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Clustering and Ranking of Provinces in Terms of Investment Security Based on Multi-Criteria Multi-Period Decision-Making

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ABSTRACT

Investment security is a critical component of economic development in countries, as its enhancement fosters investor confidence and encourages participation in productive sectors and financial markets. Given the regional disparities across the country, assessing investment security at the provincial level is essential. This study aims to rank and cluster Iranian provinces in terms of investment security over the period 2021–2023, using a multi-criteria, multi-period decision-making approach. For this purpose, two techniques—MP-TOPSIS and MULTI-MOORA—were employed to evaluate and rank the provinces, and the results were compared. Subsequently, the k-means clustering method was applied to group provinces into homogeneous clusters. The data were obtained from 12 policy reports published by the Iranian Parliament Research Center, and the weighting of criteria was performed using three methods: MEREC, Shannon entropy, and CRITIC. The findings reveal that Semnan, Golestan, and Hormozgan provinces exhibit the highest levels of investment security, while Tehran, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad rank lowest. Additionally, the correlation between the two ranking methods was estimated at 87%, indicating a high degree of consistency and validating the proposed model. The results suggest that macroeconomic stability, administrative transparency, and robust legal frameworks are the most influential factors in determining investment security. Region-specific policy recommendations based on these analyses can significantly improve the investment climate across the country.

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1) Introduction

Investment security plays a fundamental role in attracting domestic and foreign investment and in achieving sustainable economic development. As one of the key pillars of economic security, investment security ensures that investors benefit from economic stability, administrative transparency, reliable legal frameworks, and predictable governance mechanisms. In environments where such conditions prevail, investor confidence increases and capital flows more readily into productive activities and financial markets. Conversely, inadequate investment security can lead to capital outflows, reduced economic growth, and heightened social and economic instability.

Numerous domestic and international studies emphasize that investment security is a multidimensional concept influenced by a wide range of economic, legal, administrative, and social factors. These factors include macroeconomic stability, transparency and integrity of administrative systems, clear definition and effective enforcement of property rights, performance of governmental institutions, and the degree of protection afforded to citizens' life and property. Each of these elements directly affects investment decisions made by economic agents. The importance of regional-level analysis becomes particularly evident in countries such as Iran, where provinces differ substantially in terms of economic structure, institutional capacity, infrastructure, and governance quality. Such disparities necessitate a provincial assessment of investment security to identify strengths, weaknesses, and priority areas for policy intervention.

Despite the existence of several studies on economic security and regional development, most prior research has relied on cross-sectional evaluations or limited analytical tools. Furthermore, the application of multi-period and multi-criteria decision-making (MCDM) approaches, combined with clustering techniques, has remained limited. This study seeks to address these gaps by ranking and clustering Iranian provinces in terms of investment security over the 2021–2023 period using a comprehensive, dynamic, and methodologically robust framework. To achieve this objective, the study employs the MP-TOPSIS and MULTI-MOORA methods due to their ability to simultaneously consider multiple criteria across multiple time periods. Additionally, three well-established weighting techniques—MEREC, Shannon Entropy, and CRITIC—are utilized to enhance result reliability. Finally, the k-means clustering method is applied to group provinces with similar investment security characteristics, thereby facilitating region-specific policy formulation.

The present study, relying on data extracted from 12 policy reports published by the Research Center of the Islamic Consultative Assembly, attempts to present a combined and practical model for analyzing investment security. The findings of this study can be used as a basis for economic policymakers, regional planners, and investment decision-makers to take effective steps to improve the investment environment, reduce institutional risks, and enhance the economic attractiveness of different regions of the country by utilizing the results of ranking and clustering.

2) Literature Review

Investment security and its determinants have been the subject of numerous studies in Iran, particularly within the context of regional development and economic security assessment. In this section, first, domestic research related to ranking, economic indicator analysis, and investment security is reviewed. Then, foreign studies that have used multi-criteria decision-making approaches are reviewed. Finally, the existing research gaps and the position of the present study are explained.

2.1) Domestic Studies Related to Economic and the Ranking of Investment Security

Rahnama et al. (2003) employed statistical data analysis and software-based techniques to propose a new framework for classifying administrative divisions based on development indicators. Although their study did not directly address investment security, the applied methodology demonstrated strong potential for adaptation to this field.

Gorji et al. (2007), using the Morris model, analyzed economic security by dividing it into two dimensions: macroeconomic indicators and environmental indicators. This theoretical framework provided a basis for more comprehensive and multidimensional analyses of economic and investment security. Amadeh et al. (2010) evaluated the technical efficiency of the industrial sector across Iranian provinces using Data Envelopment Analysis (DEA) and the Andersen–Petersen ranking model. Their findings indicated that combining statistical analysis with decision-making techniques can generate meaningful insights into regional disparities. Abbasi Asl et al. (2012) applied fuzzy clustering methods to group Iranian provinces based on public health indicators published by the Ministry of Health, illustrating the effectiveness of clustering approaches in identifying homogeneous regional groups. Atoufi and Javidan-Darogar (2013) examined judicial, financial, and social institutions as foundational elements of economic security. Their results highlighted that weaknesses in these institutions constitute major barriers to sustainable economic development. Mohammadi et al. (2014) ranked provinces in terms of social security using Grey Relational Analysis, marking one of the earliest applications of this method in security-related studies. Alavi Ghassoni et al. (2017) analyzed social security indicators in Khorasan Razavi Province using SPSS and Pearson correlation coefficients, emphasizing the strong linkage between security and regional development.

Karami et al. (2016) employed numerical taxonomy models to rank agricultural development in Kohgiluyeh and Boyer-Ahmad Province, demonstrating that numerical approaches facilitate the identification of regional development priorities. Abdoli et al. (2017) utilized the VIKOR method combined with Shannon Entropy weighting to rank provinces based on economic value added, highlighting the effectiveness of MCDM models in identifying provincial comparative advantages.

Salehi (2022) applied income-based and indicator-oriented taxonomy methods to rank provinces in terms of human development and human capital, clearly revealing inter-provincial performance disparities. Jahangiri and Jahangiri (2019) employed dynamic multi-criteria decision-making methods to analyze the three-year performance of the Social Security Organization, examining both direct and indirect relationships through correlation analysis. Ghafarifard et al. (2020) constructed a composite index of religious capital using a combination of Delphi, AHP, and TOPSIS methods, identifying Yazd, South Khorasan, and Qom as top-ranked provinces. Hemmati (2021) evaluated provincial development levels using hierarchical TOPSIS and Delphi techniques, while Salman Mahini (2022) designed an Excel-based system for ranking provincial development levels.

2.2) International Studies Based on MCDM and Investment Security

At the international level, a growing body of research has employed Multi-Criteria Decision-Making (MCDM) models to assess investment security and related economic phenomena.

