An approach to islamic investment decision making based on integrated Entropy and WASPAS methods

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Keywords
MCDM, Entropy, Waspas, Islamic investment

Abstract
When investing in companies or indexes there is a high chance that some of these are not in accordance with Islamic principles which is a major source of confusion for many Muslims around the world. Since we cannot expect the general public to be well versed in the world of financial management, most of the information online is simple and can leave crucial information out, such as whether it includes things like interest or companies that deal with interest/sell alcohol. Investing in such companies is not allowed for Muslims and that's why it's important for Muslims to do the thorough research when engaging in investment matters. Fortunately, in recent years, Islamic investment opportunities have resurfaced with the increased development of Muslim majority countries and there is a variety of options Muslims can choose from when investing, such as, sukuks which are a type of bonds, certain regulated ETF's and more. Therefore it's important to use decision making methods when choosing which trades to make that are in accordance with Islamic financial management principles. This study will use the Entropy method to obtain the weights of the criteria and use the WASPAS method to rank the top investment decision, which in this case was A_5.

Research Article
Submission Date : 30.09.2022
Accepted Date : 10.12.2022

1. Introduction

The increase in Internet usage across the world has led to people accessing more and more information every day. Five out of ten news searches on Google in 2021 alone were investment related searches. ("Google's Year in Search", 2022) This shows that with the information that's available and accessible on the internet people are continuously looking for ways to generate an income stream. Looking at the searches alone we see that it's about three different ways, or better said, trades that people can make e.g. owning a stock or cryptocurrency. This shows that people are looking for a variety of options to choose from when it comes to investing their capital. However, for people of the Islamic faith, some of these options might not be appropriate due to some rules and regulations within the religion e.g. that interest and dealing with interest and owning stock of companies that sell alcohol is considered a sin.

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Although these rules restrict Muslims from investing freely on whatever they want, it still leaves a lot of choices to choose from e.g. stocks of companies that don't deal with interests or a savings account in an Islamic bank. There are many methods of choosing a type of investment since there are a lot of criteria related within the decision making process. Investments themselves are divided into many different types. Multi-Criteria Decision-Making (MCDM) techniques are often used to help scientists choose the ideal solution. MCDM methods in itself can be divided into two groups: methods used in weighting such as ENTROPI, CRITIC, and SWARA, etc. and methods used in classification such as TOPSIS, COPRAS, and WASPAS etc. (Yazgan & Agamyradova, 2021)

The methods can be used to assess risk and return of investment strategy in addition to portfolio selection. The article is written in a simple language which makes it accessible to the readers outside finance field, as well as the Islamic scholars who are not familiar with financial theory. I believe that this paper will make a contribution to bridging the gap between theoretical finance literature and its application in practice.

This study will focus on certain types of investments that are permissible in accordance with the Islamic faith. First, this study will examine literature on both ENTROPI and WASPAS MCDM's. Consequently, this study will give a layout of the methodology of both MCDM's and finally discuss the results of the methods and present recommendations for future research.

2. Literature Review

The entropy method has found a wide application area in the literature as it provides an objective evaluation of the criteria. When looked at databases of peer-reviewed publications, studies in various fields from environmental management to health, from logistics to production planning can be seen in the last several years.

The entropy method alone can form the basis of the solution presented in the studies, or it provides input to these methods by using it together with other multi-criteria decision making methods. When we look at the types of problems in the field of environmental management, which are most widely used in the literature, decision problems such as investigating the environmental effects of certain man-made structures (Darvishi et al., 2020), evaluating the planning and management programs of rivers arise. basins (RazaviToosi & Samani, 2019), by choosing a policy to limit carbon emissions of administrative regions (Feng, Tang, Niu & Wu, 2018). is seen. The Entropy method was used to weight the criteria considered in these studies and to objectively evaluate the opinions of the experts consulted. Studies in the field of logistics are more focused on the problem of choosing the appropriate supplier. This selection problem has been applied in various supply chains such as solar power generation (Pérez-Velázquez, Oro-Carralero & Moya-Rodríguez, 2020), imported service (Cheng, Yang, Akella & Tang, 2011). In addition, Entropy is used to rank criteria in other types of problems in logistics, such as the selection of distribution centers (Wu, Xu & Xu, 2015). There are studies in which Entropy is used in site selection problems, which is a similar field of study. Olympic facility location selection in Turkey (Karaca, Ulutaş, Yamaner & Topal, 2019) can be given as an example of this problem.

