Development of a Hybrid Decision Support System for Selecting the Air Filters Based on Multiple Criteria

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***Abstract*— To select an air purifier that fully meets the needs of consumers, this study was conducted to provide the most objective and effective suggestions in making decisions and evaluating different smart purifier options that suit the tastes of users. Such decision-making is complicated for non-professionals when there are countless large and small brands on the market today with many different prices, features, and incentives. In such complex situations, decision-making with TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) can be used to eliminate risk and to better represent the preferences of decision-makers. From modeling to using the Entropy method and the TOPSIS method, all are done to serve the ultimate goal of choosing a good air purifier that meets the needs of customers.**

Keywords*— Air Purifier, Entropy Method, MCDM, TOPSIS

I. INTRODUCTION

Since people spend a significant portion of their time indoors, understanding indoor air quality is crucial. The health risks of particulate matter exposure are well-established, contributing to substantial illness and death globally. To combat indoor air pollution, new technologies are emerging, with portable home air purifiers (HAPs) being one of the most effective solutions for eliminating harmful pollutants originating both indoors and outdoors [1]. It is important to note that this information is often obtained from mass media sources and should be evaluated objectively. Air pollution is a pressing global issue that affects billions of people worldwide. Fine particulate matter and harmful emissions in the atmosphere pose a serious threat to human health. Living in an era of continuous industrialization, humanity faces numerous problems such as air pollution caused by factories, enterprises, transport and aviation companies, thermal power plants, and other sources. Without effective interventions and remediation, this problem will continue to worsen, greatly impacting people's health, economy, and quality of life. Given the current state of heavy environmental pollution, air purifiers have become essential in protecting our health, particularly our respiratory and digestive systems. An air purifier is a device that effectively purifies dust and dirt through standard dust filter layers combined with advanced ionization technology. This machine eliminates allergens, odors, and mold, thereby minimizing the impact of smog, harmful emissions, and bacteria. The air purifier can filter out dirt in the air, improving the quality of the surrounding environment. Thus, air purifiers can significantly reduce the health risks [2]. In Vietnam, air purifiers have become an important tool to support human life. The technology market, especially the field of health support, is highly competitive and rapidly developing. Many famous manufacturers in the world produce air purifier products, such as Air purifiers from technologically advanced countries such as Japan, Korea, and Sweden, including brands like SHARP, DAIKIN, COWAY, ELECTROLUX, and SAMSUNG, which are frequently introduced with varying designs and hardware specifications. This can be overwhelming for consumers who lack technical knowledge when selecting a new air purifier for their family. To maintain growth and competitive advantage, suppliers must understand the factors that influence consumers' purchasing decisions.

There are many methods for making decisions based on multiple criteria to select the best alternatives. For example, Ref. [3] proposed a decision model for smart selection based on intuitionistic fuzzy TOPSIS. Ref. [4] used the hybrid approach of the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for evaluating mobile phones.

This study aims to assist consumers in evaluating air purifier alternatives based on factors such as filtration performance, utility, cost, and environmental impact. The goal is to provide a reliable and valuable model to aid in the selection process, offering comprehensive and useful information to help consumers make informed purchasing decisions that align with their individual needs and standards.

II. CRITERIA

The study investigated five factors that affect the decision to buy an air purifier: brand, price, membrane technology, machine capacity, and customer service.

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A. Trademarks/brand

Branding is the process of identifying and distinguishing a business or its products/services from competitors. This includes elements such as the brand name, logo, slogan, values, and brand identity. In a brand awareness survey, consumers were asked about their reasons for choosing one brand over another. The results showed that 82% of the respondents chose a familiar brand as their first choice across various sectors. Additionally, 47% of the respondents explained that they chose a brand because they had used its products or services in the past. A brand is a crucial asset for a company and can significantly influence a consumer's purchasing decision. Consumers often evaluate a brand based on its reputation, credibility, and the value it provides before deciding to purchase a particular product or service.

B. Price

Price is a crucial factor in business competition. It can determine the number of customers a business attracts, as well as its market share, revenue, and profits.

