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NEURO QUANTUM-INSPIRED DECISION-MAKING FOR INVESTOR PERCEPTION IN GREEN AND CONVENTIONAL BOND INVESTMENTS

Abstract

The purpose of this study is to make a comprehensive analysis of investor perceptions in the context of green and conventional bond investments. For this purpose, a new model is presented by considering two steps. First, a criteria set is generated by considering balanced scorecard perspectives that are finance, customer, organizational effectiveness and learning and growth. After that, the neuro Quantum fuzzy M-SWARA method is considered to weight these criteria. Secondly, seven critical determinants for bond investments are identified that are coupon rates, volume, maturity, riskiness, liquidity, volatility, and tax considerations. Neuro Quantum fuzzy TOPSIS approach is employed to rank these factors. The main contribution of the study is that by combining the balanced scorecard framework and quantum-inspired decision-making techniques, this paper offers a novel and sophisticated decision-making model to understanding investor behavior. Similarly, in the proposed model, a new methodology is generated by the name of M-SWARA. In this framework, some enhancements are adopted to the SWARA technique. The weighting results indicate that meeting customer expectations is the most critical factor that affects the investor perception to make investments to the bonds. Moreover, according to the ranking results, it is concluded that coupon rates are the most important item for both conventional and green bond investors. On the other hand, with respect to the conventional bond investor, tax is the second most essential factor. However, regarding the green bond investors, volatility plays a critical role.

Keywords investment, bonds, perception, balanced scorecard, customer, M-SWARA, investor, tax

JEL Classification D25, E22, G11

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INTRODUCTION

Considering the above-mentioned issues, both traditional and green bonds should be able to be increased. In this context, different issues need to be considered to attract investors' interest in these securities. Financial returns are very important in attracting investors' interest in bonds. Meeting customer expectations is also necessary to attract investors' interest in bonds. Moreover, the organizational efficiency of the bond issuing enterprise is another important issue for the preference of bonds. On the other hand, having an innovative perspective may also be a reason for investors to prefer the bonds issued by enterprises. In summary, there are many different variables that affect investors' decisions to purchase bonds. In this scope, there is a need for a new study to be carried out to determine the issues that most affect the decisions of investors, especially for different bond types.

Accordingly, this paper presents a comprehensive analysis of investor perceptions in the context of green and conventional bond invest-

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ments. The study employs the balanced scorecard framework as a set of criteria to evaluate investor perspectives. In the first stage, the neuro Quantum fuzzy M-SWARA method is considered to weight these criteria. This initial stage aims to determine the relative importance of the balanced scorecard perspectives in shaping investor perceptions. Moving to the second stage, seven critical determinants for bond investments are identified that are coupon rates, volume, maturity, riskiness, liquidity, volatility, and tax considerations. To compare the investment preferences of both green and conventional bond investors, the neuro Quantum fuzzy TOPSIS approach is employed. This stage enables a comprehensive comparative analysis, shedding light on the distinct preferences and priorities of investors when considering these determinant factors for bond investments.

1. LITERATURE REVIEW

The financial returns of bonds are very important to attract investors' interest in these securities. There are many different investment instruments in the financial markets. According to Chang et al. (2022), the main difference of bonds from others is that they have less risk (Nurgaliyeva et al., 2022; Mazina et al., 2022; Baker et al., 2022). On the other hand, since it is less risky, its returns may be less compared to some other investment products (Tan et al., 2022). By contrast, bonds are fixed income securities. Wang et al. (2022) defined that this situation also contributes to reducing the uncertainty in the investment process. In other words, investors know how much return they will get at maturity when purchasing the bonds. This allows investors to plan their investments more effectively. On the other hand, Zhang et al. (2022) stated that bonds generally carry less risk than other investment vehicles. This is an important opportunity to attract the attention of high risk-averse investors. Moreover, Ye and Rasoulinezhad (2023) determined that bonds have regular interest payments. This allows investors to manage their cash flows more effectively. Especially in an economy where interest rates are low, bonds can become permissible. The main reason for this is that bonds offer fixed income.

Meeting customer expectations is of great importance to attract investors' interest in bonds. Meeting customer expectations increases the confidence of investors in these products. This allows investors to buy more bonds (Karim et al., 2022; Bhutta et al., 2022). Alsmadi et al. (2023) identified that customer loyalty is important for maintaining long-term customer relationships. For the bonds to be more successful, they should be issued in different ways for different customer groups. In this context, Su et al. (2022) concluded that it should be aimed to attract the attention of investors sensitive to environmental issues by issuing green bonds for environmentally friendly projects. This makes it possible to reach a wider customer base. On the other hand, according to Teti et al. (2022), up-to-date information should be provided to investors to ensure customer satisfaction. Thanks to transparent and understandable information, it is possible to increase the interest of investors in bonds (Azhgaliyeva et al., 2022). Moreover, to ensure customer satisfaction, investors' problems need to be resolved quickly. Investors value understanding and timely support when they need it. This helps to make bonds more preferred by investors.

The organizational efficiency of issuing companies plays an important role in increasing investor interest in bonds. Operational processes can be managed more efficiently in businesses with organizational efficiency (Chang et al., 2023). In this context, Naeem et al. (2022) identified that businesses need to be financially strong. In a company that is efficient in organizational terms, costs can be managed more effectively. On the other hand, according to Dong et al. (2023), there should be no significant problems in the cash flow of this company. This situation contributes to the increase of the financial reliability of the company that will issue the bond. Furthermore, Ren et al. (2022) concluded that the ability of a company to manage its risks effectively also helps the company to be productive in an organizational sense. Bonds issued by companies that successfully manage both internal audit and risk management processes are more preferred by investors. In addition to them, Abakah et al. (2023) indicated that businesses must have a good image in the market to attract the attention of investors. In this context, it is important for businesses to be especially sensitive to environmental issues.

The issuing companies' innovative point of view has an important role in increasing investors' interest in bonds and influencing their investment decisions. The innovativeness of a business provides very important information in terms of its future growth potential (Thompson, 2022; Zhao et al., 2022). Such companies gain a significant competitive advantage over their competitors by making innovative investments. According to Naeem et al. (2023), this is another reason why the issued bonds are preferred by customers. In other words, companies with an innovative perspective can attract the attention of investors (Cui et al., 2022). On the other hand, Fernandes et al. (2023) denoted that innovative companies mainly support sustainability-oriented projects. This situation allows the image in the eyes of investors, who are especially sensitive to environmental issues, to develop in a positive way. Thus, it is possible to prefer the bonds issued by the enterprises more. Furthermore, Han and Li (2022) concluded that having an innovative perspective can strengthen the reputation and image of the company. Investors also prefer the bonds of these companies more. This situation increases the bond issuance demand and contributes to the fact that the bonds can be more valuable (Reboredo et al., 2022).

The main results of the literature evaluations are demonstrated as follows.

(i) Bonds should play a crucial role in the economic development of the countries mainly owing to have an increasing impact on the investments.

(ii) Appropriate strategies should be implemented to increase the preferences of the bonds by the investors.

(iii) In this framework, there is a need for a new study to be carried out to determine the issues that most affect the decisions of investors, especially for different bond types.

While evaluating similar studies, it is seen that there are not enough number of studies that examined this subject. To satisfy this missing part in literature, in this study, an evaluation is conducted to understand investor perception in the context of green and conventional bond investments.

2. METHODOLOGY

The techniques used in the proposed model are explained below.