Lin et al. (2008) extended the TOPSIS model by incorporating the Minkowski distance function to handle grey data conditions. Brauers and Zavadskas (2012) introduced the MULTI-MOORA method, integrating ratio systems, reference point approaches, and full multiplicative forms into a unified decision-making framework. Due to its objectivity and reduced reliance on subjective weighting, this method has gained widespread academic acceptance. Wang et al. (2017) combined AHP and PROMETHEE under hesitant fuzzy linguistic term sets (HFLTS) to evaluate investment security in China's economic sectors, allowing for uncertainty in expert judgments. Witt and Klumpp (2021) developed the PROMETHEE-MP method to analyze decision-making under deep uncertainty and applied it to energy transition investments in Germany. Ozkaya and Erdin (2021) evaluated smart cities using a hybrid ANP–TOPSIS approach, demonstrating that smart governance and smart living dimensions carry different macro-level weights. Zhang et al. (2022) ranked new cities in China based on smart development using Entropy–TOPSIS, highlighting spatial imbalances in urban performance. Yu et al. (2023) analyzed the impact of geopolitical risks on international investment security using a 20-year dataset and regression-based models, concluding that countries with higher political stability attract more investment. Soltanifar et al. (2024) proposed a precise linear model combining MOORA and COPRAS methods to rank investment security using efficiency distance concepts, further confirming the effectiveness of MCDM techniques in this domain.

2.3) Research Gap and Conclusion

A comprehensive review of the literature reveals that most domestic studies on economic and investment security rely on cross-sectional and single-period analyses, with limited application of simultaneous ranking and clustering approaches. Moreover, multi-period evaluation of investment security at the provincial level has been largely overlooked. Additionally, comparative validation between different MCDM ranking methods to assess result stability has received insufficient attention.

This study addresses these gaps by:

- Applying a multi-period framework over the 2021–2023 period
- Integrating MP-TOPSIS and MULTI-MOORA ranking methods
- Utilizing three objective weighting techniques (MEREC, Shannon Entropy, CRITIC)
- Conducting correlation and sensitivity analyses
- Implementing k-means clustering to classify provinces into homogeneous investment security groups

As a result, the study presents a comprehensive and dynamic model for analyzing and classifying provincial investment security in Iran.

3) Research Methodology

3.1) Research Framework

The present study is applied in terms of objective and descriptive–analytical in terms of methodology. The overall research framework consists of several sequential steps designed to rank and cluster Iranian provinces based on investment security over multiple periods. Figure 1 illustrates the general research process. The main stages of the study include:

- Identification of investment security indicators
- Data collection for provinces over the 2021–2023 period
- Normalization of data
- Criteria weighting using MEREC, Shannon Entropy, and CRITIC methods
- Provincial ranking using MP-TOPSIS and MULTI-MOORA
- Correlation and sensitivity analysis
- Clustering of provinces using the k-means algorithm

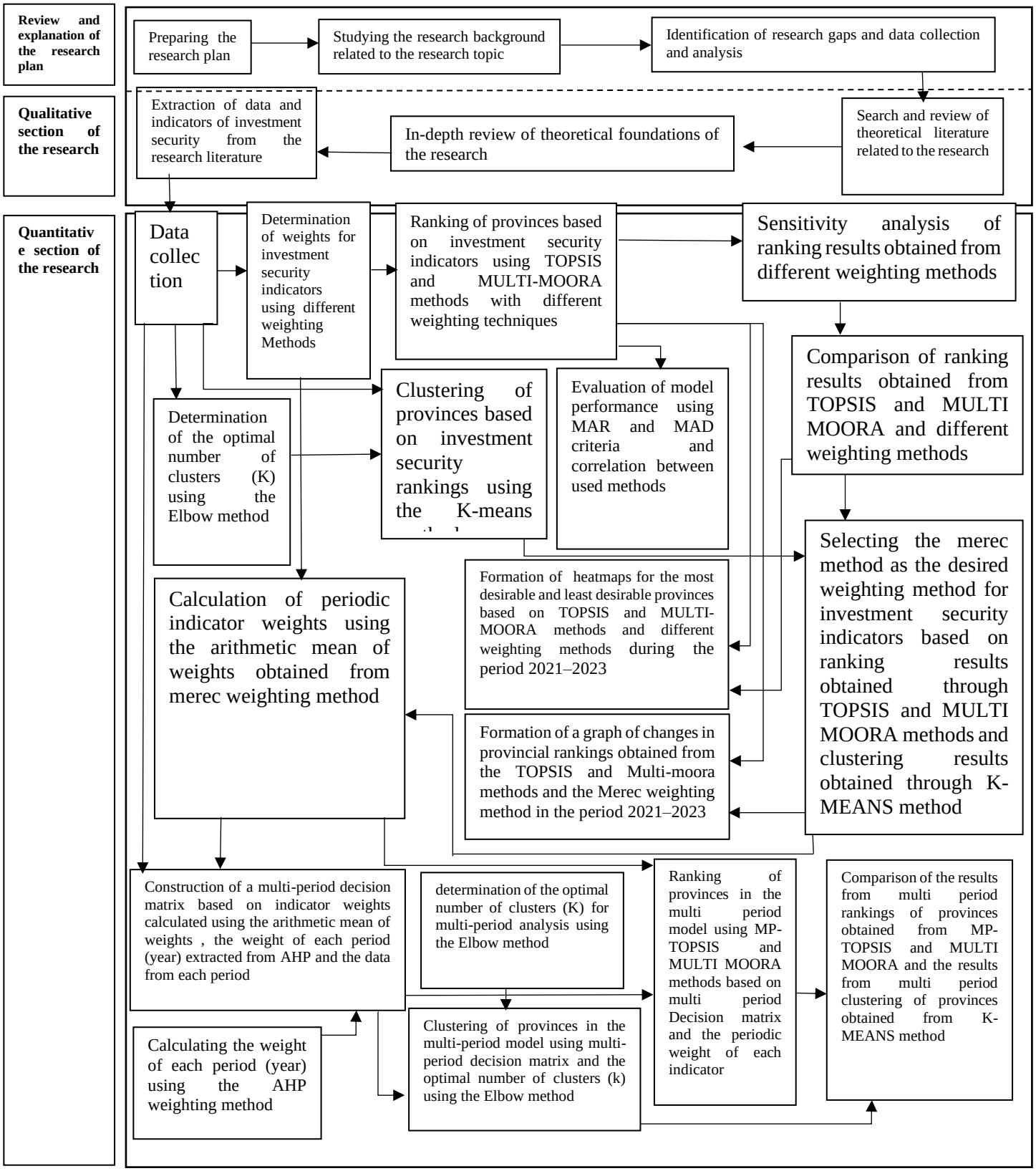

Figure 1. Research Process

3.2) Identification of Investment Security Indicators

Based on a literature review, investment security is fully established under conditions where the macroeconomic environment (inflation rate, exchange rate, etc.) is stable or predictable, laws, regulations, and executive procedures are stable, easily and effectively implemented, and if changes are necessary, stakeholders are informed in advance, information affecting economic activities is transparently and equally available to all citizens, and judicial and regulatory institutions are so equipped, sound, and efficient that any violation of property rights or unauthorized use of the physical or intellectual property of others is not cost-effective for anyone, and citizens who have lost money can, by referring to the competent institutions, receive their lost property along with the related damages in the shortest possible time. Based on the literature review, 7 indicators and 38 sub-components related to each indicator, which are divided into two categories of statistical data (HD) and survey data (SD), have been selected in Table 1 as the main criteria for ranking provinces in terms of investment security (Tehrani et al., 2018).

