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An Evaluation of Women's Human Development Level using Multi Criteria Decision-Making Methods: A Case Study of OECD Countries

Abstract. *Women's rights, role in society, education periods, and working conditions are essential societal issues and are gaining more importance daily. With the spread of technology and globalization, societies can become more conscious. It is crucial to increase the role of women in society to increase the development level, quality, welfare level, economy level, and peace level of societies. For this reason, the role of women in society is a crucial issue for countries. In this respect, this paper aimed to evaluate women's human development level in OECD (Organization for Economic Co-operation and Development) countries using multi-criteria decision-making (MCDM) methods. Suitably, the MEREC (Method based on Removal Effects of Criteria) method was used to determine the criterion weights, and the MARCOS method (Measurement of Alternatives and Ranking according to Compromise Solution) was used to determine the rankings of the countries. According to the results, Switzerland, Norway, and Iceland performed at the highest levels in women's human development. Finally, the results are tested through sensitivity analysis to compare other well-known robust MCDM methods (ARAS, TOPSIS, MABAC). A very high correlation (greater than 95%) was found between the rankings of other well-known MCDM methods and those obtained by the methods used in this study.*

Keywords: *development, women's human development level, multi-criteria decision making*.

JEL Classification: C44, O15, O57.

1. Introduction

The primary goal of all developed and developing countries is to increase the level of welfare and realize their economic growth. While the concept of growth and sustainable development was limited to only economic concepts, it has been accepted that different social and environmental structure elements are also the subject of sustainable development as time goes on. The human development level

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of countries is of great importance for various aspects of their socioeconomic progress. In this context, Human Development Reports, published yearly since 1990, include various human phenomena such as people's ability to live a long and healthy life, access to the resources necessary for a reasonable standard of living, and cultural enrichment. In these reports, the human development index (HDI) value calculated annually and for each country is also published. This index has become a widely used ranking criterion that expresses countries' economic and social development and progress (Lind, 2019).

Today, several studies (Beine et al., 2008; Gerring et al., 2012; Samimi & Jenatabadi, 2014) have highlighted the significance of human development in terms of economic growth, education, healthcare, and social welfare. The human development level of countries plays a crucial role in various aspects of their socio-economic development. Influences the type and level of education required for economic growth, the distribution of skills and knowledge, social welfare, and the ability to benefit from globalization. Understanding and improving human development levels are essential for countries to achieve sustainable and inclusive development.

The level of women's human development in countries is essential for various reasons. Firstly, studies have shown that a country's HDI, which includes factors such as education, health, and income, is closely related to maternal health outcomes. It is crucial to consider economic data and other aspects of human development and capacity for survival, especially for low-income countries (Larroca et al., 2020). Women's engagement in agriculture also plays a significant role in human capital development in developing countries. Matthew et al. emphasize women's involvement in agriculture and human capital development in selected African countries. The study highlights the importance of empowering women and providing them with opportunities to participate in economic activities (Matthew et al., 2022). In addition, women's labour force participation rates are among the essential criteria for the development level of countries. The high rate of women's participation in the workforce provides stable growth and permanent development and contributes significantly to the development level of the countries. In this context, while the involvement of women in the labour market is high in developed countries, this rate is relatively low in underdeveloped countries.

Women's status and empowerment directly impact child nutrition in developing countries. Studies have shown that indicators of women's status, such as education and economic empowerment, are positively related to female life expectancy at birth. This highlights the importance of addressing gender inequalities and promoting women's empowerment to improve well-being in developing countries (Smith et al., 2003). Costantini and Monni (2008) emphasized the importance of human development being among the priority objectives of international development policies and increasing human welfare in line with a sustainable goal.

The Human Development Index can be considered the first and most crucial step toward including sustainability concepts in development criteria (Ülengin et al., 2011). Unfortunately, some countries with a high Human Development Index cannot

offer equal development for all segments of society. On the contrary, although indicators such as per capita income or education and health opportunities reflect a high level of development, it seems that they need to be encouraged and supported, especially in the context of women, to reach the average level of development.

In conclusion, the women's human development level of countries is crucial for various aspects of development, including maternal health, human capital development, women's work participation rates, women's per capita income, and education opportunities. Addressing gender inequalities, promoting women's empowerment, and providing opportunities for women's participation in economic and administrative activities are essential to improving the overall human development of countries. Considering the references mentioned above, there appears to be a research gap regarding determining the women's human development level of countries. Although some references touch on aspects of gender inequality and women's empowerment, further research is still needed to address the women's human development level in OECD countries.

The decision-making process is a complex and multifaceted task that is crucial in various fields. It involves considering costs and benefits, weighing options, and choosing based on multiple factors. Decision theories in the literature are also developing with the development of science branches such as statistics and operations research. Multi-criteria decision-making (MCDM) is a discipline that has gained significant attention in recent years. The importance of the multi-criteria decision-making process lies in its ability to handle complex decision problems with multiple criteria and objectives. MCDM methods provide decision-makers with a structured framework for evaluating alternatives and making informed choices. By considering all relevant factors and their relative importance, MCDM methods enable decision-makers to make rational and optimal decisions in various domains.