2.1. Decision making with facial expressions

Obtaining correct evaluations from the experts is one of the most critical issues in the decision-making process. Because of this situation, the expert team should be created with qualified people about the subject. However, the experts may face hesitancy while answering the questions related to the criteria. In this framework, The Facial Action Coding System (FACS) can be used in the decision-making models because it considers emotions of the people. The facial expressions of the experts can provide important information about the hesitancy in this process. This system includes different action units (AUs) for coding facial emotions (Romero et al., 2022).

2.2. Quantum-based fuzzy sets with golden ratio

Quantum theory uses various probabilities in the evaluation process. Hence, this theory is used with fuzzy decision-making methodology in this study to minimize uncertainties. Equations (1)-(3) denote this situation where u refers to event, θ shows phase angle, φ^2 identify amplitude and ς indicates a collection of events (Kayacık et al., 2022).

$$Q\left(|u>\right)=\varphi e^{\theta}, \tag{1}$$

$$|\varsigma>=\left\{|u_1>,|u_2>,\ldots,|u_n>\right\}, \tag{2}$$

$$\sum_{|u>\subseteq|\varsigma>}\left|Q(|u>)\right|=1. \tag{3}$$

Spherical fuzzy sets, $\tilde{A}_s$, use membership degree, $\mu_{\tilde{A}s}$, non-membership degree, $v_{\tilde{A}s}$, and hesitancy degree, $h_{\tilde{A}s}$, in the examination process. With the help of this situation, more appropriate solutions can be reached. The details are demonstrated in Equations (4) and (5) (Yüksel & Dinçer, 2023).

$$\tilde{A}_S=\left\{u,(\mu_{\tilde{A}_S}(u),v_{\tilde{A}_S}(u),h_{\tilde{A}_S}(u))\middle|u\in U\right\}, \tag{4}$$

$$0\le\mu_{\tilde{A}_S}^2(u)+v_{\tilde{A}_S}^2(u)+h_{\tilde{A}_S}^2(u)\le 1,\quad \forall_u\in U. \tag{5}$$

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Equations (6)-(8) show the integration of these sets with Quantum theory.

$$\left|\varsigma_{\tilde{A}_S}>=\left\{u,(\varsigma_{\mu_{\tilde{A}_S}}(u),\varsigma_{v_{\tilde{A}_S}}(u),\varsigma_{h_{\tilde{A}_S}}(u))\middle|u\in 2^{\left|\varsigma_{\tilde{A}_S}>\right.}\right\}\right., \tag{6}$$

$$\varsigma=\left[\varsigma_{\mu}\cdot e^{j2\pi\cdot\alpha},\varsigma_{v}\cdot e^{j2\pi\cdot\gamma},\varsigma_{h}\cdot e^{j2\pi\cdot\beta}\right], \tag{7}$$

$$\varphi^2=\left|\varsigma_{\mu}\left(\left|u_i>\right)\right|\right.. \tag{8}$$

Golden ratio (G) is considered in the analysis to compute the degrees as detailed in Equations (9) and (10).

$$\varsigma_{v}=\frac{\varsigma_{\mu}}{G}, \tag{9}$$

$$\varsigma_{h}=1-\varsigma_{\mu}-\varsigma_{v}. \tag{10}$$

Equations (11)-(17) indicate the operational calculations.

$$\alpha=\left|\varsigma_{\mu}\left(\left|u_i>\right)\right|\right., \tag{11}$$

$$\gamma=\frac{\alpha}{G}, \tag{12}$$

$$\beta=1-\alpha-\gamma, \tag{13}$$

$$\lambda\cdot\tilde{A}_{\varsigma}=\left\{\begin{array}{l}\left(1-\left(1-\varsigma_{\mu_{\tilde{A}}}^{2}\right)^{\lambda}\right)^{\frac{1}{2}}\cdot e^{j2\pi\cdot\left(1-\left(1-\left(\frac{\alpha_{\tilde{A}}}{2\pi}\right)^{2}\right)^{\lambda}\right)^{\frac{1}{2}}},\varsigma_{v_{\tilde{A}}}^{\lambda}e^{j2\pi\cdot\left(\frac{\gamma_{\tilde{A}}}{2\pi}\right)^{\lambda}}, \\ \left(\left(1-\varsigma_{h_{\tilde{A}}}{}^{2}\right)^{\lambda}-\left(1-\varsigma_{\mu_{\tilde{A}}}^{2}-\varsigma_{h_{\tilde{A}}}^{2}\right)^{\lambda}\right)^{\frac{1}{2}}\cdot e^{j2\pi\cdot\left(\left(1-\left(\frac{\beta_{\tilde{A}}}{2\pi}\right)^{2}\right)^{\lambda}-\left(1-\left(\frac{\alpha_{\tilde{A}}}{2\pi}\right)^{2}-\left(\frac{\beta_{\tilde{A}}}{2\pi}\right)^{2}\right)^{\lambda}\right)^{\frac{1}{2}}}\end{array}\right\},\lambda>0, \tag{14}$$

$$\tilde{A}_{\varsigma}^{\lambda}=\left\{\begin{array}{l}\varsigma_{\mu_{\tilde{A}}}^{\lambda}e^{j2\pi\cdot\left(\frac{\alpha_{\tilde{A}}}{2\pi}\right)^{\lambda}},\left(1-\left(1-\varsigma_{v_{\tilde{A}}}^{2}\right)^{\lambda}\right)^{\frac{1}{2}}e^{j2\pi\cdot\left(1-\left(1-\left(\frac{\gamma_{\tilde{A}}}{2\pi}\right)^{2}\right)^{\lambda}\right)^{\frac{1}{2}}}, \\ \left(\left(1-\varsigma_{v_{\tilde{A}}}^{2}\right)^{\lambda}-\left(1-\varsigma_{v_{\tilde{A}}}^{2}-\varsigma_{h_{\tilde{A}}}^{2}\right)^{\lambda}\right)^{\frac{1}{2}}e^{j2\pi\cdot\left(\left(1-\left(\frac{\gamma_{\tilde{A}}}{2\pi}\right)^{2}\right)^{\lambda}-\left(1-\left(\frac{\gamma_{\tilde{A}}}{2\pi}\right)^{2}-\left(\frac{\beta_{\tilde{A}}}{2\pi}\right)^{2}\right)^{\lambda}\right)^{\frac{1}{2}}}\end{array}\right\},\lambda>0, \tag{15}$$

$$\tilde{A}_\varsigma \oplus \tilde{B}_\varsigma = \left\{ \begin{array}{l} \left(\varsigma^2_{\mu_{\tilde A}} + \varsigma^2_{\mu_{\tilde B}} - \varsigma^2_{\mu_{\tilde A}}\varsigma^2_{\mu_{\tilde B}}\right)^{\frac12} e^{j2\pi\cdot\left(\left(\frac{\alpha_{\tilde A}}{2\pi}\right)^2+\left(\frac{\alpha_{\tilde B}}{2\pi}\right)^2-\left(\frac{\alpha_{\tilde A}}{2\pi}\right)^2\left(\frac{\alpha_{\tilde B}}{2\pi}\right)^2\right)^{\frac12}}, \varsigma_{v_{\tilde A}}\varsigma_{v_{\tilde B}} e^{j2\pi\cdot\left(\left(\frac{\gamma_{\tilde A}}{2\pi}\right)\left(\frac{\gamma_{\tilde B}}{2\pi}\right)\right)}, \\ \left(\left(1-\varsigma^2_{\mu_{\tilde B}}\right)\varsigma^2_{h_{\tilde A}} + \left(1-\varsigma^2_{\mu_{\tilde A}}\right)\varsigma^2_{h_{\tilde B}} - \varsigma^2_{h_{\tilde A}}\varsigma^2_{h_{\tilde B}}\right)^{\frac12} e^{j2\pi\cdot\left(\left(1-\left(\frac{\alpha_{\tilde B}}{2\pi}\right)^2\right)\left(\frac{\beta_{\tilde A}}{2\pi}\right)^2+\left(1-\left(\frac{\alpha_{\tilde A}}{2\pi}\right)^2\right)\left(\frac{\beta_{\tilde B}}{2\pi}\right)^2-\left(\frac{\beta_{\tilde A}}{2\pi}\right)^2\left(\frac{\beta_{\tilde B}}{2\pi}\right)^2\right)^{\frac12}} \end{array} \right\}, \tag{16}$$