C. Membrane Technology

The competitiveness of each enterprise is demonstrated through two fundamental strategies: product differentiation by quality, innovation, and competitive pricing. To survive and thrive, businesses must address numerous challenges, with product quality being the most critical strategy for enhancing enterprise competitiveness. When considering purchasing an air purifier, the primary factor to consider is product quality, which is also known as efficiency of use. For this device, it is important to pay attention to the filter technology. Currently, the market offers several popular types of filters:

- Coarse membranes are typically made of metal, plastic, or glass. They are inexpensive, visually appealing, durable, and capable of handling large-sized debris such as fabric, cotton, and hair. However, they are not effective in filtering fine dust or bacteria.
- HEPA (HEPA stands for High-Efficiency Particulate Air) filters are a popular choice due to their reasonable price and ability to filter dust particles larger than 0.3μm, including dust, pollen, mold, and bacteria. However, they are not capable of absorbing viruses or toxic gases. Mold bacteria can multiply on filters if not cleaned regularly.
- Air purifiers that use negative ion technology can overcome the limitations of other filter types. Negative ions attract bacteria, break down protein structures, and produce H2O radicals. However, this technology can produce ozone, which is harmful to health. Despite its high cost, it is an effective solution.
- Other filters available on the market include activated carbon, pollen, and titanium filters. Users can choose the appropriate model based on their specific needs.

The most popular type of filter is still the HEPA filter. Therefore, this text will focus on explaining this type of filter. HEPA stands for High-Efficiency Particulate Air, which is a technology developed to filter out polluting radioactive substances. The HEPA filter is structured like a mesh made of many fiberglass fibers with a small diameter of about 0.5 ÷ 2 micrometers arranged randomly. The HEPA filter is capable of capturing microscopic dust particles that other filters cannot. Its operation principle is simple: when the dust layer is drawn into the machine from the outside, it first passes through the HEPA coarse filter, and then the mixed filter. The mixed filter performs four filtration processes, including yellow dust filter, aldehyde air filtration, deodorization, and odor filter. After the filtration process is complete, the dust layer will continue to transfer to another filter, specifically the deodorizing filter and final dust filter. The HEPA filter, due to its sophisticated structure, performs a crucial function. In an air purifier, this filter effectively removes bacteria, fur, pollen particles, dust, and other harmful agents that can affect one's health. Additionally, the HEPA filter has the capability of filtering out 99.97% of dust particles as small as 0.3 microns. At the same time, this filter also helps to eliminate asthma triggers, creating a fresh and airy atmosphere.

D. Machine Capacity and Power

When learning about air purifiers, it is important to pay attention to the maximum air flow and power of the machine. The unit of airflow is measured in m^3/h and power is measured in W. By considering these parameters, we can choose an air purifier that is suitable for the area and ensures effective air cleaning. For small spaces with an area of 15 ÷ 20 m^2, an air purifier with a capacity of 26 ÷ 43 W and an airflow of about 160 ÷ 180 m^3/h is recommended. For spaces between 20 and 30 square meters, select an air purifier with a capacity of 43 to 54 watts and an airflow of 180 to 240 cubic meters per hour. For spaces between 30 and 40 square meters, choose a purifier with a power of 54 to 66 watts and an airflow of 180 to 300 cubic meters per hour. For spaces over 40 square meters, select a machine with a power range of 60 to 75 watts and an airflow of 510 cubic meters per hour or more. To determine the appropriate air purifier for a given space, consider the area of the room.

E. Customer Service

Businesses must guarantee quality and affordability while also providing professional customer care services to consumers. Professional customer service is crucial for generating interest in products, building customer loyalty, and attracting new customers. Customer service involves providing high-quality support and service to customers throughout their use of a company's products or services. The primary goal of customer service is to fulfill customer needs, resolve issues, and cultivate a positive experience to foster satisfied and loyal customers in the company. This includes activities such as consulting and support, complaint handling, answering questions, and providing technical support. Effective customer service can greatly impact a customer's purchasing decision by establishing trust, offering information and guidance, resolving complaints and issues, and creating a positive customer experience. It allows us to quickly search for products and compare different suppliers based on set criteria. Online shopping is rapidly growing in popularity due to its convenience. Consumers place great importance on their shopping experiences, whether positive or negative. Therefore, customer service is advantageous for businesses as it helps to retain existing customers, attract potential customers, reduce business costs, and create a competitive edge. Good customer service is optimal in terms of satisfying customers, with two leading factors.