As mentioned above, women's human development level needs to be investigated and examined. At the same time, it should be considered a problem that should be decided by evaluating many criteria together. Since the concept of women's human development level includes various criteria, it was predicted that it would be beneficial to use multi-criteria decision-making methods. In this direction, the MEREC and MARCOS methods evaluate women's human development levels in OECD countries. The MEREC and MARCOS methods have been selected for several reasons. First, the MEREC method is an objective weighting method that utilizes the removal effects of criteria in the decision matrix to determine their importance (Keshavarz-Ghorabaee et al., 2021). This approach allows decision-makers to assess the impact of each criterion on the overall decision and assign appropriate weights accordingly. By considering the removal effects, the MEREC method provides a more comprehensive and accurate representation of the significance of the criteria. Another advantage of the MEREC method is its stability in ranking solutions. A study comparing different MCDM methods found that the MEREC method exhibited stable rankings of solutions, indicating its reliability and consistency. This stability is crucial in decision-making processes as it ensures that the chosen solution remains robust and reliable.

On the other hand, the MARCOS method is selected because it offers a novel approach to evaluating alternatives based on ideal and anti-ideal solutions. The MARCOS method determines utility degrees for both solutions, allowing for a comprehensive assessment of the alternatives. The MARCOS model provides a systematic and rigorous framework for evaluating alternatives and ranking them according to their performance. Furthermore, the MARCOS model has gained momentum in the literature and has been applied to various decision-making problems (Kovač et al., 2021). This feature indicates its versatility and effectiveness in solving MCDM problems. Additionally, the MARCOS model has been used with other weighting methods such as the SWARA, BWM, FUCOM, and Entropy, further enhancing its applicability and operability. Combining the MARCOS model with other techniques makes the decision-making process more robust and comprehensive.

In summary, the MEREC and MARCOS models are selected to solve MCDM problems due to their ability to calculate weights for criteria, evaluate alternatives based on ideal and anti-ideal solutions, and provide a comprehensive and systematic framework for decision-making. These models have been widely applied and have demonstrated their effectiveness in various domains, making them suitable for solving MCDM problems. Considering the ideas and plans mentioned, this study will contribute to the literature on the subject discussed, the method used, and the use of objective data. For the purpose given above, this study is guided by the following research questions:

RQ1: Which indicator is more critical in assessing countries' women's human development levels?

RQ2: What are women's human development level status in OECD countries?

RQ3: How can countries' human development levels be monitored regarding women?

In summary, the contributions of this article can be expressed as follows:

- MCDM methods were used in a real case study to fill the gap in the related literature, primarily based on human development related to women indicators.
- The women's human development level in OECD countries was measured using various MCDM techniques.
- The proposed MCDM model assisted in achieving accurate and reliable results with fewer computations in a reasonable time; therefore, it was not laborious and time-consuming for decision-makers.
- This case study using MCDM methods can also be extended or modified for other countries.

The remaining sections of this study are structured as follows. Section 2 mentions the literature about the women's human development level, which constitutes the study's data set, and the methods used. The theoretical backgrounds of the proposed methods are given in Section 3. Section 4 shows the indicators, explanations, and references to women's human development level provided under the research methodology title. The results of the MEREC and MARCOS methods

and the sensitivity analyses regarding the robustness of the proposed mode are included in Section 5. Finally, the results and suggestions for future studies are presented in the seventh and last part of the study.

2. Literature review

Human development began to be recognized in 1990 under the Human Development Reports of the United Nations Development Program (UNDP). The programme has become an index that measures and ranks the human development performance of countries since 1990. In addition, this index has become a tool used to compare and measure countries' investments in human development. In the early 1980s, it was understood that income level alone could not be seen as an indicator of the development of countries. After this awareness, the perspective of countries has changed, and it has been seen that human issues are also important. In other words, it has been understood that development has economic and social dimensions. The concept of human development began to be used extensively in the literature in the 1990s. In this way, the factors that show the development level of the countries have started to change.

In other words, with the advancement of information technologies, there has been a transition from an industrial society to an information society. A change has occurred in the world economy with the effect of globalization. As a result, profound changes have happened in the countries' development and development stages. As a result of further growth and development approaches, information, research and development, and innovation-based development strategies have come to the fore. As a result of the analysis based on gender, which is an essential indicator of the level of development, the role of women in economic life and the labour of women are highlighted under the title of human capital. In the transition process from an income-based development approach in the world economy to a human-oriented, that is, human factors-based development approach, it has been observed that an understanding has been adopted to reduce the situations related to gender inequalities and women's being in the background (Tunç, 2018). When the literature is examined, it is shown that there were limited studies related to women's human development level. Some of the studies on women's human development level are given below.