$$\tilde{A}_\varsigma \oplus \tilde{B}_\varsigma = \left\{ \begin{array}{l} \varsigma_{\mu_{\tilde A}}\varsigma_{\mu_{\tilde B}} e^{j2\pi\cdot\left(\frac{\alpha_{\tilde A}}{2\pi}\right)\left(\frac{\alpha_{\tilde B}}{2\pi}\right)}, \left(\varsigma^2_{v_{\tilde A}} + \varsigma^2_{v_{\tilde B}} - \varsigma^2_{v_{\tilde B}} - \varsigma^2_{v_{\tilde A}}\varsigma^2_{v_{\tilde B}}\right)^{\frac12} e^{j2\pi\cdot\left(\left(\frac{\gamma_{\tilde A}}{2\pi}\right)^2+\left(\frac{\gamma_{\tilde B}}{2\pi}\right)^2-\left(\frac{\gamma_{\tilde A}}{2\pi}\right)^2\left(\frac{\gamma_{\tilde B}}{2\pi}\right)^2\right)^{\frac12}}, \\ \left(\left(1-\varsigma^2_{v_{\tilde B}}\right)\varsigma^2_{h_{\tilde A}} + \left(1-\varsigma^2_{v_{\tilde A}}\right)\varsigma^2_{h_{\tilde B}} - \varsigma^2_{h_{\tilde A}}\varsigma^2_{h_{\tilde B}}\right)^{\frac12} e^{j2\pi\cdot\left(\left(1-\left(\frac{\gamma_{\tilde B}}{2\pi}\right)^2\right)\left(\frac{\beta_{\tilde A}}{2\pi}\right)^2+\left(1-\left(\frac{\gamma_{\tilde A}}{2\pi}\right)^2\right)\left(\frac{\beta_{\tilde B}}{2\pi}\right)^2-\left(\frac{\beta_{\tilde A}}{2\pi}\right)^2\left(\frac{\beta_{\tilde B}}{2\pi}\right)^2\right)^{\frac12}} \end{array} \right\}. \tag{17}$$

2.3. The extended approach to M-SWARA

In this study, SWARA methodology is enhanced, and a new technique is generated (M-SWARA). These new enhancements provide to consider the causal directions among the factors (Mikhaylov et al., 2023). The evaluations are provided in the first step. Next, relation matrix is created by Equation (18).

$$\varsigma_k = \begin{bmatrix} 0 & \varsigma_{12} & \cdots & \cdots & \varsigma_{1n} \\ \varsigma_{21} & 0 & \cdots & \cdots & \varsigma_{2n} \\ \vdots & \vdots & \ddots & \cdots & \cdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \varsigma_{n1} & \varsigma_{n2} & \cdots & \cdots & 0 \end{bmatrix}. \tag{18}$$

Equation (19) is used to compute aggregated values (Dinçer et al., 2022).

$$\varsigma = \left\{ \begin{array}{l} \left[1-\prod_{i=1}^{k}\left(1-\varsigma^2_{\mu_i}\right)^{\frac1k}\right]^{\frac12} e^{2\pi\cdot\left[1-\prod_{i=1}^{k}\left(1-\left(\frac{\alpha_i}{2\pi}\right)^2\right)^{\frac1k}\right]^{\frac12}}, \prod_{i=1}^{k}\varsigma_{v_i}^{\frac1k} e^{2\pi\cdot\prod_{i=1}^{k}\left(\frac{\gamma_i}{2\pi}\right)^{\frac1k}}, \\ \left[\prod_{i=1}^{k}\left(1-\varsigma^2_{\mu_i}\right)^{\frac1k} - \prod_{i=1}^{k}\left(1-\varsigma^2_{\mu_i}-\varsigma^2_{h_i}\right)^{\frac1k}\right]^{\frac12} e^{2\pi\cdot\left[\prod_{i=1}^{k}\left(1-\left(\frac{\alpha_i}{2\pi}\right)^2\right)^{\frac1k}-\prod_{i=1}^{k}\left(1-\left(\frac{\alpha_i}{2\pi}\right)^2-\left(\frac{\beta_i}{2\pi}\right)^2\right)^{\frac1k}\right]^{\frac12}} \end{array} \right\} \tag{19}$$

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Equation (20) gives information about the defuzzification process.

$$Def\,\varsigma_i = \varsigma_{\mu_i} + \left(\frac{\varsigma_{\mu_i}}{\varsigma_{\mu_i} + \varsigma_{h_i} + \varsigma_{v_i}}\right) + \left(\frac{\alpha_i}{2\pi}\right) + \left(\frac{\left(\frac{\alpha_i}{2\pi}\right)}{\left(\frac{\alpha_i}{2\pi}\right) + \left(\frac{\gamma_i}{2\pi}\right) + \left(\frac{\beta_i}{2\pi}\right)}\right), \quad (20)$$

After that, s_j (importance ratio), k_j (coefficient), q_j (recalculated weight), and w_j (weights) are defined as in Equations (21)-(23).

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases}, \quad (21)$$

$$q_j = \begin{cases} 1 & j = 1 \\ \frac{q_{j-1}}{k_j} & j > 1 \end{cases}, \quad (22)$$

If $s_{j-1} = s_j$, $q_{j-1} = q_j$; if $s_j =$, $k_{j-1} = k_j$.

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}. \quad (23)$$

Stable values are identified while getting the transpose and limiting the matrix to the power of $2t + 1$. With the help of this issue, impact directions can be created by considering the threshold value.

2.4. The extended approach to TOPSIS

TOPSIS methodology is integrated with the Quantum Spherical fuzzy numbers. The evaluations are taken from the decision makers (Erdebilli et al., 2023). Decision matrix is generated in the following stage as in Equation (24).

$$X_k = \begin{bmatrix} 0 & X_{12} & \cdots & \cdots & X_{1m} \\ X_{21} & 0 & \cdots & \cdots & X_{2m} \\ \vdots & \vdots & \ddots & \cdots & \cdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ X_{n1} & X_{n2} & \cdots & \cdots & 0 \end{bmatrix}. \quad (24)$$

Next, the values are defuzzified. Equation (25) is considered to compute normalized values.

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}}. \quad (25)$$

Equation (26) is used to calculate weighted values.

$$v_{ij} = w_{ij} \times r_{ij}. \quad (26)$$

The positive and negative ideal solutions, A^+ and A^-, are defined with Equations (27) and (28) (Dong et al., 2022).

$$A^+ = \{v_{1j}, v_{2j}, \ldots, v_{mj}\} = \{\max v_{1j}\ for\ \forall j \in n\}, \quad (27)$$

$$A^- = \{v_{1j}, v_{2j}, \ldots, v_{mj}\} = \{\min v_{1j}\ for\ \forall j \in n\}. \quad (28)$$

The distances to the best and worst alternatives, D_i^+ and D_i^-, are calculated by Equations (29) and (30).