Table 1. Investment Security Indicators and Associated Sub-Components Applied in This Study (Tehrani, 2018)

Indicator	Sub-Components
Government performance	▪ Ease of enforcing citizens' legal rights within administrative institutions – SD ▪ Disruption to business activities as a result of newly imposed foreign sanctions – SD ▪ Support and cooperation of provincial authorities with prospective investors – SD
Macroeconomic stability	▪ Stability of raw material prices – SD ▪ Absence of volatility in the consumer price inflation index – HD ▪ Stability of the exchange rate – HD
Definition and protection of property rights	▪ Trust in the judiciary for the timely and fair enforcement of rights in commercial and financial disputes – SD ▪ Responsiveness and commitment of law enforcement authorities (police) in addressing complaints raised by economic actors – SD ▪ Specialized handling of commercial disputes within judicial authorities – SD ▪ Full and timely enforcement of judicial rulings – HD ▪ Resolution of commercial disputes through arbitration – HD ▪ Case disposition rate of judicial files (percentage of cases resolved relative to incoming cases) – HD ▪ Average duration of adjudication for each incoming case (days) – HD
Culture of honoring commitments, integrity, and honesty	▪ Presence of fraud or deceit in the market – SD ▪ Degree of commitment to fulfilling obligations in the execution of written or oral contracts in the market – SD ▪ Government adherence to contractual commitments – SD ▪ Fulfillment of promises made by national officials – SD ▪ Fulfillment of promises made by local officials – SD ▪ Number of breach of trust cases (per 100,000 population) – HD ▪ Number of debt recovery cases (per 100,000 population) – HD ▪ Percentage of dishonored (bounced) checks – HD ▪ Number of fraud cases (per 100,000 population) – HD
Stability and predictability of regulations and	▪ Stability or predictability of laws and regulations (enacted by the Parliament, the Cabinet, or ministers) – SD ▪ Stability or predictability of executive practices (decisions of

implementation procedures	provincial or local authorities) – SD ▪ Clarity and unambiguous nature of business-related laws and regulations and their implementing by-laws – SD ▪ Stability of provincial officials – HD
Administrative transparency and integrity	▪ Access to smuggled goods to the detriment of certain economic actors in the market – SD ▪ Free and public access to information and decisions of authorities – SD ▪ Prevalence of bribery in administrative offices – SD ▪ Influence peddling and collusion in government procurement – SD
Protection of citizens' life and property from harm	▪ Financial theft (cash, goods, equipment, and machinery) – SD ▪ Theft or unauthorized use of trademarks or intellectual property – SD ▪ Punishable theft (per 100,000 population) – HD ▪ Aggressive encroachment (per 100,000 population) – HD ▪ Property-related harassment (per 100,000 population) – HD ▪ Intentional assault and battery (per 100,000 population) – HD ▪ Number of traffic accidents resulting in death or injury (per 100,000 population) – HD ▪ Insurance penetration rate – HD

3.3) Methods of Ranking Used in the Study

3.3.1) MP-TOPSIS Method

The TOPSIS method is one of the most widely used multi-criteria decision-making approaches, operating based on the calculation of the relative closeness of alternatives to the positive ideal and their distance from the negative ideal. In the MP-TOPSIS model, data from multiple time periods are utilized for ranking, which enhances the accuracy of the analysis. In this method, provinces that have the shortest distance to the positive ideal and the greatest distance from the negative ideal are assigned higher ranks.

a) Construction of the Decision Matrix

In the TOPSIS technique, m alternatives are evaluated based on n criteria. Accordingly, each alternative is assigned a score for each criterion. These scores can be based on quantitative and actual values or on qualitative and subjective assessments. In any case, a m × n decision matrix must be constructed.

b) Normalization of the Decision Matrix

As in other multi-criteria decision-making methods, the decision matrix must be normalized. For normalization, the vector normalization method is used. Unlike the simple linear normalization method, vector normalization is performed as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

c) Construction of the Weighted Normalized Decision Matrix

The next step is to construct the weighted normalized decision matrix based on the criteria weights. Therefore, the weights of the criteria must have been previously determined using appropriate weighting techniques. The weighting process is straightforward: The weight of each criterion is multiplied by the corresponding elements in the decision matrix.

d) Calculation of Positive and Negative Ideals

The subsequent step involves calculating both the positive ideal point (PIP) and the negative ideal point (NIP). In this step, a positive ideal and a negative ideal are determined for each criterion.

- For criteria with positive weights, the positive ideal is the maximum value of that criterion.
- For criteria with positive weights, the negative ideal is the minimum value of that criterion.
- For criteria with negative weights, the positive ideal is the minimum value of that criterion.
- For criteria with negative weights, the negative ideal is the maximum value of that criterion.

e) Distance from Positive and Negative Ideals and Calculation of the Ideal Solution

In this step, the relative proximity of each option to the ideal solution is calculated. The Euclidean distance of each option from the positive and negative ideals is computed using the following formulae:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}$$

f) Calculation of the Ideal Solution

In this step, the relative proximity of each option to the ideal solution is determined. For this, the following formula is used:

$$CC_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

Where :

D_i^+: Distance of option i from the positive ideal

D_i^-: Distance of option iii from the negative ideal

CC_i : Relative proximity of option iii to the positive ideal

In this formula, by calculating the distance of the desired value from the positive and negative ideal values and comparing this value with other options, the ranking of this option is determined.

2-3-3 MULTI-MOORA Method

MULTI-MOORA is a powerful multi-criteria decision-making method that includes three approaches:

- System ratio approach: Comparing criteria using ratios of different values.
- Reference point approach: Using a reference value as a scale to measure other options.
- Complete multiplicative approach: Using the product of values to obtain an optimal ranking.