Apart from the main application areas given above, there are also decision problems in which the Entropy method is used in different areas. The problem of evaluation of mobile services to be used in preventive health studies in the field of health (Noee, Akbari Sari, Olyaeemanesh & Mobinizadeh, 2020), the problem of portfolio management where listed cement companies are evaluated in the field of finance (Çakır, 2016), and the problem of evaluating and ranking the engineering faculty performances of 16 universities in India (Ranjan, Chatterjee & Chakraborty, 2014). These can be given as examples of different field applications. In the articles examined in the literature, spreadsheet programs such as Microsoft Office Excel are mostly used in the solution of the method.

3. Methodology

3.1 Entropy method

The entropy method reaches the solution in 5 steps. Since there is a connection and integrity between the steps, it is not possible to move on to the next before the processes related to one step are completed. The entropy method consists of the following steps, starting with the creation of the decision matrix in all MCDM problems (White, Hwang & Yoon, 1982).

Step 1: Creation of the decision matrix

In the entropy method, first of all, a decision matrix (D) containing the values of the criteria used on the basis of the alternatives is created. In the decision matrix, m is the number of alternatives, n is the number of criteria, x_{ij} represents the i. alternative as the value of the criterion j.

$$D = \begin{bmatrix} x_{11} & x_{12} \cdots x_{1n} \\ x_{21} & x_{22} \cdots x_{2n} \\ \vdots & \vdots \quad \cdots \quad \vdots \\ x_{m1} & x_{m2} \quad\; x_{mn} \end{bmatrix} \tag{1}$$

Step 2: Creating the normalized decision matrix

In this step, the values given in the decision matrix are normalized. At this stage, the normalized decision matrix is calculated by equation (2).

p_{ij} represents the i. alternative as the normalized value of the criterion j.

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \forall i, j \tag{2}$$

Normalized decision matrix ($[P]_{m*n}$) is obtained as a result of normalization for each value with equation (2).

$$P = \begin{bmatrix} p_{11} & p_{12} \cdots p_{1n} \\ p_{21} & p_{22} \cdots p_{2n} \\ \vdots & \vdots \cdots \vdots \\ p_{m1} & p_{m2} \quad p_{mn} \end{bmatrix} \quad (3)$$

Step 3: Finding the entropy values for the criteria

In this step, the Entropy values (E_j) of the criteria are found with the help of Equation (4)

$$E_j = -k \sum_{i=1}^{m} p_{ij} ln p_{ij}, \forall j \quad (4)$$

The k in the equation is a coefficient and is expressed as k = 1/ln m and guarantees $0 \leq E_j \leq 1$.

Step 4: Calculate the degree of differentiation of information (d_j)

In this step, the degree of differentiation of information (d_j) is found with the help of Equation (5). The high degree of differentiation (d_j) values of the information indicates that the distance or differentiation between alternative results regarding the criteria is high.

$$d_j = 1 - E_j, \forall j \quad (5)$$

Step 5: Calculating criterion weights

In this step, if the decision maker prefers one criterion over the other, the best expected weight values are determined by using Equation (6).

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}, \forall j \quad (6)$$

In the equation w; value refers to the weight values, which are the indicators of the importance levels of the criteria. The sum of the entropy probability values is always equal to 1 (Equation (7)).

$$w_1 + w_2 + \cdots + w_n = 1 \quad (7)$$

After determining the weight of the criteria we can work on the WASPAS method.

3.2 WASPAS method

WASPAS is a benefit identification approach introduced by Zavadskas, Turskis, Antucheviciene, and Zakarevicius (Zavadskas, Turskis & Antucheviciene, 2012) in 2012. It is proposed by integrating the Weighted Sum Model and the Weighted Product Model. The method consists of 6 steps: (Chakraborty & Zavadskas, 2014)

Step 1: Identifying alternatives and criteria

Using various sources such as historical data, customer complaints, expert opinions, literature reviews, and management priorities, criteria are determined and alternatives are evaluated.