Er (2012) aimed to determine which indicators of education, employment, health, and political factors among women's human development level indicators significantly explain economic growth. Şahin and Alp (2020) examine the negativities of sociocultural, economic, bureaucratic, and political issues based on the gender of people and the discriminations made based on this. While calculating the economic growth contribution in the study, the data of the gross domestic product, gross fixed capital formation, and female labour force participation rate for the Turkish economy were used.

Mammen and Paxson (2000) discuss how the role of women in the workforce changes according to the level of economic development. Okeke-Uzodike (2019) examines the gendered policy approaches and initiatives of governments to advance

entrepreneurial development. The study findings provide insight into the gaps in creating sustainable women's entrepreneurship and development activities. Selvi and Karanfil (2016), in their study, examined the relationship between physical and sexual intimate partner violence rates, which varied based on countries, power distance within Hofstede's cultural dimensions, and individualism/collectivism and tried to determine the mediating effect of the country economy variable on these relations. Güney (2017) analyses the effect of population growth on sustainable development. Colak (2020) draws attention to women's employment in the agricultural sector in his study, which examines the relationship between Turkey's development process and the transformation of the agricultural sector. The rate of female employment in the agricultural sector and the effect of female employment in the agricultural sector on agricultural production in this period were investigated. Mangaraj and Aparajita (2020) designed a generalized human development index (GHDI) model using the DEA-MCDM approach. Mirziyoyeva and Salahodjaev (2021) contribute to the growing research on the political empowerment of women and its impact on their quality of life in their studies. In particular, the relationship between the Dec parliamentary representation of women and the sustainable development goals is being investigated.

When the literature related to OECD countries was investigated, some papers touched on the various aspects of women's human development level. Duflo (2012) provides a masterful summary of the long-term evaluation of the place of women in society; Borgonovi et al. (2018) discuss the gender gap in educational outcomes in Norway; Jütting et al. (2008) examine the correlation between gender inequality and women's labour-force participation in OECD countries; Tahir et al. (2020) examine the correlation between gender inequality and women's labour-force participation in OECD countries; Giner et al. (2022) focus on gender aspects and policies that address gender inequality in food systems.

Considering the importance of women's human development levels in OECD countries and the existence of limited studies related to this issue, this study will fill this critical gap in the literature. For this purpose, a hybrid methodology that integrates MCDM methods has been used to evaluate women's human development levels in OECD countries.

3. Theoretical background of the proposed methods

This paper used the MEREC method to determine the importance of the criteria weights related to women's human development level. Then, women's human development levels in the OECD countries are analysed using the MARCOS method. The theoretical background of these methods is explained in detail below.

3.1 MEREC method

This study used an objective weighting method called MEREC to determine the criterion weight proposed by Keshavarz-Ghorabaee et al. (2021). Objective weighting methods are based on initial data or a decision matrix to assess criterion

weights. These methods use variations in the performance of the different alternatives for each criterion to determine the weights. The weights of the criteria with more variation will be higher. When MEREC determines the weight of a criterion, it turns off that criterion and focuses on the change in the total criterion weight. In other words, the proposed method uses each criterion's lifting effects on the alternatives' overall performance to calculate criterion weights. If the elimination of a criterion has a more significant effect on the overall performance of the alternatives, then that criterion can have a greater weight. This perspective can help decision-makers to exclude some criteria from the decision-making process. This feature mentioned in the preceding paragraph distinguishes the MEREC method from other objective weighting methods such as ENTROPY, CRITIC, and CILOS. In addition, ease of understanding, ease of calculation, and solid mathematical background are among the crucial advantages of the method compared to other objective weighting methods. The MEREC method consists of the following steps (Keshavarz-Ghorabaee et al., 2021).

Step 1: The decision matrix includes a set of n criteria and m alternatives, as shown in Eq. (1).

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \tag{1}$$

Step 2: The normalized decision-making matrix is calculated by Eq. (2) where *B* represents a set of beneficial criteria, while *C* represents a set of non-beneficial criteria.

$$n_{ij} = \begin{cases} \dfrac{\min\limits_k x_{kj}}{x_{ij}} & if\ j \in B \\ \dfrac{x_{ij}}{\max\limits_k x_{kj}} & if\ j \in C \end{cases} \tag{2}$$

Step 3: The overall performance of the alternatives is calculated by using Eq. (3).

$$S_i = ln\left(1 + \left(\frac{1}{n}\sum_j \left|\ln(n_{ij})\right|\right)\right) \tag{3}$$

Step 4: The performance of the alternatives by removing each criterion is calculated using Eq. (4). By removing each criterion from the whole criteria set, *n* sets of performances are gained concerning *n* criteria.

$$S'_{ij} = ln\left(1 + \left(\frac{1}{n}\sum_{k,k\neq j} \left|\ln(n_{ij})\right|\right)\right) \tag{4}$$

Step 5: The summation of absolute deviations is calculated by Eq. (5), whereas E_j represents the effect of removing the *j*th criterion.