Steps of the MULTI-MOORA Method

a) Decision Matrix Formation

The decision matrix for this method is formed with criteria in columns and options in rows.

b) Decision Matrix Normalization

For normalization, the following relation is used:

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{m} x_{ij}^2}}$$

c) Ranking Options Based on the System Ratio Approach

In this step, options are ranked based on the system ratio approach using the following relations:

$$y_j^* = \sum_{i=1}^{i=g} w_j x_{ij}^* - \sum_{i=g+1}^{i=n} w_j x_{ij}^*$$

where g includes the positive criteria, and $g+1$ includes the negative criteria.

d) Ranking Options Based on the Reference Point Approach In this step, a reference point is first determined for each criterion. The reference point for positive criteria is the maximum value, while it is the minimum value for negative criteria. Mathematically, this is expressed as:

$$\mathrm{r_i} = \max_{\mathrm{j}} w_j \mathrm{x_j^*} \text{ for objectives to be maximized,}$$
$$\mathrm{r_i} = \min_{\mathrm{j}} w_j \mathrm{x_j^*} \text{ for objectives to be minimized,}$$

The ranking of options in the reference point approach is derived using the following formula:

$$\min_j \{\max_i | w_j r_i - w_j x_{ij}^* |$$

Here, we select the maximum d_{ij} in the row of options; from these values, the smallest one is subsequently chosen as the best option.

e) Ranking Options Based on the Complete Multiplicative Approach

Using the following formula, the complete multiplicative index is calculated, and based on this, the options are ranked:

$$U_i = \frac{\Pi_{j=1}^{g}\left(w_j x_{ij}^*\right)}{\Pi_{j=g+1}^{n}\left(w_j x_{ij}^*\right)}$$

where g includes the positive criteria, and $g+1$ includes the negative criteria.

f) Dominance Theory

According to the principles of cardinal and ordinal numbers, as well as the Kendall and Gibbons theory, performing algebraic operations with cardinal numbers in the space of ordinal numbers is not possible. These numbers can only be transformed into another type of ordinal numbers. The advantage of dominance theory is that all problem-solving steps are carried out in the space of ordinal numbers. Dominance occurs when the rank of one option dominates the ranks of others. General dominance occurs when two out of three rankings of an option dominate others. For example, "d-a-a" dominates "c-b-b" because transitivity holds in this theory: if a dominates b, and b dominates c, then a will dominate c. These rules are applied in all three ranking methods of the MULTI-MOORA technique, and the final ranking is provided.

3.4) Determining Weights of Indicators

In this research, three methods are used to determine the weights of indicators, and the Analytic Hierarchy Process (AHP) is employed to determine the weight of each period (year):

- MEREC Method: Based on the technique of eliminating indicators in multiple stages to determine the importance (weight) of these indicators (Keshavarz-Ghorabaee et al., 2021).
- Shannon Entropy Method: This method performs weighting based on the level of data variability (Ayan et al., 2023).

- CRITIC Method: This method is based on the correlation between criteria and statistical information (Ayan et al., 2023).
- AHP Method: In this method, options are compared in pairs to assess their relative priorities and preferences (Ayan et al., 2023).

3.5) Evaluation of the Proposed Model's Performance

To evaluate the accuracy of the proposed model in this study, two indicators—mean absolute deviation (MAD) and mean relative deviation (MRD)—were initially used. Then, the correlation between the two proposed methods was calculated. This process determines the accuracy and predictive capability of the model. The calculated values for these three criteria show that the proposed model has high accuracy in ranking provinces.

MAD and MRD values are derived using following formulae:

$$MAD = \frac{1}{n}\sum_{i=1}^{n} |A_i - F_i|$$

$$MRD = \frac{1}{n}\sum_{i=1}^{n} \frac{|A_i - F_i|}{A_i}$$

Where :

A_i : Actual value of the data for option i

F_i : Predicted value of the data for option i

The correlation between ranking methods can be Calculated using following formula:

$$r = \frac{n\sum(X_iY_i) - \sum X_i \sum Y_I}{\sqrt{\left[n\sum X_i^2 - (\sum X_i)^2\right]\left[n\sum Y_i^2 - (\sum Y_i)^2\right]}}$$

Where :

X_i: Rank of province i obtained through MP-TOPSIS method

Y_i : Rank of province i obtained through MULTI-MOORA method

n : Number of provinces

3.6) Cluster Analysis

In this study, the K-Means method was used for cluster analysis to group the provinces based on their investment security data. The data matrix includes the normalized scores of selected investment security indicators for the 2021–2023 period, and the similarity between provinces is measured using Euclidean distance in multi-criteria space. The optimal number of clusters is determined using the Elbow Method, as described in section 3.۷. After determining the optimal value of K and executing the K-Means algorithm, the provinces were classified into several relatively homogeneous groups in terms of investment security characteristics. The final results of this clustering and the composition of each cluster are detailed in Tables 4 to 6 and section 4.3.

3.7) Elbow Method

One of the main challenges in clustering is determining the appropriate number of clusters. This number varies depending on the data and the clustering objective, and it can have a significant impact on the final quality of clustering. Incorrectly determining the number of clusters can lead to inappropriate results, with clusters being too large or too small, which may result in important information being lost or analysis becoming ineffective.

To obtain the optimal cluster size (K), the Elbow Method can be used. In this method, an elbow plot is first drawn. The plot of the elbow method shows the sum of squared distances within clusters (WCSS) as a function of the number of clusters. In this plot, the horizontal axis represents the number

of clusters, and the vertical axis represents the WCSS value. The "elbow" point is the point where the reduction in WCSS becomes less steep. In other words, it is where the curve changes from rapidly decreasing WCSS to gradually decreasing WCSS. This point indicates that adding more clusters does not significantly reduce WCSS. Therefore, the ideal number of clusters is indicated by this point.

$$WCSS = \sum_{i=1}^{K} \sum_{x \in C_i} (x - \mu_i)^2$$

Where :

K: Number of clusters

C_i: Cluster i

x: Score of the data in cluster C_i

μ_i: Centroid of the cluster C_i

4) Findings

This section presents the results obtained from the MP-TOPSIS and MULTI-MOORA methods, and the ranking of provinces based on investment security is examined. Additionally, the findings related to the impact of key investment security indicators are analyzed, and comparative charts between the multi-criteria decision-making methods are provided.

4.1) Province Ranking Results

4.1.1) Final Ranking Results of Options Using the Multi-MOORA Method with Weighting Methods: MERK, Entropy, and Critic

In Table 2, the results of the Multi-MOORA ranking method using weights obtained from the MERK, Entropy, and Critic methods can be observed.

4.1.2) Final Ranking Results of Options Using the TOPSIS Method with Weighting Methods: MERK, Entropy, and Critic

In Table 3, the results of the TOPSIS ranking method using weights obtained from the MERK, Entropy, and Critic methods can be observed.

4.2) Sensitivity Analysis

After obtaining the ranking results from both the TOPSIS and Multi-MOORA methods with different weights, these results were compared to identify the differences and similarities between them.

In this study, provinces were ranked using the two methods MP-TOPSIS and MULTI-MOORA, and their results were compared. This comparison was aimed at determining the stability of the results and the degree of correlation between the two methods. Some key findings are as follows:

- The MP-TOPSIS method performed better in identifying provinces with stable investment security trends.
- The MULTI-MOORA method showed better performance in cases where different indicators had varying and changing weights.

The correlation between the results of these two methods was approximately 87%, indicating a high similarity in the ranking of the provinces.

