Method

The COPRAS technique assumes that the relevance and priority of the studied alternatives are directly and proportionally dependent on a set of criteria. Four stages can be used to succinctly summarize the determination of relevance and priority of options using the COPRAS technique (Zavadskas et al., 1994):

**Step one:** The  $D$  matrix of normalized decision-making is built. Criteria used in the MCDM process typically include many measurement units. Utilizing a normalizing process, the performances of the options under consideration are converted into equivalent dimensionless numbers. The most significant multi-criteria approaches are described in general, together with their normalization processes which covered in (Zavadskas et al., 2008) is a thorough explanation of the key normalizing techniques.

The following formula is used in the COPRAS method for normalization:

$$\widetilde{X}_{ij} = \frac{X_{ij}}{\sum_{i=1}^m X_{ij}} \quad (16)$$

When  $m$  is the number of choices,  $\widetilde{X}_{ij}$  is the normalized value of  $X_{ij}$ , which measures how well the  $i$ th alternative performs in relation to the  $j$ th criterion.

**Step two:** Calculations are made to determine the sums of weighed normalized criteria describing the  $i$ th alternative. Each alternative in the COPRAS technique is represented in terms of the total of its maximizing attributes ( $S_{+i}$ ) and minimizing criteria ( $S_{-i}$ ), where  $S_{+i}$  represents the maximization direction and  $S_{-i}$  represents the minimization direction, respectively.

Maximizing criteria are placed first in the decision-making matrix columns, followed by minimizing criteria, to streamline the calculation of  $S_{+i}$  and  $S_{-i}$ . In these situations,  $S_{+i}$  and  $S_{-i}$  are determined as follows:

$$S_{+i} = \sum_{j=1}^k \widetilde{X}_{ij} \cdot q_j \quad (17)$$

$$S_{-i} = \sum_{j=k+1}^n \widetilde{X}_{ij} \cdot q_j \quad (18)$$

In Eq. 17 and 18,  $k$  denotes the number of criteria that maximize,  $n$  is the total number of criteria, and  $q_j$  denotes the significance of the  $j$ th criterion.

**Step three:** calculating the relative importance of each option. This is how the relative weight  $Q_i$  of the  $i$ th, alternative is determined:

$$Q_i = S_{+i} + \frac{\min_i S_{-i} \sum_{i=1}^m S_{-i}}{S_{-i} \sum_{i=1}^m \frac{\min_i S_{-i}}{S_{-i}}} \quad (19)$$

Eq. (19) can also be written in simplified form as follows:

$$Q_i = S_{+i} + \frac{\sum_{i=1}^m S_{-i}}{S_{-i} \sum_{i=1}^m \frac{1}{S_{-i}}} \quad (20)$$

Step three: Establish the order of importance for each possibility. The relative weights of the compared alternatives are used to determine the priority order. The alternative with the highest relative weight is the most preferable alternative. The alternative with a greater relative weight has a higher priority (rank).

$$A^* = \left\{ A_i \mid \max_i Q_i \right\} \quad (21)$$

The COPRAS method's described approach suggests that it can be employed with ease for weighing the available alternatives and choosing the most effective one, provided that the decision-maker is fully aware of the process' physical purpose. But lots of choices are made in actual life circumstances where the exact values of the criteria are not known. Criterion values can then be expressed as intervals. A new method of multiple-criteria complicated proportional assessment with values set in intervals called COPRAS-G is created as a result.

### 3.5 The Shannon's Entropy Method

Obtaining weights for a MADM problem using Shannon's entropy is a well-known technique, particularly when it is unable to conduct DM experiments or find an appropriate weight based on preferences. A set of phases can be used to express the original Shannon's entropy process:

**Step one:** Normalize the decision matrix Set

$$p_{ij} = \frac{X_{ij}}{\sum_{j=1}^m X_{ij}}, j=1, 2\dots m; i=1, 2\dots, n \quad (22)$$

To get rid of irregularities with various measuring scales and units, the raw data are normalized. To enable comparisons of diverse criteria, this method converts various scales and units among various criteria into common measurable units.

**Step two:** Calculate the entropy  $h_i$  using the formula  $h_i = h_0 \sum_{j=1}^m p_{ij} \cdot \ln p_{ij}$ ,  $i = 1, 2, \dots, n$  where  $h_0$  is the entropy constant and equals  $(\ln m)^{-1}$  and  $p_{ij} \cdot \ln p_{ij}$  is defined as 0 if  $p_{ij} = 0$ .