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - A_j^+\right)^2}, \quad (29)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - A_j^-\right)^2}. \quad (30)$$

Relative closeness, RC_i is calculated with Equation (31).

$$RC_i = \frac{D_i^-}{D_i^+ + D_i^-}. \quad (31)$$

3. RESULT

While integrating the techniques discussed in the previous section, a novel model is proposed. There are mainly two parts in this model. At the first stage, the key factors related to the investor perception are evaluated. Secondly, investment priorities are ranked. The main contributions of the study are explained below. (i) By combining the balanced scorecard framework and quantum-inspired decision-making techniques, this paper offers a novel

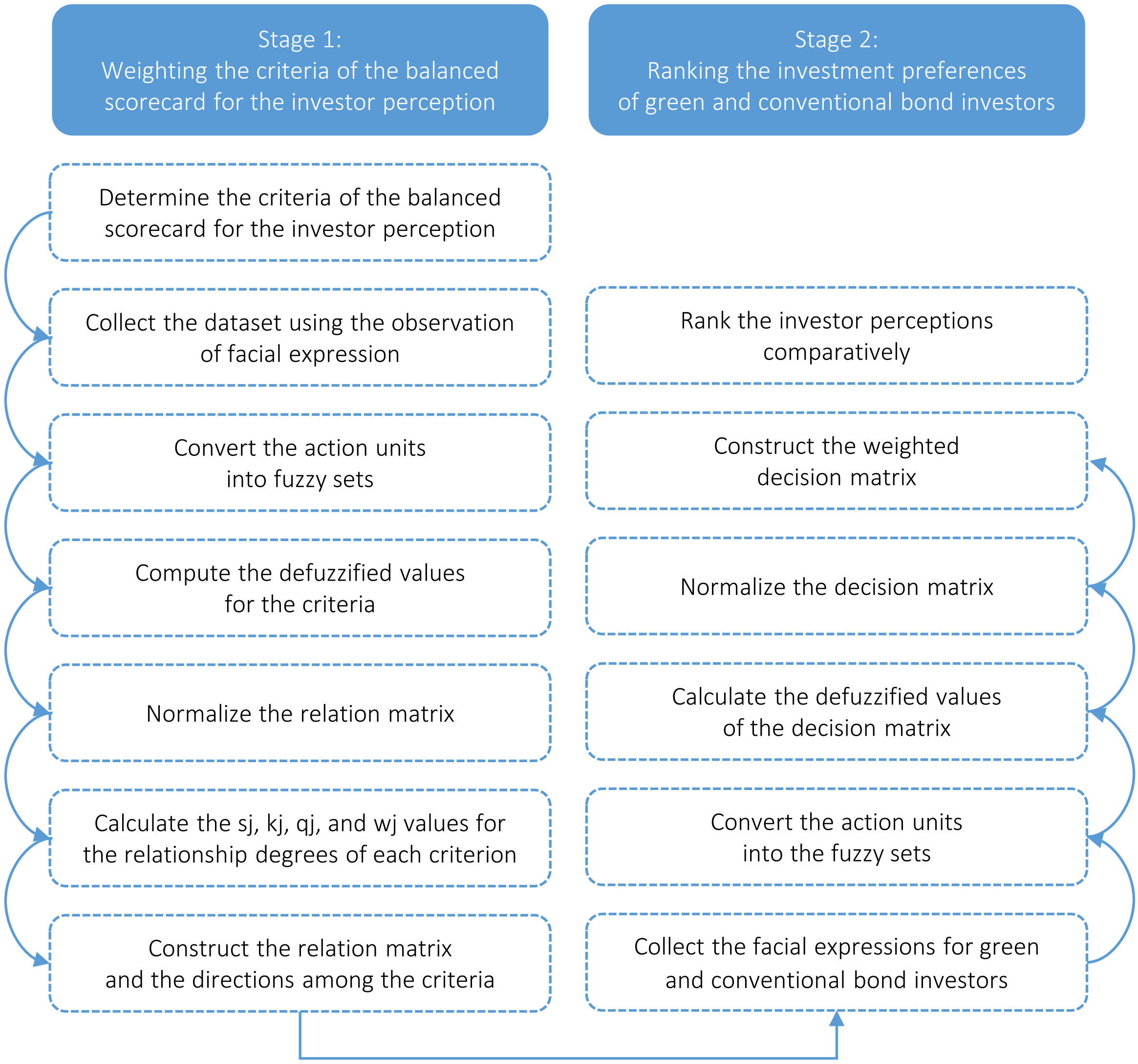

Figure 1. The flowchart

and sophisticated approach to understanding investor behavior. Because balanced scorecard approach focuses on both financial and nonfinancial issues, more effective evaluations can be conducted. (ii) In the proposed model, a new methodology is created by the name of M-SWARA. In this framework, some enhancements are adopted to the SWARA technique. With the help of them, the causal directions can be considered in the evaluation process. The main determinants of investor perception in the context of green and conventional bond investments can affect each other. Therefore, this new methodology helps to achieve more convenient solutions. The main steps of this new model are demonstrated in Figure 1.

Analysis results of each section are presented in the following subsections.

3.1. Weighting the criteria of the balanced scorecard for the investor perception

The criteria for the investor perception to purchase the bonds are defined by using balanced scorecard perspectives that are finance, customer, internal process and learning and growth. The details of these items are given in Table 1.

Table 1. Selected criteria for the investor perception

Criteria	Literature
Finance	(Baker et al., 2022)
Customer	(Tan et al., 2022)
Internal Process	(Karim et al., 2022)
Learning and Growth	(Chang et al., 2023)

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The dataset is collected using the observation of facial expression by considering the values in Table 2. Observation results of facial expressions for the relation degrees are shown in Table 3. AUs are converted into fuzzy sets as in Table 4.

Defuzzified values are computed in the following process as in Table 5. Normalized relation matrix is constructed in Table 6. Table 7 includes the critical values.

Table 2. Emotional expressions and action unit combinations

Emotions	Combinations	Scales for items	Scales for strategies	Degrees	QSFNs
Disdain	(7/10)/(7/14)/(7/15)/(10/14)/ (10/15)/(14/15)	No (n)	Weakest (w)	.40	$\left[\sqrt{.16}e^{j2\pi..4}, \sqrt{.10}e^{j2\pi..25}, \sqrt{.74}e^{j2\pi..35}\right]$
Intermediate	(7/1)/(7/2)/(7/5)/(7/27)/(10/1)/ (10/2)/(10/5)/(10/27)/(14/1)/ (14/2)/(14/5)/(14/27)/(15/1)/ (15/2)/(15/5)/(15/27)	some (s)	bad (p)	.45	$\left[\sqrt{.20}e^{j2\pi..45}, \sqrt{.13}e^{j2\pi..28}, \sqrt{.67}e^{j2\pi..27}\right]$
Surprise	(1/2)/(1/5)/(1/27)/(2/5)/(2/27)/ (5/27)(7/6)/(7/12)/(7/25)/ (7/26)/(10/6)/(10/12)/(10/25)/ (10/26)/(14/6)/(14/12)/(14/25)/ (14/26)/(15/6)/(15/12)/(15/25)/ (15/26)	normal (m)	normal (f)	.50	$\left[\sqrt{.25}e^{j2\pi..50}, \sqrt{.15}e^{j2\pi..31}, \sqrt{.60}e^{j2\pi..19}\right]$
Intermediate	(1/6)/(1/12)/(1/25)/(1/26)/ (2/6)/(2/12)/(2/25)/(2/26)/ (5/6)/ (5/12)/(5/25)/(5/26)/(27/6)/ (27/12)/(27/25)/(27/26)	hig (h)	nice (g)	.55	$\left[\sqrt{.30}e^{j2\pi..55}, \sqrt{.19}e^{j2\pi..34}, \sqrt{.51}e^{j2\pi..11}\right]$
Happiness	(6/12)/(6/25)/(6/26)/(12/25)/ (12/26)/(25/26)	very high (vh)	wonderful (b)	.60	$\left[\sqrt{.36}e^{j2\pi..6}, \sqrt{.22}e^{j2\pi..37}, \sqrt{.42}e^{j2\pi..03}\right]$