Step 2: Creating the decision matrix

A decision matrix is created to express the performance of m candidates in terms of n evaluation criteria. x_{ij} indicates the alternative i's score for criterion j.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$$

Step 3: Normalization of the decision matrix

In order to get rid of the effect of unit and value range differences in the criteria values, the normalization process is applied. Therefore, the decision matrix created is normalized depending on whether each criterion is benefit or cost based. If the criterion is benefit based, Equation (8) is used:

$$\bar{x}_{ij} = \frac{x_{ij}}{max_i x_{ij}} \tag{8}$$

If the criterion is cost-based, the normalization is performed using Equation (9):

$$\bar{x}_{ij} = \frac{min_i x_{ij}}{x_{ij}} \tag{9}$$

The values calculated in this step form the normalized decision matrix. The normalized decision matrix is as shown below.

$$\bar{X} = \begin{bmatrix} \bar{x}_{11} & \cdots & \bar{x}_{1n} \\ \vdots & \ddots & \vdots \\ \bar{x}_{m1} & \cdots & \bar{x}_{mn} \end{bmatrix}$$

Step 4: Evaluation by weighted sum method

According to the weighted sum method, the score of each alternative i is calculated according to Equation (10). To show the weight value of the j criterion w_j expresses the evaluation score using $Q^{(1)}_i$ with the i alternative according to the weight-sum method.

$$Q_i^{(1)} = \sum_{j=1}^{n} \bar{x}_{ij} \cdot w_j \tag{10}$$

Step 5: Evaluation with the weighted product method

According to the weighted product method (Zavadskas, Turskis & Antucheviciene, 2012), the overall relative importance of the alternative is calculated by Equation (11). $Q^{(2)}_i$ expresses the evaluation score of the i alternative based on the weighted multiplication method.

$$Q_i^{(2)} = \prod_{j=1}^{n} \bar{x}_{ij}^{\,w_j} \tag{11}$$

Step 6: Integrate the weighted sum and weighted product results

The scores obtained according to the weighted sum and weighted multiplication methods are integrated to form a single value to facilitate decision-making. As a result of the integration, the weighted common criterion value is obtained. The weighted common criterion value of the i alternative is expressed with Q_i and is calculated with the help of the expression given by Equation (12).

$$Q_i = 0{,}5Q_i^1 + 0{,}5Q_i^2 = 0{,}5\sum_{j=1}^{n} \bar{x}_{ij} \cdot w_j + 0{,}5\prod_{j=1}^{n} \bar{x}_{ij}^{\,w_j} \tag{12}$$

Equation (12) is based on the assumption that the results from the weighted sum and weighted multiplication methods are of equal importance. In Equation (6), instead of this assumption, the generalized weighted common criterion score expression, in which the significance level of the weighted sum model is expressed with λ, is presented. Here λ can take values between 0 and 1.

$$Q_i = \lambda Q_i^1 + (1-\lambda)Q_i^2 = \lambda\sum_{j=1}^{n} \bar{x}_{ij} \cdot w_j + (1-\lambda)\prod_{j=1}^{n} \bar{x}_{ij}^{\,w_j} \tag{13}$$

As the value λ approaches 0, the method is similar to the weighted product model, while as it approaches 1, it turns into the weighted sum method.

Step 7: Selection

The alternatives are ranked in descending order according to the weighted common criterion score. As stated in equation (14), the alternative with the highest score is the best alternative. The order of the alternatives is determined according to the score ranking.

$$Q_i^{(*)} = Max(Q_i) \tag{14}$$

4. Application and Results

4.1 Entropy Method Application Stages

This study will use the entropy method to determine the weights of the criteria when investing. The criteria have been chosen according to a group of investors that are engaged in investing and using savings accounts to increase the value of their assets. These criteria as well as alternatives and their tag are shown in Table 1.