$$E_j = \sum_i \left| S'_{ij} - S_i \right| \tag{5}$$

Step 6: In the last step of the MEREC method**,** the weight coefficients of the criteria are calculated by Eq. (6).

$$w_j = \frac{E_j}{\sum_k E_k} \tag{6}$$

3.2 MARCOS method

Stevic et al. presented the main ideas of the MARCOS (Measurement of Alternatives and Ranking according to Compromise Solution) method. The MARCOS method is based on defining the relationship between alternatives and reference values (ideal and anti-ideal alternatives). Based on the defined relationships, the utility functions of alternatives are determined, and compromise ranking is made concerning ideal and anti-ideal solutions. Decision preferences are defined based on utility functions. Utility functions represent the position of an alternative concerning an ideal and anti-ideal solution. The best alternative is the one closest to the ideal and, simultaneously, furthest from the anti-ideal reference point (Stevic et al., 2020).

The procedure for the MARCOS method consists of the following steps (Stevic et al., 2020):

Step 1*:* Form the initial decision matrix.

The initial decision matrix includes a set of n criteria and m alternatives. In the case of group decision-making, expert evaluation matrices are aggregated into an initial group decision-making matrix.

Step 2*:* Form the extended initial decision matrix.

The extended initial decision matrix is created by defining ideal (AI) and anti-ideal (AAI) solutions, as shown in Eq. (7).

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \\ A_{AAI} \\ A_{AI} \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \\ x_{aa1} & x_{aa2} & \cdots & x_{aan} \\ x_{ai1} & x_{ai2} & \cdots & x_{ain} \end{bmatrix} \end{array} \tag{7}$$

AI and AAI are calculated by using Eqs. (8)-(9) depending on the nature of the criteria.

$$AI = \max x_{ij} \text{ if } j \in B \text{ and } \min x_{ij} \text{ if } j \in C \tag{8}$$

$$AAI = \min x_{ij} \text{ if } j \in B \text{ and } \max x_{ij} \text{ if } j \in C \tag{9}$$

where B represents the benefit-based criteria, while C represents the cost-based criteria

***Step 3**:* Normalization of the extended initial decision matrix.

The normalized matrix N is calculated by using Eqs. (10)-(11).

$$n_{ij} = \frac{x_{ij}}{x_{ai}} \quad \text{if } j \in B \tag{10}$$

$$n_{ij} = \frac{x_{ai}}{x_{ij}} \quad \text{if } j \in C \tag{11}$$

where x_{ij} and x_{ai} represent the elements of the extended initial decision matrix (X).

***Step 4**:* Determination of the weighted decision matrix (V).

The weighted matrix V is obtained by multiplying the normalized matrix elements with the weight coefficients of the criterion w_j as shown in Eq. (12).

$$v_{ij} = n_{ij} \times w_j \tag{12}$$

***Step 5**:* Forming the utility degrees of alternatives (K_i).

The utility degrees of alternatives are calculated by using Eqs. (13)-(14).

$$K_i^{+} = \frac{S_i}{S_{ai}} \tag{13}$$

$$K_i^{-} = \frac{S_i}{S_{aai}} \tag{14}$$

S_i represents the sum of the weighted decision matrix (V) elements, as shown in Eq. (15).

$$S_i = \sum_{i=1}^{n} v_{ij} \tag{15}$$

***Step 6**:* Forming of the utility function of alternatives $f(K_i)$.

The utility function compromises the observed alternative concerning the ideal and anti-ideal solution. This function is calculated by using Eq. (16).

$$f(K_i) = \frac{K_i^{+} + K_i^{-}}{1 + \frac{1-f(K_i^{+})}{f(K_i^{+})} + \frac{1-f(K_i^{-})}{f(K_i^{-})}} \tag{16}$$

Utility functions concerning the ideal and anti-ideal solution are calculated using Eqs. (17)-(18), respectively.

$$f(K_i^{+}) = \frac{K_i^{-}}{K_i^{+} + K_i^{-}} \tag{17}$$

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-} \quad (18)$$

Step 7: Ranking the alternatives.

The best alternative has the highest rank in terms of the value of the utility function $f(K_i)$.

4. Case Study: Evaluation of women's human development level in OECD countries

This study focuses on secondary data, including indicators of various levels of human development for women. The human development level of women is evaluated according to ten independent indicators, as shown below, with their short explanations and units.

C1: Life Expectancy: The average number of years of life expected by a hypothetical group of individuals who will be exposed to mortality rates of a particular period during their entire lives. It has been expressed over the years (https://hdr.undp.org/en/content/gender-development-index-gdi).

C2: Estimated Gross National Income Per Capita: GNP per capita (formerly GNP per capita) is the gross national income converted into US dollars using the World Bank Atlas method and divided by the midyear population. GNP is the sum of the net revenues of any product tax (fewer subsidies) plus primary income from abroad (compensation of employees and property income), which are not included in the valuation of value-added plus output by all established producers (https://hdr.undp.org/en/content/gender-development-index-gdi).