Table 3. Observation results of facial expressions for the relation degrees

	Expert 1			
	FINANCE	**CUSTOMER**	**INTERNAL**	**LEARNING**
FINANCE	–	(15.26)	(15.12)	(15.26)
CUSTOMER	(2.6)	–	(15.12)	(27.12)
INTERNAL	(14.5)	(14.25)	–	(15.26)
LEARNING	(15.12)	(27.12)	(2.6)	–
	Expert 2			
	FINANCE	**CUSTOMER**	**INTERNAL**	**LEARNING**
FINANCE	–	(15.12)	(14.5)	(15.26)
CUSTOMER	(5.6)	–	(15.26)	(2.6)
INTERNAL	(14.5)	(27.12)	–	(14.1)
LEARNING	(14.1)	(5.6)	(5.6)	–
	Expert 3			
	FINANCE	**CUSTOMER**	**INTERNAL**	**LEARNING**
FINANCE	–	(15.26)	(15.12)	(15.26)
CUSTOMER	(5.6)	––	(27.12)	(27.12)
INTERNAL	(14.25)	(15.12)		(2.6)
LEARNING	(15.26)	(5.6)	(27.12)	–

Table 4. Aggregated QFNS values

	FINANCE	CUSTOMER	INTERNAL	LEARNING
FINANCE	–	$\left[\sqrt{.25}e^{j2\pi..50}, \sqrt{.15}e^{j2\pi..31}, \sqrt{.60}e^{j2\pi..19}\right]$	$\left[\sqrt{.24}e^{j2\pi..48}, \sqrt{.14}e^{j2\pi..30}, \sqrt{.62}e^{j2\pi..22}\right]$	$\left[\sqrt{.25}e^{j2\pi..50}, \sqrt{.15}e^{j2\pi..31}, \sqrt{.60}e^{j2\pi..19}\right]$
CUSTOMER	$\left[\sqrt{.30}e^{j2\pi..55}, \sqrt{.19}e^{j2\pi..34}, \sqrt{.51}e^{j2\pi..11}\right]$	–	$\left[\sqrt{.27}e^{j2\pi..51}, \sqrt{.16}e^{j2\pi..31}, \sqrt{.59}e^{j2\pi..20}\right]$	$\left[\sqrt{.30}e^{j2\pi..55}, \sqrt{.19}e^{j2\pi..34}, \sqrt{.51}e^{j2\pi..11}\right]$
INTERNAL	$\left[\sqrt{.22}e^{j2\pi..47}, \sqrt{.13}e^{j2\pi..29}, \sqrt{.65}e^{j2\pi..25}\right]$	$\left[\sqrt{.27}e^{j2\pi..51}, \sqrt{.16}e^{j2\pi..31}, \sqrt{.59}e^{j2\pi..20}\right]$	–	$\left[\sqrt{.26}e^{j2\pi..51}, \sqrt{.16}e^{j2\pi..31}, \sqrt{.58}e^{j2\pi..18}\right]$
LEARNING	$\left[\sqrt{.24}e^{j2\pi..48}, \sqrt{.14}e^{j2\pi..30}, \sqrt{.62}e^{j2\pi..22}\right]$	$\left[\sqrt{.30}e^{j2\pi..55}, \sqrt{.19}e^{j2\pi..34}, \sqrt{.51}e^{j2\pi..11}\right]$	$\left[\sqrt{.30}e^{j2\pi..55}, \sqrt{.19}e^{j2\pi..34}, \sqrt{.51}e^{j2\pi..11}\right]$	–

Table 5. Defuzzified values

	FINANCE	CUSTOMER	INTERNAL	LEARNING
FINANCE	.000	1.500	1.437	1.500
CUSTOMER	1.705	.000	1.570	1.705
INTERNAL	1.373	1.570	.000	1.509
LEARNING	1.437	1.705	1.705	.000

Table 6. Normalized relation matrix

	FINANCE	CUSTOMER	INTERNAL	LEARNING
FINANCE	.000	.338	.324	.338
CUSTOMER	.342	.000	.315	.342
INTERNAL	.308	.353	.000	.339
LEARNING	.296	.352	.352	.000

Table 7. Sj, kj, qj, and wj values

FINANCE	Sj	kj	qj	wj	CUSTOMER	Sj	Kj	qj	Wj
CUSTOMER	.338	1.000	1.000	.363	FINANCE	.342	1.000	1.000	.362
LEARNING	.338	1.338	1.000	.363	LEARNING	.342	1.342	1.000	.362
INTERNAL	.324	1.324	.755	.274	INTERNAL	.315	1.315	.760	.275
INTERNAL	**Sj**	**kj**	**qj**	**wj**	**LEARNING**	**Sj**	**Kj**	**qj**	**Wj**
CUSTOMER	.353	1.000	1.000	.431	INTERNAL	.352	1.000	1.000	.361
LEARNING	.339	1.339	.747	.322	CUSTOMER	.352	1.352	1.000	.361
FINANCE	.308	1.308	.571	.246	FINANCE	.296	1.296	.771	.278

Total relation matrix is created with these critical values. By using total relation matrix, impact directions can be identified as in Table 8.

Table 8 states that the customer is affected by all other three perspectives. Moreover, it is also found that finance and customer have an impact on learning and growth. Stable matrix is generated as in Table 9.

The weights of the factors are illustrated in Figure 2.

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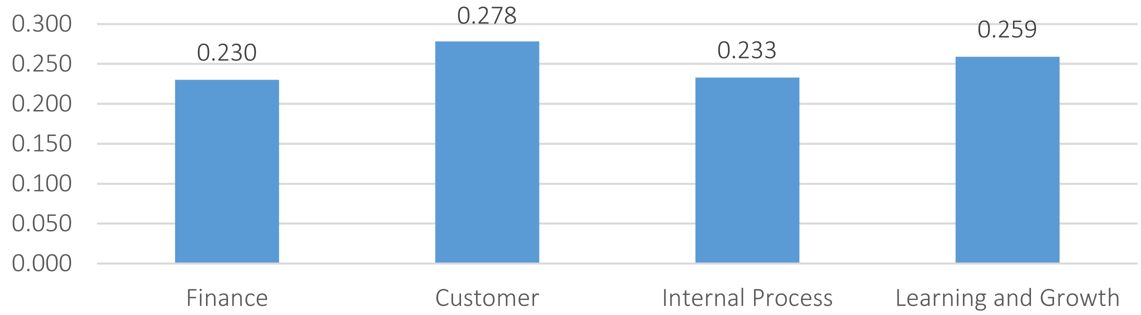

Figure 2. Criteria weights

Table 8. Relation matrix and the impact directions

	FINANCE	CUSTOMER	INTERNAL	LEARNING	Impact directions
FINANCE	–	.363	.274	.363	FINANCE → CUSTOMER, FINANCE → LEARNING
CUSTOMER	.362	–	.275	.362	CUSTOMER → FINANCE, CUSTOMER → LEARNING
INTERNAL	.246	.431	–	.322	INTERNAL → CUSTOMER
LEARNING	.278	.361	.361	–	LEARNING → CUSTOMER, LEARNING → INTERNAL

Table 9. Stable matrix

	FINANCE	CUSTOMER	INTERNAL	LEARNING
FINANCE	.230	.230	.230	.230
CUSTOMER	.278	.278	.278	.278
INTERNAL	.233	.233	.233	.233
LEARNING	.259	.259	.259	.259

Figure 2 denotes that customer is the most critical factor that affects the investor perception to make investments to the bonds. Learning and growth also has an important role in this context because of high weight (0,259). However, the weights of finance and internal process are lower than other ones.