Table 1. Criteria used and their tags

Criteria	Tag
Minimum Investments	C1
Profit Rate	C2
Costs (maintenance)	C3
Accessibility	C4
Volatility	C5
Alternatives	
SPUS	A1
HLAL	A2
Emirates	A3
Franklin	A4
KSA	A5
Kuveyt Turk	A6
Ziraat Katilim	A7

Criteria and alternatives used in Table 1 can be described as follows;

- **Minimum Investments:** the minimum amount of money is needed to participate in the investment or open a savings account.
- **Profit Rate:** the average annual return on investment.
- **Costs (maintenance):** the annual fees regarding administration and maintenance costs regarding investment/savings relative to the investment amount.
- **Accessibility:** the availability of the investment product worldwide
- **Volatility:** the risk that comes with investing and the chance of a loss
- **SPUS:** SP Funds S&P 500 Sharia Industry Exclusions ETF
- **WAHD:** Wahed FTSE USA Shariah ETF
- **Emirates:** Emirates REIT Sukuk Limited
- **Franklin:** Franklin Global Sukuk Fund
- **KSA:** Kingdom of Saudi Arabia (KSA) Sukuk Limited
- **Kuveyt Turk:** Islamic Bank
- **Ziraat Katilim:** Islamic Bank

Microsoft Excel has been used for the application of the methods used in this study.

Step 1: Creation of the decision matrix

The decision matrix is displayed in Table 2. The data within the matrix is taken from a brokerage platform (Interactive Brokers) and the information regarding the savings accounts are taken directly from the banks' internet website.

Table 2. Decision Matrix

	C1 c	C2 b	C3 c	C4 b	C5 c
ETF					
A1	30	0,11	0,04	0,2	0,3
A2	50	0,1	0,04	0,2	0,4
Sukuk					
A3	10000	2,5	0,01	0,15	0,01
A4	5000	3	0,01	0,15	0,02
A5	1000	2,5	0,01	0,15	0,01
Islamic Savings accounts					
A6	250	15,34	0,18	0,05	0,5
A7	250	14,62	0,18	0,04	0,5
Minimum	30,00	-	0,01	-	0,01
Maximum	-	15,34	-	0,20	-
Total	16580	38,17	0,47	0,94	1,74

Step 2: Creating the normalized decision matrix

In this step, the data from Table 2 is put through equation (2) to get the normalized decision matrix which is then displayed in Table 3.

Table 3. Normalized Decision Matrix

	C1	C2	C3	C4	C5
A1	0,001809	0,002882	0,085106	0,212766	0,172414
A2	0,003016	0,00262	0,085106	0,212766	0,229885
A3	0,603136	0,065496	0,021277	0,159574	0,005747
A4	0,301568	0,078596	0,021277	0,159574	0,011494
A5	0,060314	0,065496	0,021277	0,159574	0,005747
A6	0,015078	0,401886	0,382979	0,053191	0,287356
A7	0,015078	0,383023	0,382979	0,042553	0,287356

Step 3: Finding the entropy values for the criteria

In this step, by using equation (3), the value of entropy (E_j) is found. Since we have seven alternatives k = (1/ln(7)) = 0,480898. The values of E_j are shown in Table 4.

Table 4. Entropy (E_j) values

C1	C2	C3	C4	C5

E_j	0,476693	0,63638	0,673393	0,878846	0,706135

Step 4: Calculate the degree of differentiation of information (d_j)

In this step equation (4) is used to calculate the degree of differentiation of information (d_j) which are shown in Table 5.

Table 5. The degree of differentiation of information (d_j)

	C1	**C2**	**C3**	**C4**	**C5**
d_j	0,523307	0,36362	0,326607	0,121154	0,293865

Step 5: Calculating criterion weights

In the final step of the entropy method equation (5) is used to calculate the criterion weights that are going to be used in the WASPAS method. These are displayed in Table 6.

Table 6. The criteria weights (w_j)

	C1	**C2**	**C3**	**C4**	**C5**
w_j	0,321333	0,223278	0,200551	0,074394	0,180445

4.2 WASPAS Method Application Stages

Step 1: Identifying alternatives and criteria

The alternatives and criteria have been mentioned in Table 1.

Step 2: Creating the decision matrix

The decision matrix remains the same as the decision matrix used in the entropy method in Table 2.

Step 3: Normalization of the decision matrix

In this step, the decision matrix has to be normalized. Since the WASPAS method is used, the normalization of the decision matrix is calculated according to different equations than the entropy method. To normalize according to the WASPAS method, the data in the decision matrix (Table 2) are used with equations (8) or (9) depending on if the criteria are a cost or a benefit. The normalized matrix is shown in Table 7.