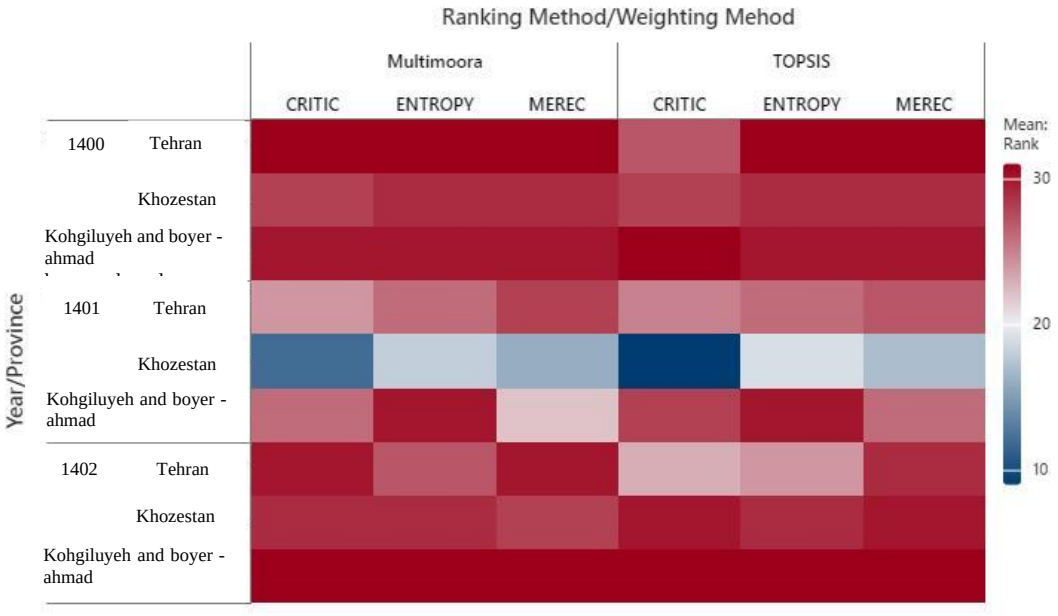

Figure 2. Heatmap of the Least Desirable Provinces

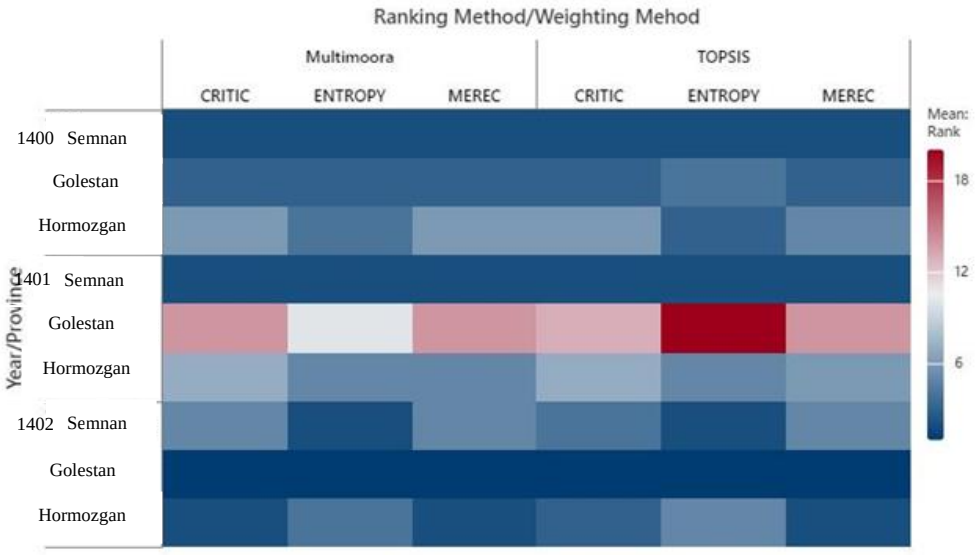

Figure 3. Heatmap of the Most Desirable Provinces

Additionally, after creating the heatmaps for the most and least desirable provinces (Figures 2 and 3), it was observed that the ranking results for these provinces from the two methods, TOPSIS and MULTI-MOORA, with different weights, did not differ significantly over the time period from 2021 to 2023, and remained relatively stable and consistent.

4.3) Priodic Clustering of Provinces

After ranking the provinces using the TOPSIS and MULTI-MOORA methods based on investment security indicators, the ideal number of clusters was first determined using the Elbow method. Then, using the K-means method, the provinces were grouped into homogeneous clusters.

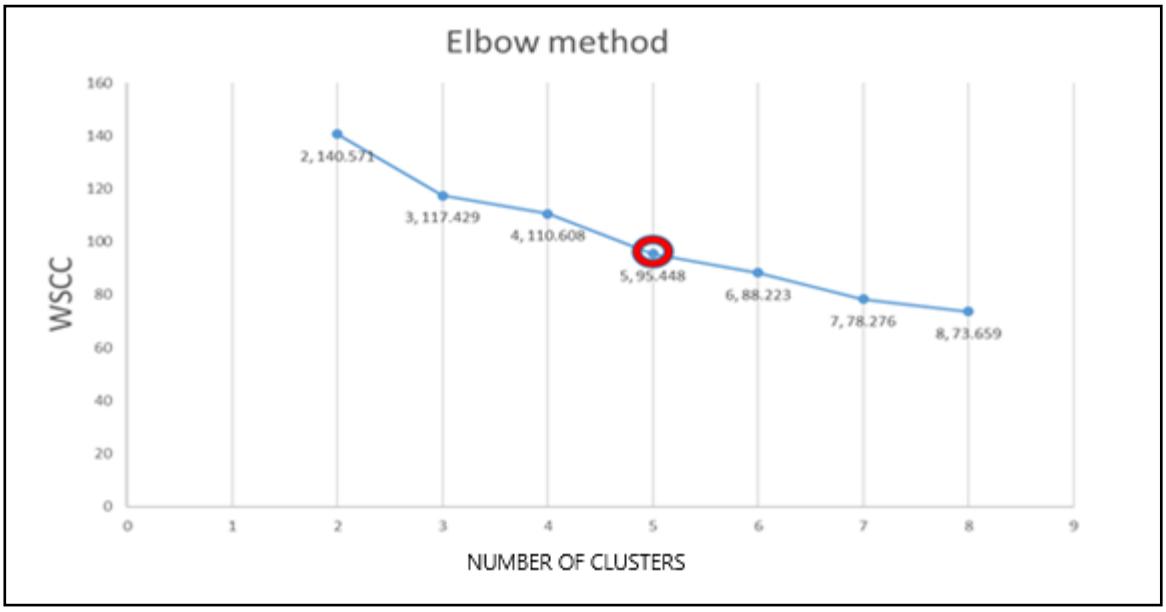

Figure 4. The Elbow Method to Determine Optimal Number of Clusters

Based on Figure 4, the desired value for the number of clusters in this study is five. According to the criteria for determining the number of clusters, five clusters were chosen. The clustering order for the 2021–2023 period is as follows:

Cluster 1 as "the least desirable," Cluster 2 as "the most desirable," Cluster 3 as "average," Cluster 4 as "relatively desirable," and Cluster 5 as "relatively undesirable." (Additionally, the distances of the criteria have been normalized).