C3: Mean years of schooling: The average number of years of education taken by persons aged 25 and over has been converted from education level levels using the official times for each level (https://hdr.undp.org/en/content/gender-development-index-gdi).

C4: Labour Force Percent for Female: The percentage of the female workforce in the total shows how active women are in the workforce. The labour force consists of persons aged 15 years and older who provide labour for producing goods and services within a certain period (http://wdi.worldbank.org).

C5: Women in Parliaments: Women in parliaments are the percentage of parliamentary seats women hold in a single or lower chamber (http://wdi.worldbank.org).

C6: Business and Law Index Score: The index measures how laws and regulations affect women's economic opportunities. Total scores are calculated by taking the average score for each of the eight areas (Going Places, Getting a Job, Getting a Salary, Getting Married, Having a Child, Doing a Business, Managing Assets, and Receiving a Pension), with 100 representing the highest possible score (http://wdi.worldbank.org).

C7: Perception of Community Safety: The percentage of women aged 15 and over who report feeling safe walking alone at night in the city or area where they live (https://giwps.georgetown.edu/the-index/).

C8: Intimate Partner Violence: Percentage of women who are always partners who have experienced physical or sexual violence committed by their close partners in the previous 12 months (https://giwps.georgetown.edu/the-index/).

C9: Birth Rate: The birth rate is the number of live births per 1,000 people in a population over a certain period (https://worldpopulationreview.com/country-rankings/birth-rate-by-country).

C10: Female Unemployment: Unemployment refers to the percentage of the labour force that is unemployed but looking for work and looking for a job.

(https://www.indexmundi.com/facts/indicators/SL.UEM.TOTL.FE.ZS/rankings).

The following part of the study will use secondary data regarding the criteria as mentioned above. The MEREC method is used to prioritize and weigh various criteria influencing women's human development, while MARCOS is applied to rank countries based on these criteria. This hybrid approach comprehensively assesses women's human development levels across OECD countries. Fig. 1 exhibits the flowchart of the introduced framework.

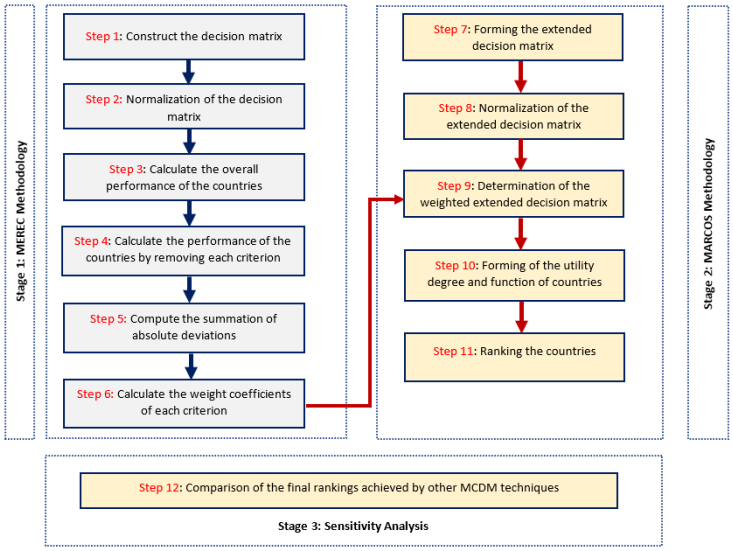

Figure 1. The Flowchart of Proposed Methodology

Source: Authors' own creation.

The data of 37 OECD countries have been obtained according to ten independent indicators, as explained above, and the decision matrix used in the MEREC and MARCOS methods was created, as shown in Table 1.

Table 1. Decision matrix

Country/ Criterion	C1 max	C2 max	C3 max	C4 max	C5 max	C6 max	C7 max	C8 min	C9 min	C10 min
Australia	85.8	37486	12.8	47.2	31.1	96.9	54.0	3.0	11.4	4.8
Austria	84.1	43414	12.0	46.8	40.4	96.9	82.0	4.0	9.5	6.2