3.2. Ranking the investment preferences of green and conventional bond investors

In this part of the model, the preferences of the bond investors are ranked. Selected alternatives of the investor preferences are volume, coupon rates, maturity, riskiness, volatility, liquidity, and tax. First, the facial expressions for green and conventional bond investors are obtained. Observation results of facial expressions for the decision degrees are shown in Table 1. In the next step, aggregated values are calculated as in Table 11.

After that, defuzzified values are created in Table 12. Table 13 indicates the normalized values. Weighted decision matrix is demonstrated in Table 14. Finally, the investor perceptions are ranked comparatively. The results are given in Table 15. The comparative ranking results are illustrated in Figure 3.

Figure 3 denotes that coupon rates are the most important item for both conventional and green bond investors. On the other hand, with respect to the conventional bond investor, tax is the second most essential factor. However, regarding the green bond investors, volatility plays a critical role.

4. DISCUSSIONS

It is understood that meeting customer expectations is of great importance to attract investors' interest in bonds. Meeting customer expectations creates confidence in investors. Cicchiello et al.

Table 10. Observation results of facial expressions for the decision degrees

Conventional Bond Investors					Green Bond Investors				
Expert 1					Expert 1				
	FINANCE	CUSTOMER	INTERNAL	LEARNING		FINANCE	CUSTOMER	INTERNAL	LEARNING
Volume	–6.26	–7.2	–7.2	–10.26	Volume	–2.6	–10.26	–10.26	–10.26
Coupon rates	–5.25	–6.26	–10.2	–2.6	Coupon rates	–2.6	–6.26	–10.26	–6.26
Maturity	–14.6	–14.6	–14.6	–10.2	Maturity	–10.26	–6.26	–14.6	–12.25
Riskiness	–2.6	–10.2	–2.6	–10.26	Riskiness	–5.25	–7.2	–14.6	–7.2
Volatility	–5.25	–10.26	–14.6	–5.25	Volatility	–14.6	–12.25	–14.6	–2.6
Liquidity	–14.6	–7.2	–14.6	–7.2	Liquidity	–14.6	–10.2	–14.6	–10.2
Tax	–14.6	–7.2	–6.26	–10.26	Tax	–10.26	–10.26	–6.26	–14.6
Expert 2					Expert 2				
	FINANCE	CUSTOMER	INTERNAL	LEARNING		FINANCE	CUSTOMER	INTERNAL	LEARNING
Volume	–5.25	–7.2	–7.2	–7.2	Volume	–5.25	–10.26	–14.6	–2.6
Coupon rates	–5.25	–2.6	–10.2	–2.6	Coupon rates	–2.6	–5.25	–14.6	–6.26
Maturity	–10.2	–10.26	–14.6	–10.2	Maturity	–10.26	–2.6	–14.6	–5.25
Riskiness	–2.6	–7.2	–2.6	–5.25	Riskiness	–5.25	–7.2	–14.6	–10.2
Volatility	–2.6	–7.2	–10.26	–2.6	Volatility	–10.26	–6.26	–10.26	–5.25
Liquidity	–14.6	–7.2	–7.2	–7.2	Liquidity	–10.26	–7.2	–10.26	–10.2
Tax	–14.6	–10.2	–12.25	–10.2	Tax	–10.26	–14.12	–2.6	–2.6
Expert 3					Expert 3				
	FINANCE	CUSTOMER	INTERNAL	LEARNING		FINANCE	CUSTOMER	INTERNAL	LEARNING
Volume	–6.26	–7.2	–7.2	–10.26	Volume	–5.25	–10.26	–10.26	–10.26
Coupon rates	–2.6	–2.6	–10.2	–2.6	Coupon rates	–2.6	–5.25	–14.6	–6.26
Maturity	–14.6	–14.6	–14.6	–10.2	Maturity	–2.6	–5.25	–14.6	–1.25
Riskiness	–5.25	–10.2	–14.6	–10.26	Riskiness	–5.25	–7.2	–14.6	–10.26
Volatility	–10.26	–14.6	–14.6	–14.6	Volatility	–2.6	–6.26	–10.26	–5.25
Liquidity	–2.6	–7.2	–10.26	–10.2	Liquidity	–14.6	–14.6	–14.6	–10.26
Tax	–10.26	–7.2	–12.25	–5.25	Tax	–10.26	–10.26	–2.6	–10.26

Table 11. Aggregated values

Conventional Bond Investors				
	FINANCE	CUSTOMER	INTERNAL	LEARNING
Volume	$\begin{bmatrix}\sqrt{.34}e^{j2\pi..58}, \\ \sqrt{.21}e^{j2\pi..36}, \\ \sqrt{.45}e^{j2\pi..07}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.20}e^{j2\pi..45}, \\ \sqrt{.13}e^{j2\pi..28}, \\ \sqrt{.67}e^{j2\pi..27}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.20}e^{j2\pi..45}, \\ \sqrt{.13}e^{j2\pi..28}, \\ \sqrt{.67}e^{j2\pi..27}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.24}e^{j2\pi..48}, \\ \sqrt{.14}e^{j2\pi..30}, \\ \sqrt{.62}e^{j2\pi..22}\end{bmatrix}$
Coupon rates	$\begin{bmatrix}\sqrt{.30}e^{j2\pi..55}, \\ \sqrt{.19}e^{j2\pi..34}, \\ \sqrt{.51}e^{j2\pi..11}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.32}e^{j2\pi..57}, \\ \sqrt{.20}e^{j2\pi..35}, \\ \sqrt{.48}e^{j2\pi..09}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.20}e^{j2\pi..45}, \\ \sqrt{.13}e^{j2\pi..28}, \\ \sqrt{.67}e^{j2\pi..27}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.30}e^{j2\pi..55}, \\ \sqrt{.19}e^{j2\pi..34}, \\ \sqrt{.51}e^{j2\pi..11}\end{bmatrix}$
Maturity	$\begin{bmatrix}\sqrt{.24}e^{j2\pi..48}, \\ \sqrt{.14}e^{j2\pi..30}, \\ \sqrt{.62}e^{j2\pi..22}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.25}e^{j2\pi..50}, \\ \sqrt{.15}e^{j2\pi..31}, \\ \sqrt{.60}e^{j2\pi..19}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.25}e^{j2\pi..50}, \\ \sqrt{.15}e^{j2\pi..31}, \\ \sqrt{.60}e^{j2\pi..19}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.20}e^{j2\pi..45}, \\ \sqrt{.13}e^{j2\pi..28}, \\ \sqrt{.67}e^{j2\pi..27}\end{bmatrix}$
Riskiness	$\begin{bmatrix}\sqrt{.30}e^{j2\pi..55}, \\ \sqrt{.19}e^{j2\pi..34}, \\ \sqrt{.51}e^{j2\pi..11}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.20}e^{j2\pi..45}, \\ \sqrt{.13}e^{j2\pi..28}, \\ \sqrt{.67}e^{j2\pi..27}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.29}e^{j2\pi..54}, \\ \sqrt{.18}e^{j2\pi..33}, \\ \sqrt{.53}e^{j2\pi..13}\end{bmatrix}$	$\begin{bmatrix}\sqrt{.27}e^{j2\pi..51}, \\ \sqrt{.16}e^{j2\pi..31}, \\ \sqrt{.59}e^{j2\pi..20}\end{bmatrix}$