According to the results obtained from cluster analysis of the provinces and comparing these results with the rankings of the period based on the TOPSIS and MULTI-MOORA methods, the best and worst indicators for each cluster, based on the provinces within each cluster, were identified, as presented in Table 4.

Based on Tables 4, 5, and 6, the results of the clustering of the provinces are as follows: Cluster 1: East Azerbaijan, Tehran, and Khuzestan

Cluster 2: West Azerbaijan, South Khorasan, North Khorasan, Semnan, Kerman, Golestan, Markazi, Hormozgan

Cluster 3: Ardabil, Busherhr, Razavi Khorasan, Sistan and Baluchistan , Fars, Kermanshah,

Kohgiluyeh and Boyer-Ahmad, Gilan, Lorestan, Hamedan

Cluster 4: Isfahan, Mazandaran, Yazd

Cluster 5: Alborz, Chaharmahal and Bakhtiari, Zanjan, Qazvin, Qom, Kurdistan, Ilam

4.4) Results from Periodic Ranking Using the TOPSIS and MULTI-MOORA Methods

In this part of the research, an effort was made to apply the TOPSIS and MULTI-MOORA methods to rank the provinces periodically in terms of investment security and compare the results obtained from the two methods. It is noteworthy that the periodic weights of each criterion were obtained using the average weights derived from the Merk method and the weight of each period (year) based on the Analytic Hierarchy Process (AHP) pairwise comparison method.

According to the results obtained from the MP-TOPSIS method, the provinces of the country were ranked in terms of investment security for the period 2021–2023. The findings showed that the provinces of Semnan, Golestan, and Hormozgan ranked at the top in the investment security ranking and are considered the safest regions for attracting investment. In contrast, the provinces of Tehran, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad ranked the lowest due to economic, social, and infrastructural challenges. Additionally, an analysis of the trend changes during this three-year period revealed that provinces such as Yazd and Chaharmahal and Bakhtiari showed relative stability in investment security, whereas provinces such as Isfahan and Alborz experienced significant fluctuations in this index.

The results from the MULTI-MOORA method showed that the provinces of Semnan, Golestan, and Hormozgan still ranked highest in investment security, although their order slightly changed compared to the MP-TOPSIS method. In contrast, the provinces of Tehran, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad, due to severe economic fluctuations and infrastructural challenges, obtained the lowest rankings. Additionally, some provinces such as Gilan and Kurdistan performed better in the MULTI-MOORA method compared to MP-TOPSIS. To evaluate the alignment of the results from these two methods, the correlation coefficient between them was calculated, and the findings showed that the correlation coefficient was 87%, indicating a high degree of agreement between the results of the two methods. Although slight differences were observed in the ranking of some provinces, the overall results were similar and confirmable. Provinces that ranked higher in both methods were identified as provinces with higher investment security.

It should also be noted that despite the high economic capacity of Tehran as the capital of the country, according to quarterly and annual statistics published by the Research Center of the Islamic Consultative Assembly, Tehran has unfortunately performed highly weakly in some investment security indicators, such as government performance, administrative transparency, and property rights assurance. Since these indicators, after applying different weighting methods, always hold significant weights and are essential in determining investment security, we observe that Tehran ranks low in investment security.

4.5. Evaluation of the Proposed Model's Performance and Temporal Trend Analysis of Provincial Investment Security

In this section, two main aspects are evaluated to assess the reliability of the findings: within-model validation and the temporal stability of the provincial ranking results. The aim is to show that first, the results are not merely a product of one specific multi-criteria decision-making method and have good internal consistency; second, the observed pattern for the provinces, including Semnan, is not a result of an exceptional year but is consistent over the three-year study period.

A) Within-Model Validation of the Model

In the first step, to validate the model internally, the results of the MP-TOPSIS and MULTI-MOORA methods were compared. For this purpose, the average absolute deviation (MAD) and the average relative deviation (MRD) between the ranks of the two methods were calculated. The low values of these indices indicated that the rank differences were at an acceptable level, and provinces that ranked higher or lower in one method mostly remained in the same categories in the other method as well.

Additionally, the Pearson correlation coefficient between the final rankings from the two methods was approximately 0.87, showing a high level of alignment and consistency in the results. This high correlation suggests that the change in the computational logic from MP-TOPSIS to MULTI-MOORA does not fundamentally alter the overall ranking structure, and therefore, the multi-criteria decision-making model used can be considered internally reliable and robust. In other words, the difference in the aggregation and normalization methods results in limited shifts in provincial rankings, while the overall pattern distinguishing provinces with higher and lower investment security remains intact.

B) Temporal Stability of the Results and Three-Year Trend Analysis of the Provinces

In the second step, the temporal stability of the results over the three-year period of 2021–2023 was examined. To do so, the rank of each province was calculated separately for each year, and the trend of changes was analyzed. The results showed that provinces like Semnan, Golestan, and Hormozgan consistently ranked among the provinces with higher investment security over all three years, experiencing only minor shifts within this group. In contrast, provinces such as Tehran, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad were generally ranked in the lower half of the table in most years. This pattern indicates a relative three-year stability in the investment security status of the provinces, suggesting that the research results reflect not only a snapshot of a single year but a broader, more consistent trend.

A closer examination of the provincial ranking trends reveals that distinct temporal patterns can be identified among the provinces. A group of provinces, including Semnan, Golestan, and Hormozgan, remained in the higher rankings in all the studied years, experiencing only slight shifts within this category. This group can be categorized as provinces with "high and relatively stable investment security." In contrast, provinces such as Tehran, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad consistently ranked in the lower half, classifying them as provinces with "low and relatively stable investment security."

Along with these two groups, several provinces showed a pattern of "relative improvement" or "mid-range fluctuations," meaning they moved from middle ranks to higher ones over the three-year period or experienced occasional improvements and slight declines in certain years, without being consistently ranked very high or very low. These patterns indicate that investment security at the provincial level not only behaves differently over time but also reveals meaningful trends that offer a more comprehensive picture of stability or fragility in investment conditions.

However, it is important to emphasize that the model presented in this study is essentially a descriptive-analytical model based on past and present data, and its function is to evaluate the investment security status during the study period, not to predict future years with certainty. For example, Semnan's position among the provinces with the highest investment security for three consecutive years reflects its good and relatively stable performance during 2021 to 2023; however, the continuation of this situation in future years depends on the sustainability of institutional, economic, and social conditions, and the exact continuation of this security level cannot be guaranteed solely based on this model. Therefore, the results of this study should be used as an important scientific input, alongside other complementary information, up-to-date analyses, and continuous monitoring of indicators, by policymakers and investors in decision-making, considering potential future scenarios and possible changes in the institutional and economic environment.