**Step three:** Set  $d_i = 1 + h_i$ ,  $i = 1, 2, \dots, n$  as the degree of diversification.

**Step four:** Set  $w_i = \frac{d_i}{\sum_{s=1}^n d_s}$ ,  $i = 1, 2, \dots, n$  as the degree of importance of attribute  $i$ .

#### 4. Results and discussion

The weight, for each criterion in Table 1, has been calculated using Shannon's entropy.

**Table 2**

Calculating the weights of the criteria of the MADM problem

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Entropy ( $h_i$ )	0.9552	0.9592	0.6088	0.7274	0.7764	0.4312	0.8676	0.9646	0.9778
Degree of diversification ( $d_i$ )	0.0448	0.0408	0.3912	0.2726	0.2236	0.5688	0.1324	0.0354	0.222
Degree of importance of attribute $i$ ( $w_i$ )	0.0259	0.0236	0.2259	0.1574	0.1291	0.3284	0.0765	0.0205	0.0128

Following, the TOPSIS, VICKOR, and COPRAS procedures are applied to these values to identify the ideal option. First, we create a decision matrix using 36 investment sectors (alternatives) and criteria from C1 up to C9.

A number is eventually obtained using the TOPSIS approach and in accordance with the 9 criteria, showing an industry investment decision indicator in the industry zone of Debre Berhan city. Table 3 displays the mathematically determined investment priorities for the industrial sectors 21, 13, 15, 24, 26, 22, 16, 28, 32, and 27, rated from 1 to 10, accordingly.

**Table 3**

Proposed investments' rank with TOPSIS results<sup>2</sup>

Investment sectors	$d_i^-$	$d_i^+$	$\bar{R}_i = \frac{d_i^-}{d_i^- + d_i^+}$	Rank
13 Processing and preserving of Meat and milk products	0.373	0.210	0.360	2
14 Electronics Materials production	0.416	0.023	0.052	13
15 Leather processing and tanning up to finished goods	0.370	0.182	0.330	3
16 Cement production	0.389	0.039	0.091	7
21 Spinning, weaving, and finishing of textile fabrics	0.247	0.324	0.568	1
22 Production of Paper products	0.411	0.060	0.127	6
23 Manufacturing of Fertilizer and other chemical industries	0.423	0.019	0.043	14
24 Processing and preserving of Grains, Pulses, Fruits, and Vegetables	0.375	0.071	0.159	4
25 Production, processing and preserving of Fish and Fish products	0.414	0.023	0.052	11
26 Manufacturing of Sugar, Brewery, Winery and Soft drinks/Beverages	0.371	0.061	0.141	5
27 Manufacturing of Starch and Starch products	0.420	0.025	0.056	10
28 Pharmaceutical manufacturing	0.412	0.028	0.064	8
29 Manufacturing of lime, gypsum, marble, granite, glass	0.425	0.016	0.036	15
30 Rendering agricultural services to commercial farms	0.409	0.023	0.052	12
31 Rental of agricultural machinery	0.430	0.011	0.025	17
32 Production of dimensional stone, floor tiles, aggregate production, hollow blocks	0.410	0.028	0.063	9
33 Installation of irrigation systems, input supply and output marketing	0.423	0.009	0.021	18
36 Veterinary facilities and plant protection services	0.417	0.015	0.035	16

For each criterion, we select the best and worst alternatives using the VICKOR technique.

**Table 4**

Best and worst alternatives of each criteria using VIKOR

	C1	C2	C3	C4	C5	C6	C7	C8	C9
$f_i$	0.47	0.48	0.94	0.89	0.90	0.98	0.66	0.40	0.50
$f_i^-$	0.07	0.08	0.00	0.00	0.00	0.00	0.00	0.05	0.13

<sup>2</sup> Among the total 36 investment alternatives, here the most prominent and applicable in the area have been screened out with discussions of the company experts, city administration personnel and the researcher to get candidate alternatives for statistical evaluation using TOPSIS, VIKOR, and COPRAS, and then to rank.

The  $S_i$  and  $R_i$  values for each possibility are then determined. We calculate the VIKOR index after figuring out the highest and lowest values of  $S_i$  and  $R_i$ . Table 5 displays the  $S_i$ ,  $R_i$ , and  $Q_i$  indices for a few possibilities. Table 5 displays, in order from 1 to 10, the investment priorities using the VIKOR technique for the investment sectors 21,15,24,26,13,16,22,32,30, and 27.