Country/ Criterion	C1 max	C2 max	C3 max	C4 max	C5 max	C6 max	C7 max	C8 min	C9 min	C10 min
Belgium	84.3	42533	12.3	46.8	42.0	100.0	56.0	5.0	9.8	6.5
Canada	84.7	38652	13.9	47.1	30.5	100.0	61.0	3.0	9.8	7.3
Chile	81.4	17553	10.8	41.0	35.5	80.0	28.0	6.0	11.5	9.4
Colombia	76.4	10281	9.0	41.1	18.8	84.4	36.0	12.0	13.7	18.3
Czech Republic	80.9	30455	12.7	44.4	25.0	93.8	67.0	4.0	9.5	3.6
Denmark	83.3	49876	13.2	46.9	39.7	100.0	78.0	3.0	11.0	4.9
Estonia	81.2	30995	13.8	48.8	25.7	97.5	71.0	4.0	9.9	6.0
Finland	84.7	41698	13.0	47.8	46.0	97.5	78.0	8.0	8.5	6.9
France	85.5	38403	11.4	48.8	39.5	100.0	69.0	5.0	10.4	8.0
Germany	83.2	46150	13.8	46.7	34.9	100.0	71.0	3.0	9.1	3.1
Greece	82.9	22890	11.1	44.8	21.7	100.0	56.0	5.0	7.4	18.8
Hungary	77.9	25909	12.1	46.5	13.1	96.9	64.0	6.0	10.2	4.3
Iceland	84.2	47136	13.9	45.9	47.6	100.0	74.0	3.0	12.1	6.2
Ireland	83.8	61104	11.8	46.5	22.5	100.0	78.0	3.0	11.2	6.6
Israel	84.3	34960	13.4	47.9	28.3	80.6	77.0	6.0	19.0	4.9
Italy	85.1	31100	10.6	42.6	35.7	97.5	64.0	4.0	6.9	11.2
Japan	87.7	30621	13.3	44.6	9.7	78.8	70.0	4.0	6.6	2.5
Korea	86.8	29300	11.9	42.7	19.0	85.0	75.0	8.0	5.6	3.5
Latvia	77.8	27882	13.6	49.3	29.0	100.0	62.0	6.0	8.7	6.8
Lithuania	78.8	33891	13.6	49.6	27.7	93.8	61.0	5.0	9.4	7.4
Luxembourg	84.8	70117	13.0	46.8	35.0	100.0	88.0	4.0	10.3	5.7
Mexico	74.9	12456	9.1	38.3	50.0	88.8	40.0	10.0	14.5	4.2
Netherlands	83.4	46301	12.4	47.0	39.3	97.5	72.0	5.0	10.4	4.0
New Zealand	84.3	36864	12.9	47.5	49.2	97.5	42.0	4.0	12.3	4.1
Norway	84.9	54699	13.1	47.2	45.0	96.9	86.0	4.0	10.0	4.8
Poland	80.4	25261	13.3	45.3	28.3	93.8	65.0	3.0	10.2	3.4
Portugal	84.1	28713	9.6	49.7	40.0	100.0	72.0	4.0	7.8	6.9
Slovakia	78.4	24849	12.9	47.0	22.7	85.0	58.0	6.0	10.7	7.0
Slovenia	83.8	33038	12.8	46.2	26.7	96.9	85.0	3.0	8.7	5.4
Spain	85.8	31213	10.5	47.1	43.4	100.0	78.0	3.0	7.4	16.7
Sweden	84.9	49580	12.8	47.2	47.0	100.0	74.0	6.0	10.7	8.8
Switzerland	85.9	54597	13.5	46.8	42.5	88.1	85.0	2.0	9.8	5.6
Turkey	76.1	9920	8.3	32.0	17.3	82.5	48.0	12.0	14.1	15.6
United Kingdom	82.8	37374	13.4	47.9	34.3	97.5	74.0	4.0	10.0	4.3
United States	80.2	51539	13.7	46.1	27.6	91.3	61.0	6.0	11.0	5.2

Source: Authors' processing.

5. Results and sensitivity analysis

In the first phrase of analysis, MEREC calculates the relative importance of women's human development level using Eqs. (1)-(6). The findings are demonstrated in Table 2 and illustrated in Figure 2.

Table 2. The weight coefficients of woman's development indicators

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
w_j	0.0175	0.1041	0.0834	0.1170	0.1773	0.1533	0.1127	0.0840	0.0869	0.0637

Source: Authors' processing.

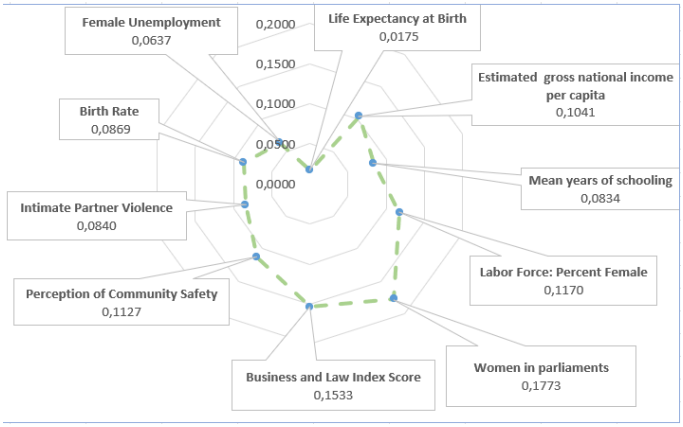

Figure 2. The radar chart of the indicators' weights
Source: Authors' own creation.

Concerning the results of the MEREC method, "Women in Parliaments" is the most significant indicator for determining women's human development level of the OECD countries, followed by "Business and Law Index Score" and "Labour Force: Percent Female." This result shows that countries should work in a disciplined manner on the "Women in Parliament," "Business and Law Score," and "Labour Force: Percent Female" criteria to increase women's human development level. In the next step of the study, these weights are used to calculate the rankings of the OECD countries using the MARCOS method.