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Table 11 (cont.). Aggregated values

Conventional Bond Investors				
	FINANCE	**CUSTOMER**	**INTERNAL**	**LEARNING**
Volatility	$\left[\begin{matrix}\sqrt{.29}e^{j2\pi..54},\\ \sqrt{.18}e^{j2\pi..33},\\ \sqrt{.53}e^{j2\pi..13}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.24}e^{j2\pi..48},\\ \sqrt{.14}e^{j2\pi..30},\\ \sqrt{.62}e^{j2\pi..22}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.29}e^{j2\pi..54},\\ \sqrt{.18}e^{j2\pi..33},\\ \sqrt{.53}e^{j2\pi..13}\end{matrix}\right]$
Liquidity	$\left[\begin{matrix}\sqrt{.27}e^{j2\pi..51},\\ \sqrt{.16}e^{j2\pi..31},\\ \sqrt{.59}e^{j2\pi..20}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.20}e^{j2\pi..45},\\ \sqrt{.13}e^{j2\pi..28},\\ \sqrt{.67}e^{j2\pi..27}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.24}e^{j2\pi..48},\\ \sqrt{.14}e^{j2\pi..30},\\ \sqrt{.62}e^{j2\pi..22}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.20}e^{j2\pi..45},\\ \sqrt{.13}e^{j2\pi..28},\\ \sqrt{.67}e^{j2\pi..27}\end{matrix}\right]$
T	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.20}e^{j2\pi..45},\\ \sqrt{.13}e^{j2\pi..28},\\ \sqrt{.67}e^{j2\pi..27}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.36}e^{j2\pi..60},\\ \sqrt{.22}e^{j2\pi..37},\\ \sqrt{.42}e^{j2\pi..03}\end{matrix}\right].$	$\left[\begin{matrix}\sqrt{.26}e^{j2\pi..51},\\ \sqrt{.16}e^{j2\pi..31},\\ \sqrt{.58}e^{j2\pi..18}\end{matrix}\right]$
G Bond Investors				
	NANCE	**CUSTOMER**	**INTERNAL**	**LEARNING**
Volume	$\left[\begin{matrix}\sqrt{.30}e^{j2\pi..55},\\ \sqrt{.19}e^{j2\pi..34},\\ \sqrt{.51}e^{j2\pi..11}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right].$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.27}e^{j2\pi..51},\\ \sqrt{.16}e^{j2\pi..31},\\ \sqrt{.59}e^{j2\pi..20}\end{matrix}\right]$
Coupon rates	$\left[\begin{matrix}\sqrt{.30}e^{j2\pi..55},\\ \sqrt{.19}e^{j2\pi..34},\\ \sqrt{.51}e^{j2\pi..11}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.32}e^{j2\pi..57},\\ \sqrt{.20}e^{j2\pi..35},\\ \sqrt{.48}e^{j2\pi..09}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.36}e^{j2\pi..60},\\ \sqrt{.22}e^{j2\pi..37},\\ \sqrt{.42}e^{j2\pi..03}\end{matrix}\right]$
Maturity	$\left[\begin{matrix}\sqrt{.27}e^{j2\pi..51},\\ \sqrt{.16}e^{j2\pi..31},\\ \sqrt{.59}e^{j2\pi..20}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.32}e^{j2\pi..57},\\ \sqrt{.20}e^{j2\pi..35},\\ \sqrt{.48}e^{j2\pi..09}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.32}e^{j2\pi..57},\\ \sqrt{.20}e^{j2\pi..35},\\ \sqrt{.48}e^{j2\pi..09}\end{matrix}\right]$
Riskiness	$\left[\begin{matrix}\sqrt{.30}e^{j2\pi..55},\\ \sqrt{.19}e^{j2\pi..34},\\ \sqrt{.51}e^{j2\pi..11}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.20}e^{j2\pi..45},\\ \sqrt{.13}e^{j2\pi..28},\\ \sqrt{.67}e^{j2\pi..27}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.22}e^{j2\pi..47},\\ \sqrt{.13}e^{j2\pi..29},\\ \sqrt{.65}e^{j2\pi..25}\end{matrix}\right]$
Volatility	$\left[\begin{matrix}\sqrt{.27}e^{j2\pi..51},\\ \sqrt{.16}e^{j2\pi..31},\\ \sqrt{.59}e^{j2\pi..20}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.36}e^{j2\pi..60},\\ \sqrt{.22}e^{j2\pi..37},\\ \sqrt{.42}e^{j2\pi..03}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.30}e^{j2\pi..55},\\ \sqrt{.19}e^{j2\pi..34},\\ \sqrt{.51}e^{j2\pi..11}\end{matrix}\right]$
Liquidity	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.22}e^{j2\pi..47},\\ \sqrt{.13}e^{j2\pi..29},\\ \sqrt{.65}e^{j2\pi..25}\end{matrix}\right].$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.22}e^{j2\pi..47},\\ \sqrt{.13}e^{j2\pi..29},\\ \sqrt{.65}e^{j2\pi..25}\end{matrix}\right]$
Tax	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.25}e^{j2\pi..50},\\ \sqrt{.15}e^{j2\pi..31},\\ \sqrt{.60}e^{j2\pi..19}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.32}e^{j2\pi..57},\\ \sqrt{.20}e^{j2\pi..35},\\ \sqrt{.48}e^{j2\pi..09}\end{matrix}\right]$	$\left[\begin{matrix}\sqrt{.27}e^{j2\pi..51},\\ \sqrt{.16}e^{j2\pi..31},\\ \sqrt{.59}e^{j2\pi..20}\end{matrix}\right]$

Table 12. Defuzzified values of the decision matrix

Determinant	Conventional Bond Investors				Green Bond Investors			
	FINANCE	CUSTOMER	INTERNAL	LEARNING	FINANCE	CUSTOMER	INTERNAL	LEARNING
Volume	1.846	1.305	1.305	1.437	1.705	1.500	1.500	1.570
Coupon rates	1.705	1.776	1.305	1.705	1.705	1.776	1.500	1.920
Maturity	1.437	1.500	1.500	1.305	1.570	1.776	1.500	1.776
Riskiness	1.705	1.305	1.638	1.570	1.705	1.305	1.500	1.373
Volatility	1.638	1.437	1.500	1.638	1.570	1.920	1.500	1.705
Liquidity	1.570	1.305	1.437	1.305	1.500	1.373	1.500	1.373
Tax	1.500	1.305	1.920	1.509	1.500	1.500	1.776	1.570