**Table 5**  
Investment sector rank using,  $S_i$ ,  $R_i$  and  $Q_i$  values

Investment sectors	$S_i$	$R_i$	$Q_i$	Rank
13 Processing and preserving of Meat and milk products	0.74	0.33	0.72	5
14 Electronics Materials production	0.92	0.33	0.94	15
15 Leather processing and tanning up to finished goods	0.65	0.31	0.52	2
16 Cement production	0.87	0.30	0.78	6
21 Spinning, weaving, and finishing of textile fabrics	0.56	0.19	0.00	1
22 Production of Paper products	0.83	0.33	0.82	7
23 Manufacturing of Fertilizer and other chemical industries	0.92	0.33	0.94	14
24 Processing and preserving of Grains, Pulses, Fruits, and Vegetables	0.79	0.29	0.64	3
25 Production, processing and preserving of Fish and Fish products	0.92	0.33	0.93	11
26 Manufacturing of Sugar, Brewery, Winery and Soft drinks/Beverages	0.80	0.30	0.68	4
27 Manufacturing of Starch and Starch products	0.91	0.33	0.92	10
28 Pharmaceutical manufacturing	0.92	0.33	0.93	13
29 Manufacturing of lime, gypsum, marble, granite, glass	0.95	0.33	0.97	17
30 Rendering agricultural services to commercial farms	0.91	0.32	0.89	9
31 Rental of agricultural machinery	0.97	0.33	1.00	18
32 Production of dimensional stone, floor tiles, aggregate production, hollow blocks	0.88	0.32	0.87	8
33 Installation of irrigation systems, input supply and output marketing	0.95	0.33	0.97	16
36 Veterinary facilities and plant protection services	0.93	0.32	0.93	12

$S^- = 0.97, S^+ = 0.56, R^- = 0.33, R^+ = 0.19, v = 0.5$

The decision matrix is first normalized using the COPRAS approach using Eq. (16) Then, using Eq. (17), the corresponding weighted normalized decision matrix is created. The sums of the weighted normalized values for both the favorable criteria  $S_{+i}$  and the unfavorable criteria are computed using Eq. (17) and (18).  $S_{-i}$ . Following this, the relative importance or priority value  $Q_i$  for each choice is calculated and is shown in Table 6 after using Eq. (19) and (20). Based on the calculation results of COPRAS technique the total ranking of the investment sectors (alternatives) is 21,15,13,22,24,26,32,27,16, and 23, rated from 1 to 10, correspondingly.

**Table 6**  
Calculating investment sectors' index using COPRAS

Investment sectors	P	R	I/R	Q	N	Rank
13 Processing and preserving of Meat and milk products	0.009	0.002	514	0.009	0.028	13
14 Electronics Materials production	0.009	0.001	985	0.010	0.030	12
15 Leather processing and tanning up to finished goods	0.233	0.001	704	0.233	0.708	2
16 Cement production	0.011	0.001	1510	0.013	0.038	9
21 Spinning, weaving, and finishing of textile fabrics	0.327	0.000	3156	0.329	1	1
22 Production of Paper products	0.050	0.002	602	0.050	0.152	4
23 Manufacturing of Fertilizer and other chemical industries	0.010	0.001	1382	0.011	0.032	10
24 Processing and preserving of Grains, Pulses, Fruits, and Vegetables	0.038	0.000	2671	0.040	0.121	5
25 Production, processing and preserving of Fish and Fish products	0.005	0.000	7563	0.010	0.031	11
26 Manufacturing of Sugar, Brewery, Winery and Soft drinks/Beverages	0.031	0.002	647	0.031	0.095	6
27 Manufacturing of Starch and Starch products	0.009	0.000	4957	0.013	0.039	8
28 Pharmaceutical manufacturing	0.009	0.002	514	0.009	0.028	13
29 Manufacturing of lime, gypsum, marble, granite, glass	0.007	0.004	259	0.007	0.022	14
30 Rendering agricultural services to commercial farms	0.006	0.001	1070	0.007	0.022	15
31 Rental of agricultural machinery	0.004	0.001	698	0.004	0.012	17
32 Production of dimensional stone, floor tiles, aggregate production, hollow blocks	0.012	0.000	4116	0.015	0.046	7
33 Installation of irrigation systems, input supply and output marketing	0.003	0.001	689	0.004	0.011	18
36 Veterinary facilities and plant protection services	0.006	0.005	208	0.006	0.018	16

## 5. Conclusion

The research's conclusions on the Debre Berhan city's industries can be shown in the following ways based on the measures that were used. According to the findings of this study, "21,15,13,22,24,26,32,27,16,23" sectors rank from 1 to 10 for the investment priority based on the investment index using statistical methods TOPSIS, VIKOR, and COPRAS. Additionally, the existing facility allocation model used by investors differs from the optima model. As a result, based on the investment index, we should modify the quantities and percentages of these facilities to each industry sector.

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