5) Conclusion and suggestions

Based on the analysis of the data obtained, economic stability was identified as the most important factor affecting investment security at the provincial level of the country. The ranking results showed that Semnan, Golestan, and Hormozgan provinces had the highest level of investment security, while Tehran, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad provinces had the lowest scores. it was also found that the three components of economic stability, political and social risks, and legal transparency play the greatest role in determining the level of investment security.

Examining the correlation between the two multi-criteria decision-making methods, MP-TOPSIS and MULTI-MOORA, also indicated a high correlation (87 percent) between the results of these two methods, which confirms the validity and reliability of the rankings.

Furthermore, analysis of the trend of changes in investment security over the past three years showed that some provinces such as Semnan and Golestan have enjoyed a relatively stable situation, while provinces such as Alborz and Isfahan have experienced significant fluctuations. Comparing the results of this research with similar domestic and foreign studies indicates that domestic research has mainly focused on economic and social indicators. However, this research, in addition to paying attention to these indicators, has used multi-criteria decision-making methods and correlation analysis between methods. On the other hand, foreign studies have often used methods such as PROMETHEE

and ELECTRE, while in this research, MP-TOPSIS and MULTI-MOORA methods were used, which have higher accuracy in multi-period analyses. Moreover, comparison with international reports showed that provinces with stronger legal and economic infrastructure typically enjoy a higher level of investment security.

Based on the findings of this study, a set of policy measures is proposed to enhance investment security at the provincial level across the country. First, strengthening economic stability at the provincial level by controlling fluctuations in exchange rates, inflation rates, and raw material prices, especially in provinces where low investment security rankings is presented as a fundamental strategy for reducing investors' perceived risks. Second, enhancing transparency and integrity in the administrative system by combating corruption, increasing transparency in decision-making processes, and providing free access to information for economic actors which lays the groundwork for improving the investment climate. Third, reforming the judicial and law enforcement structures related to economic activities, including expediting the resolution of disputes, specializing judicial bodies, and enhancing the efficiency of court enforcement, plays a significant role in boosting investor confidence. Fourth, stabilizing local laws and procedures with the goal of creating transparent, predictable, and non-interpretive legal frameworks will reduce economic uncertainty. Fifth, special attention is recommended for provinces with low levels of investment security through supportive policies, such as tax exemptions, insurance incentives, and the development of economic and administrative infrastructure, particularly in provinces such as Tehran, Sistan and Baluchestan, and Kohgiluyeh and Boyer-Ahmad. Sixth, establishing regular, multi-criteria investment security monitoring systems at the provincial level enables the formulation of more precise and targeted policies. Seventh, developing a culture of good faith and social trust in the market through the institutionalization of professional ethics, honesty, and adherence to contractual commitments among economic actors and government managers is considered essential. Eighth, the formulation of regional policies tailored to the functional clustering of provinces, through the use of cluster analysis results, can lead to the optimal allocation of resources and the enhancement of the effectiveness of development policies.

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Appendix

Table 2. Sensitivity Analysis of MULTI-MOORA Rankings under Different Weighting Schemes (MEREC, Entropy, and CRITIC)

Options	Rankings of 2021			Rankings of 2022			Rankings of 2023		
	Multi Moora / Merec	Multi Moora / Entropy	Multi Moora / Critic	Multi Moora / Merec	Multi Moora / Entropy	Multi Moora / Critic	Multi Moora / Merec	Multi Moora / Entropy	Multi Moora / Critic
East Azerbaijan	۲۸	۲۸	۲۹	۲۱	۱۷	۱۶	۲۰	۱۷	۱۸
West Azerbaijan	۱۷	۱۲	۲	۶	۶	۵	۱۰	۱۰	۱۰
Ardabil	۱۲	۱۱	۱۳	۱۳	۱۳	۱۳	۲۱	۲۰	۱۹
Isfahan	۱۸	۱۷	۲۷	۱۷	۲۴	۲۱	۱۴	۱۶	۱۵
Alborz	۲۷	۲۷	۲۶	۲۵	۲۲	۲۵	۲۳	۱۹	۲۸
Ilam	۲۶	۲۶	۲۵	۲۹	۲۰	۲۹	۲۲	۳۰	۲۷
Bushehr	۱۴	۱۳	۱۴	۲۰	۱۹	۱۸	۱۷	۱۸	۱۷

Tehran	۳۱	۳۱	۳۱	۲۸	۲۶	۲۴	۳۰	۲۷	۳۰
Chaharmahal and	۲۵	۲۵	۱۸	۲۷	۱۱	۲۷	۲۷	۲۵	۲۲
South Khorasan	۱	۱	۱	۱	۱	۱	۸	۶	۸
Razavi Khorasan	۱۶	۱۸	۱۶	۱۵	۱۶	۲۰	۱۱	۱۱	۱۳
North Khorasan	۸	۸	۹	۱۵	۱۵	۱۵	۶	۷	۶
khozestan	۲۹	۲۹	۲۸	۱۶	۱۸	۱۲	۲۸	۲۹	۲۹
Zanjan	۲۳	۲۳	۲۳	۲۶	۲۵	۲۸	۱۲	۱۴	۱۱
Semnan	۲	۲	۲	۲	۲	۲	۵	۲	۵
Sistan and Baluchistan	۱۰	۹	۱	۳۱	۳۱	۳۱	۲۶	۲۸	۲۶
Fars	۲۴	۲۰	۲۴	۱۹	۱۵	۹	۹	۸	۹
Qazvin	۷	۱۰	۷	۳	۳	۳	۲۴	۲۴	۲۳
Qom	۱۳	۱۴	۱۰	۱۸	۱۴	۱۹	۲۵	۲۱	۲۱
Kordestan	۱۹	۲۲	۱۷	۱۱	۲۷	۱۰	۱۸	۲۶	۲۴
Kerman	۵	۶	۵	۴	۴	۴	۴	۵	۴
Kermanshah	۲۱	۱۹	۲۱	۳۰	۲۹	۳۰	۱۶	۱۵	۱۶
Kohgiluyeh and Boyer	۳۰	۳۰	۳۰	۲۲	۳۰	۲۶	۳۱	۳۱	۳۱
Golestan	۳	۳	۳	۱۴	۱۰	۱۴	۱	۱	۱
Gilan	۲۲	۲۴	۱۹	۲۴	۲۱	۲۲	۱۹	۲۲	۲۰
Lorestan	۲۰	۲۱	۲۰	۱۰	۹	۱۱	۲۹	۲۳	۲۵
Mazandaran	۱۱	۱۵	۱۲	۸	۸	۸	۷	۹	۷
Markazi	۱۵	۱۶	۱۵	۹	۲۸	۱۷	۱۵	۱۲	۱۴
Hormozgan	۶	۴	۶	۵	۵	۷	۲	۴	۲
Hamedan	۹	۷	۸	۲۳	۲۳	۲۳	۱۳	۱۳	۱۲