In the second phrase of analysis, MARCOS method was applied to define the ranks of OECD countries regarding women's human development level using Eqs. (7)-(18). The findings are demonstrated in Table 3.

Table 3. Rankings of the OECD countries

Country	f(Ki)	Ranking
Australia	0.6484	20
Austria	0.7011	9
Belgium	0.6710	15
Canada	0.6620	19
Chile	0.5177	35
Colombia	0.4334	36
Czech Republic	0.6279	25
Denmark	0.7262	5
Estonia	0.6381	23
Finland	0.7048	8
France	0.6654	18
Germany	0.7259	6
Greece	0.5691	31
Hungary	0.5631	33
Iceland	0.7352	3
Ireland	0.6698	17
Israel	0.6034	30

Country	f(Ki)	Ranking
Italy	0.6405	22
Japan	0.6048	29
Korea	0.6118	28
Latvia	0.6277	26
Lithuania	0.6222	27
Luxembourg	0.7348	4
Mexico	0.5680	32
Netherlands	0.6944	11
New Zealand	0.6830	12
Norway	0.7469	2
Poland	0.6461	21
Portugal	0.6739	14
Slovakia	0.5596	34
Slovenia	0.6703	16
Spain	0.6980	10
Sweden	0.7062	7
Switzerland	0.7614	1
Turkey	0.4167	37
United Kingdom	0.6828	13
United States	0.6318	24

Source: Authors' processing.

Table 3 shows that Switzerland, Norway, and Iceland have the highest performance scores, while Turkey, Colombia, and Chile have the lowest. Finally, a sensitivity analysis can help decision-makers prove the outcomes by examining some changes in the primary model and understanding the robustness of the proposed model. For this purpose, the ranking results were obtained using well-known MCDM methods such as MABAC (Attributive Border Approximation Area Comparison), TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), and ARAS (Additive Ratio Analysis). A comparative result of these MCDM methods is shown in Fig. 3. The weight set obtained by the MEREC method, as shown in Table 2, was used in this step of the sensitivity process.

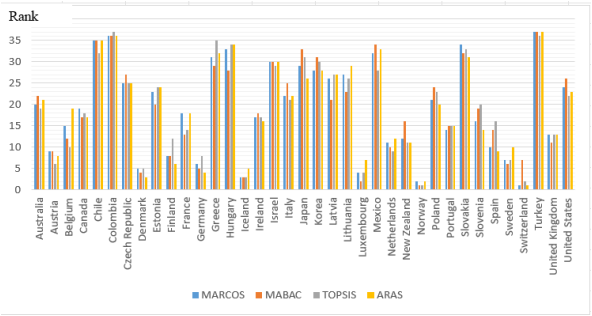

Figure. 3. Sensitivity analysis
Source: Authors' processing.

In addition, Spearman's correlation coefficient (SCC) was used to determine the ranking position of the results between the MEREC-MARCOS model and all the other MCDM methods mentioned. The Spearman correlation coefficients are shown in Table 4.

Table 4. The Spearman correlation results

		MEREC&MABAC	MEREC&TOPSIS	MEREC&ARAS	Average Value
(Proposed model)	SCC	0.968**	0.977**	0.989**	0.978
	n	37	37	37	

**p<0.001

Source: Authors' processing.

Table 4 shows a significant correlation between the ranks of the proposed MEREC-MARCOS model and all other mentioned MCDM methods ($p<0.001$). It is clearly visible that the results of the MEREC-MARCOS model are close to those of the other methods mentioned. Therefore, the outcomes verify the applicability of the proposed model.

6. Conclusion and Discussion

This study aims to measure women's human development level with MCDM methods based on OECD countries. In this direction, data from 37 OECD countries based in 2021 were used to measure women's human development level. Within the scope of the study, criteria weights were determined by applying the MEREC method and then using the MARCOS method; the OECD countries within the scope of the research were ranked according to the human development level criteria for women. In addition, a sensitivity analysis was performed to test the sensitivity and reliability of the results.

According to the findings, the highest weighted criteria were women in Parliament (% 17,73), the business and law index score (% 15,33), and the labour force percent for females (% 11,70), respectively. The lowest weighted criteria were life expectancy (% 1,75), female unemployment (% 6,37), and mean years of schooling (% 8,34). Women in Parliament refers to the presence and participation of women in legislative bodies. It encompasses the descriptive representation of women, meaning the proportion of women in Parliament, and the substantive representation of women's interests and concerns (Wängnerud, 2009). The related works show that women in Parliament play a crucial role in strengthening the position of women's interests (Wängnerud, 2009), stimulating economic growth (Altuzarra et al., 2021), harming corruption (Jha & Sarangi, 2018), and advocating for gender equality (Verge, 2020). These findings align with the current study's results and support the importance of the women in parliament criteria in terms of the human development level of countries.