Table 13. Normalized decision matrix

Determinant	Conventional Bond Investors				Green Bond Investors			
	FINANCE	CUSTOMER	INTERNAL	LEARNING	FINANCE	CUSTOMER	INTERNAL	LEARNING
Volume	.427	.345	.323	.362	.400	.353	.368	.366
Coupon rates	.394	.470	.323	.429	.400	.418	.368	.447
Maturity	.332	.397	.371	.328	.369	.418	.368	.414
Riskiness	.394	.345	.405	.395	.400	.307	.368	.320
Volatility	.379	.380	.371	.412	.369	.452	.368	.397
Liquidity	.363	.345	.356	.328	.352	.323	.368	.320
Tax	.347	.345	.475	.380	.352	.353	.435	.366

Table 14. Weighted decision matrix

Determinant	Conventional Bond Investors				Green Bond Investors			
	FINANCE	CUSTOMER	INTERNAL	LEARNING	FINANCE	CUSTOMER	INTERNAL	LEARNING
Volume	.098	.096	.075	.094	.092	.098	.086	.095
Coupon rates	.091	.130	.075	.111	.092	.116	.086	.116
Maturity	.077	.110	.087	.085	.085	.116	.086	.107
Riskiness	.091	.096	.094	.102	.092	.085	.086	.083
Volatility	.087	.106	.087	.107	.085	.125	.086	.103
Liquidity	.084	.096	.083	.085	.081	.090	.086	.083
Tax	.080	.096	.111	.098	.081	.098	.101	.095

Table 15. Ranking investor perceptions

Determinant	Conventional Bond Investors				Green Bond Investors			
	D+	D-	RCİ	Ranking	D+	D-	RCİ	Ranking
Volume	.053	.023	.308	5	.038	.021	.352	5
Coupon rates	.036	.046	.557	1	.018	.046	.717	1
Maturity	.046	.018	.282	6	.022	.039	.646	3
Riskiness	.040	.030	.425	4	.054	.011	.169	6
Volatility	.037	.028	.436	3	.022	.045	.675	2
Liquidity	.054	.010	.163	7	.052	.004	.078	7
Tax	.041	.038	.480	2	.036	.024	.393	4

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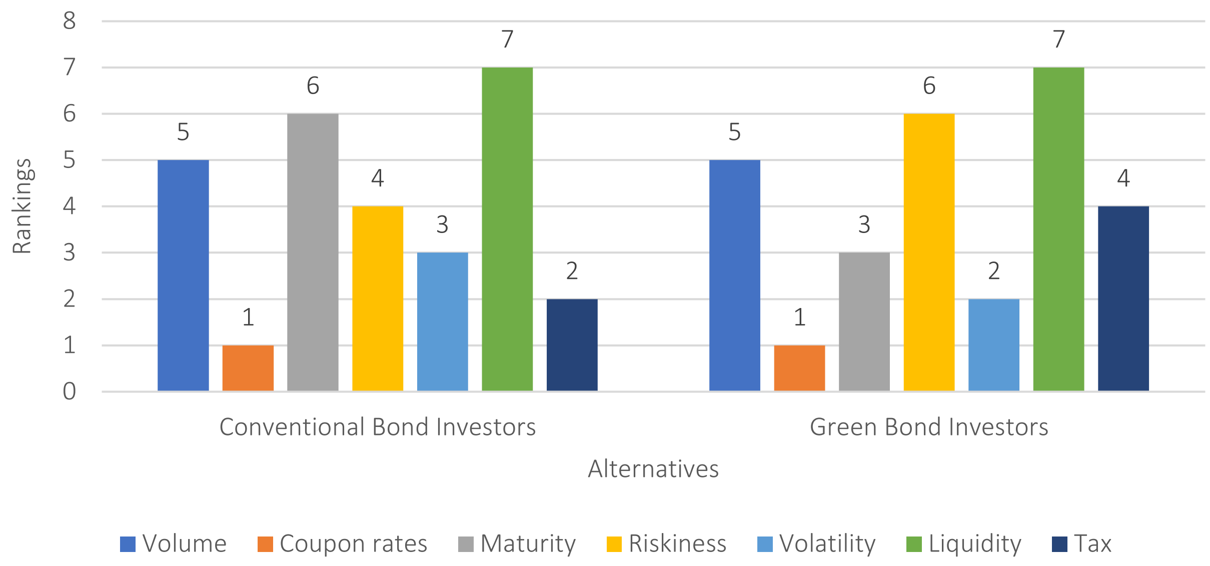

Figure 3. Comparative ranking results

(2022) mentioned that customer loyalty is important for maintaining long-term customer relationships. Therefore, it is very important for the performance of these bonds to take into consideration the expectations of the customers while issuing the bonds. In other words, in this process, it is necessary to offer diversity to meet customer expectations. On the other hand, Umar et al. (2023) and Jiang et al. (2022) concluded that one of the most important ways to meet customer expectations is transparency. In this context, clear information should always be provided to investors regarding the issued bonds. Moreover, necessary actions should be taken for the rapid solution of the problems that occur in the process. In this context, it is necessary to take quick actions regarding customer complaints thanks to effective solution centers.

It is seen that the low volatility of investments is very important in increasing the performance of green bonds. Renewable energy projects have many advantages. On the other hand, it is possible to talk about many disadvantages such as high costs, need for advanced infrastructure, energy storage difficulties and high payback time of projects. Therefore, low volatility contributes to safer green bonds. In this context, Elsayed et al. (2022) and Lin and Hong (2022) identified that it is necessary to reduce volatility especially in green bonds. In this context, first, bond issuing institutions should carefully evaluate their green bond projects. More accurate planning of projects increases the confidence of investors as it reduces volatility. The effectiveness of risk management is another issue to be considered in this process. Syed et al. (2022) and Rao et al. (2022) indicated that companies must accurately identify the risks of projects and implement appropriate risk management strategies. Thus, it is possible to reduce the volatility in the process.

CONCLUSIONS

This paper aims to evaluate the investor perception in the context of green and conventional bond investments. Within this scope, a new model is presented by considering two steps. First, a criteria set is generated by considering balanced scorecard perspectives. After that, the neuro Quantum fuzzy M-SWARA method is considered to weight these criteria. Secondly, seven critical determinants for bond investments are identified that are coupon rates, volume, maturity, riskiness, liquidity, volatility, and tax considerations. Neuro Quantum fuzzy TOPSIS approach is employed to rank these alternatives. It is identified that the customer is affected by all other three perspectives. Moreover, it is also found that finance and customer have an impact on learning and growth. The weighting results indicate that customer is the most critical factor that affects the investor perception to make investments to the bonds. Learning and growth also has an important role in this context. According to the ranking results, it is concluded that coupon rates are the most important item for both conventional and green bond investors. On the other side, with respect to the conventional bond investor, tax is the second most essential factor. However, regarding the green bond investors, volatility plays a critical role.

The main contribution of the study is that by combining the balanced scorecard framework and quantum-inspired decision-making techniques, this paper offers a novel and sophisticated approach to understanding investor behavior. The findings of this study hold significant implications for financial institutions, policymakers, and investors, providing valuable insights into promoting sustainable financing practices and optimizing investment decisions in the dynamic landscape of green and conventional bond markets. Similarly, in the proposed model, a new methodology is generated by the name of M-SWARA. In this framework, some enhancements are adopted to the SWARA technique. With the help of them, the causal directions can be considered in the evaluation process. However, the main limitation is that this analysis is conducted for only Kazakhstan. The results can be changed for different countries. Thus, for future research, a comparative analysis can be conducted between developing and developed economies. Therefore, it can be possible to generate appropriate strategies for the customers from different countries.

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