Yazd	۴	۵	۴	۷	۷	۶	۳	۳	۳

Table 3. Sensitivity Analysis of TOPSIS Rankings under Different Weighting Schemes (MEREC, Entropy, and CRITIC)

Options	Rankings of 2021			Rankings of 2022			Rankings of 2023		
	TOPSIS / Merec	TOPSIS / Entropy	TOPSIS / Critic	TOPSIS / Merec	TOPSIS / Entropy	TOPSIS / Critic	TOPSIS / Merec	TOPSIS / Entropy	TOPSIS / Critic
East Azerbaijan	۲۸	۲۶	۳۰	۱۸	۱۳	۱۴	۱۸	۱۶	۱۶
West Azerbaijan	۱۵	۱۰	۱۸	۵	۳	۵	۱۰	۱۵	۱۱
Ardabil	۱۲	۱۳	۱۳	۱۱	۱۷	۱۵	۱۹	۲۰	۱۹
Isfahan	۱۸	۱۷	۲۲	۲۱	۲۳	۲۳	۱۵	۱۸	۱۵
Alborz	۲۷	۲۷	۲۴	۲۲	۷	۱۹	۲۱	۱۹	۲۱
Ilam	۲۶	۲۸	۲۹	۲۹	۲۴	۲۷	۲۳	۳۰	۲۹
Bushehr	۱۱	۱۲	۱۴	۲۳	۲۱	۱۷	۱۷	۲۲	۱۷
Tehran	۳۱	۳۱	۲۷	۲۷	۲۶	۲۵	۲۹	۲۴	۲۳
Chaharmahal and Bakhtiari	۲۵	۲۴	۲۵	۲۸	۲۹	۲۹	۲۵	۱۳	۲۲
South Khorasan	۱	۱	۱	۱	۱	۱	۸	۴	۶
Razavi Khorasan	۱۷	۲۱	۱۶	۱۹	۲۸	۲۲	۱۱	۱۰	۱۰
North Khorasan	۸	۱۱	۹	۱۲	۱۴	۱۸	۶	۸	۹
khozestan	۲۹	۲۹	۲۸	۱۷	۱۹	۹	۳۰	۲۹	۳۰
Zanjan	۲۲	۱۴	۲۳	۲۴	۱۲	۲۶	۱۳	۱۷	۱۴

Semnan	۲	۲	۲	۲	۲	۲	۵	۲	۴
Sistan and Baluchistan	۱۰	۸	۱۱	۳۱	۳۱	۳۱	۲۷	۲۸	۲۸
Fars	۲۳	۱۶	۲۶	۱۶	۱۵	۱۱	۹	۷	۷
Qazvin	۹	۹	۸	۳	۴	۳	۲۶	۲۶	۲۶
Qom	۱۳	۱۵	۱۰	۱۵	۱۱	۱۶	۲۴	۲۱	۲۰
Kordestan	۲۱	۲۳	۱۹	۱۰	۱۶	۱۲	۲۰	۲۷	۲۷
Kerman	۶	۶	۵	۴	۶	۴	۳	۶	۵
Kermanshah	۲۰	۱۹	۲۱	۳۰	۲۲	۳۰	۱۶	۱۴	۱۸
Kohgiluyeh and Boyer–Ahmad	۳۰	۳۰	۳۱	۲۶	۳۰	۲۸	۳۱	۳۱	۳۱
Golestan	۳	۴	۳	۱۴	۲۰	۱۳	۱	۱	۱
Gilan	۲۴	۲۵	۱۷	۲۰	۱۸	۲۰	۲۲	۲۵	۲۵
Lorestan	۱۹	۲۲	۲۰	۹	۹	۱۰	۲۸	۲۳	۲۴
Mazandaran	۱۴	۱۸	۱۲	۸	۱۰	۸	۷	۱۲	۸
Markazi	۱۶	۲۰	۱۵	۱۳	۲۷	۲۱	۱۴	۹	۱۳
Hormozgan	۵	۳	۶	۶	۵	۷	۲	۵	۳
Hamedan	۷	۷	۷	۲۵	۲۵	۲۴	۱۲	۱۱	۱۲
Yazd	۴	۵	۴	۷	۸	۶	۴	۳	۲

Table 4. Best and Worst Criteria in Each Cluster

Ci	Best criterion	Worst criterion
C1	Macroeconomic stability	Administrative transparency and integrity
C2	Protection of citizens' life and property from harm	Macroeconomic stability
C3	Culture of honoring commitments, integrity, and honesty	government performance
C4	Macroeconomic stability	Culture of honoring commitments, integrity, and honesty
C5	government performance	Macroeconomic stability

Table 5 . Center of Clusters

Indicators	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	General cluster
Government performance	0.7827	-0.5121	0.7832	-1.1289	-0.3853	0.0000
Macroeconomic stability	-0.6548	-0.2709	0.3135	-1.5004	0.7653	0.0000
Definition and protection of property rights	0.9980	-0.9142	0.6443	-0.8731	0.0709	0.0000
Culture of honoring commitments, integrity, and honesty	1.2275	-1.612	-0.1845	0.9821	0.5151	0.0000
Stability and predictability of regulations and implementation procedures	0.7361	-0.9186	0.4737	-1.1852	0.5657	0.0000
Administrative transparency and integrity	1.9771	-0.9339	0.0460	-0.0840	0.1903	0.0000
Protection of citizens' life and property from harm	0.7301	-1.1018	0.4575	-0.2933	0.4184	0.0000

Table 6 . Clustering Information

Clusters	Number of observations	Sum of squares within the cluster	Mean distance to cluster center	Maximum distance to cluster center
Cluster 1	3	8.524	1.670	1.975

Cluster 2	8	30.938	1.946	2.437
Cluster 3	10	24.974	1.481	2.534
Cluster ۴	3	8.260	1.626	1.899
Cluster ۵	7	22.572	1.722	2.489

Table 7. Periodic Ranking of Options

Options	Periodic Rankings of 2021-2023	
	TOPSIS	MULTI-MOORA
East Azerbaijan	19	22
West Azerbaijan	9	9
Ardabil	18	19
Isfahan	15	15
Alborz	24	25
Ilam	29	27
Bushehr	17	17
Tehran	28	31
Chaharmahal and Bakhtiari	26	28
South Khorasan	5	6
Razavi Khorasan	11	13
North Khorasan	7	7
Khozestan	27	26
Zanjan	16	16
Semnan	1	2

Sistan and Baluchistan	30	29
Fars	10	10
Qazvin	13	12
Qom	21	23
Kordestan	22	18
Kerman	4	4
Kermanshah	20	20
Kohgiluyeh and Boyer−Ahmad	31	30
Golestan	2	3
Gilan	25	21
Lorestan	23	24
Mazandaran	8	8
Markazi	12	11
Hormozgan	3	1
Hamedan	14	14
Yazd	6	5