The Business and the Law index is associated with more women in the labour force with higher incomes and better development outcomes. Equality before the law and economic opportunity are not only wise social policies, but also sound economic

policies. The equal participation of women and men will give every country a chance to achieve its potential. The labour force percentage for females refers to the percentage of women who actively participate in the labour force. It is an essential criterion for assessing the human development level of countries. The related works show that it reflects progress towards gender equality (Goldin, 2014), contributes to economic growth (Ustabas & Gulsoy, 2017), and has implications for socio-economic empowerment and poverty reduction (Majumder & Dey, 2021). Understanding the factors that influence participation in the female labour force is crucial for designing policies and interventions that promote gender equality and inclusive economic development. These findings align with the current study's results that support the importance of "the labour force percent for females" criterion.

After determining the importance levels of the criteria, the human development levels of women in the OECD countries were determined using the MARCOS method. According to the results, Switzerland, Norway, and Iceland received the highest scores, with scores very close to each other. Switzerland has the best ranking in terms of women's level of human development. The reason for this can be cited as an example of the various investments made in public health and education by countries that have reached the top of the human development level for women (Hickel, 2020). In the context of Iceland, it can be stated that being one of the oldest parliamentary democracies in the world, receiving high scores on scales indicating equality and human rights, and having a presence in the export economy despite its small population have factors that put it at the top (Schoper et al., 2018). In addition, factors such as the medium population size, stable election periods, and a sound and sustainable market economy are among the reasons that keep Switzerland, Norway, and Iceland in the first place. Although the Human Development Report (2021) ranked Switzerland and Norway at the top with scores of 0,962 and 0.961, it also touched on the importance of standard measurements such as life expectancy, education level, and GDP for countries. Especially in Nordic countries, the existence of a large and developed middle class and the development of civil society have led to the development of essential social factors. The Women's Economic Opportunity Index (WEOI) is defined as an index that measures and evaluates the enabling environment for women's participation in the economy. WEOI considers the laws and regulations that allow women to work equally with men as business owners. In this index, it can be considered remarkable that Norway, Finland, and Germany have the best rankings, which shows a similarity to the paper's results (Gaye et al., 2010). According to the results obtained, it is seen that these countries, which are in the top three in the ranking, are more conscious about the human development level of women compared to other countries.

On the other hand, Turkey, Colombia, and Chile are at the bottom of the rankings. According to Tunç and Ertuna's study, based on the HDI index in the years 1980-2013, it is said that although Turkey has increased its score, it appears to be a middle-level country compared to nearby bloc countries. Although it is known that the investments made in this field are of profound importance, it would be appropriate to point out that the results can be seen over a long period. Turkey should

give more importance to education and health and invest in these areas (Tunç & Ertuna, 2015). In addition, the Human Development Report (2021) results show that Turkey has increased its score. Despite this improvement, it lags behind the European countries, especially in human development issues related to women, according to the results of this paper.

When explicitly evaluated in Colombia, it has been stated that factors such as gender inequality, income difference between women and men, and poverty rate measured by the Gender Development Index (GDI) hurt the country's human development. In addition, political violent conflicts and attacks by minority groups also negatively affect the country's level of development, both in terms of humanity and women and children (Gómez et al., 2003). In the case of Chile, unlike most Latin America, the fact that family units are settled distinguishes the country from others. However, the country's colonial periods and independence struggles kept the human security issue on the agenda (Crowther, 2021). The country's decentralization process creates inequality between Chilean regions and municipalities (UNDP, 1996). In order to achieve better rankings on the Human Development Index specifically for women, the country must first improve security, economic, health, environmental, personal, social, and political issues.

This paper presents an applicable methodological framework to identify influential criteria and evaluate alternatives. Thus, it can help to adequately structure decision-making problems that are suitable for real-life conditions. The proposed methodology is an effort to ensure a reliable decision support system to evaluate the human development capability of OECD countries in terms of women's indicators. Considering the weaknesses, the study outcomes can give policymakers and authorities an idea of how to improve women's human development levels in a country.

Future studies could especially investigate women's human development levels in emerging countries. In addition, it could focus on topics such as women's empowerment and economic development, women in educational administration, socioeconomic gender inequality, the impact of trade liberalization on women's empowerment, and women's entrepreneurship. In conclusion, future research on women's human development levels can employ various decision-making methods, including examining the relationship between women's empowerment and economic development and investigating the role of women in economic development. Investigation of these topics can provide valuable insights into promoting gender equality and enhancing women's human development worldwide.

Naturally, this paper has some limitations. The number of evaluation criteria related to women's human development level may need to be increased to determine the actual ranking of countries. Considering the issues mentioned for further studies, related criteria may be added. In addition, this study used only the MEREC method to determine the criteria weights. Therefore, other objective methods can support the analysis to reach more reliable results in the future. Lastly, considering the OECD countries in this study can be a limitation. Future studies may focus on different,

especially emerging countries or other organizations such as the European Union, United Nations, and G7 countries.

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