Table 7. Normalized decision matrix

	C1	**C2**	**C3**	**C4**	**C5**
	c	**b**	**c**	**b**	**c**
A1	1,00	0,01	0,25	1,00	0,03
A2	0,60	0,01	0,25	1,00	0,03
A3	0,00	0,16	1,00	0,75	1,00
A4	0,01	0,20	1,00	0,75	0,50
A5	0,03	0,16	1,00	0,75	1,00
A6	0,12	1,00	0,06	0,25	0,02
A7	0,12	0,95	0,06	0,20	0,02

Step 4: Evaluation by weighted sum method

In this step, by using equation (10), the scores of the alternatives are calculated according to the weighted sum method as displayed on Table 8.

Table 8. Weighted sum scores of the alternatives

Alternative	**Score**
A1	0,453480
A2	0,323298
A3	0,474143
A4	0,392162
A5	0,482819
A6	0,295187
A7	0,280987

Step 5: Evaluation with the weighted product method

In this step, by using equation (11), the scores of the alternatives are calculated according to the weighted product method as displayed on Table 9.

Table 9. Weighted product scores of the alternatives

Alternative	**Score**
A1	0,136117
A2	0,107359
A3	0,10095
A4	0,11593
A5	0,211562
A6	0,126184
A7	0,122782

Step 6: Integrate the weighted sum and weighted product results

This study assumes that the results from the weighted sum and weighted multiplication methods are of equal importance. Therefore, in this step, using equation (12), the integrated results of the weighted sum and weighted products are calculated and ranked as shown in Table 10.

Table 10. Integrated scores and ranks of the alternatives

Alternative	Score	Rank
A1	0,294799	2
A2	0,215328	5
A3	0,287546	3
A4	0,254046	4
A5	0,347191	**1**
A6	0,210685	6
A7	0,201885	7

It is important to note the significance level of the weighted sum model. This is as mentioned before called the generalized weighted common criterion score expression and is presented as the value λ. Here λ can take values between 0 and 1 and can be calculated using equation (13). In Table 11, the scores of the alternatives are displayed for different λ values.

Table 11. Integrated scores of the alternatives for different λ values

Alternative	0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1
A1	0,136	0,168	0,200	0,231	0,263	0,295	0,327	0,358	0,390	0,422	0,453
A2	0,107	0,129	0,151	0,172	0,194	0,215	0,237	0,259	0,280	0,302	0,323
A3	0,101	0,138	0,176	0,213	0,250	0,288	0,325	0,362	0,400	0,437	0,474
A4	0,116	0,144	0,171	0,199	0,226	0,254	0,282	0,309	0,337	0,365	0,392
A5	0,212	0,239	0,266	0,293	0,320	0,347	0,374	0,401	0,429	0,456	0,483
A6	0,126	0,143	0,160	0,177	0,194	0,211	0,228	0,244	0,261	0,278	0,295
A7	0,123	0,139	0,154	0,170	0,186	0,202	0,218	0,234	0,249	0,265	0,281

Step 7: Selection

In the final step of the WASPAS method we use equation (14) to find the ideal choice and as it can be seen from Table 10, the order of preference should be as follows A5>A1>A3>A4>A2>A6>A7. Since A5 has the highest Q score it should be the first to be considered for an investment. This is also the case, according to Table 11, even for other values of λ.

5. Conclusion

In this study, investment alternatives were evaluated with the Entropy and WASPAS method on the basis of different criteria. The presented study is important in terms of supporting Muslim decision makers in choosing the most suitable investments by considering different criteria. The decision maker tries to cope with many criteria and these criteria have different weights. A systematic approach is essential to consider all criteria. The Integrated Entropy and WASPAS method becomes a convenient tool for decision makers when it is necessary to weigh and rank criteria with different data together.

This study has introduced the Entropy and WASPAS method. Moreover, some of its applications in the literature have been discussed and the steps are explained, and the operation of the method steps is shown on a sample application study on Islamic investment selection. In the implementation study, 7 candidate investment opportunities (alternatives) were ranked on the basis of 5 criteria.

Conventional finance and investments and their decision making processes' are widely available in literature. However, the same cannot be said about Islamic finance and investment. Thus it is important to note that more research and study is needed in the MCDM methods within this field.

Conflicts of Interest

The authors declared that there is no conflict of interest.

Contribution of Authors

Emir Mustafa İşler: Conceptualization, Methodology, Validation, Investigation, Writing – original draft.

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