Speed is crucial for businesses to succeed in customer interaction, consulting, support, problem-solving, and delivery. Commitment and punctuality are essential to ensure a positive customer experience. Professionalism is also important. A customer care business must ensure that all employees communicate with customers in a synchronized manner to reflect the professionalism of the business. This

includes having knowledgeable employees who can provide useful advice about products and services.

III. Alternatives

The top five best-selling air purifiers in 2021, based on the number of units sold, are the SHARP FP-J30E-A, DAIKIN MC30VVM-A, ELECTROLUX FA31-202GY, COWAY AP-1009CH, and SAMSUNG AX60R5080WD/SV, according to Dienmayxanh statistics. Dienmayxanh is a retail group in Vietnam that specializes in mobile phones, digital devices, and consumer electronics.

A. Sharp

Sharp Corporation's predecessor was a retail electronics manufacturing garden founded in 1911. In the air purifier market in Vietnam, Sharp has long been a familiar brand to customers. Grand View Research predicts that the global air purifier market will reach $12.26 billion in 2021 and is expected to increase to about $22.8 billion by 2028. Currently, Sharp holds the leading position in the Vietnamese air purifier market with over 30% market share.

B. Daikin

Daikin Vietnam is one of Daikin Group's main distribution hubs in Southeast Asia-Oceania, contributing to Daikin's leading position in the air conditioning industry. In Vietnam's rapidly growing market, customers demand high-quality air conditioning products, dedicated services, and energy-saving technologies. Despite the favorable conditions that have contributed to the strong increase in sales of Daikin's product line, there are also challenges in the Vietnamese market. These include high levels of competition, the emergence of more air conditioning companies, and the impact of technicians and consultants whose quality may not be synchronized, which can significantly affect the image of Daikin's products in the eyes of consumers. Therefore, Daikin's position in the Vietnamese market is affirmed by its after-sales service policy.

C. Electrolux

Electrolux is committed to realizing its vision and goals for 2030, which aim to create a better and more sustainable life for all. The company is focused on helping customers optimize their experiences with food, apparel care, health care, and production processes. Additionally, Electrolux is expanding its range of sustainable links to contribute to global solutions for new challenges. The company's motto is 'Sustainable development is our important mission.'

D. Coway

Coway Co., Ltd. is a Korean-based international manufacturer of household appliances, specializing in water purifiers and water softeners. The company is headquartered in Seoul. Coway is the largest water purifier company in Korea and has subsidiaries in China, Indonesia, Malaysia, Thailand, and the United States. With a commitment to quality for over 30 years, Coway has established itself as a heavyweight in the Vietnamese household appliance industry. The brand's confidence in the quality of its products and services remains unwavering. The Coway air purifier was developed by a team of patent experts at Coway's research and development (R&D) center. Coway is a young enterprise with many strengths, including a clear origin, proactive ownership of technology, an independent production process, and pioneering in creating new consumer solutions. Additionally, their customer care services are exceptional. As a result, Coway has gradually gained the trust of Vietnamese consumers and was listed as one of the 'Top 10 Brands and Famous Trademarks in Vietnam' in 2018.

E. Samsung

In particular, Samsung air purifiers are trusted by many people because of their luxurious design, powerful operating capacity, 3-membrane intensive filter system, easy control via SmartThings application, and many other features.

IV. Decision-Making Model

Selecting the best air purifier for the customers' needs can be a challenge with various factors to consider. Here's where a hybrid decision model combining Entropy and TOPSIS comes in as in Fig. 1. This approach leverages the strengths of both methods to provide a robust and objective evaluation process. Entropy tackles the issue of assigning weights to different criteria. By analyzing the variation in values for each criterion, Entropy assigns higher weights to those offering more informative data for the decision. This reduces subjectivity and ensures each factor is considered based on its ability to differentiate between air purifiers. Once weights are established, TOPSIS takes center stage. It defines an ideal air purifier scenario, where all criteria perform at their best. Each actual air purifier is then evaluated based on its distance from this ideal and a worst-case scenario (negative ideal). The air purifier closest to the ideal and farthest from the worst is considered the most suitable option. By combining the data-driven weighting of Entropy with the rigorous comparison logic of TOPSIS, this hybrid model offers a comprehensive and unbiased approach to selecting the best air purifier for customers' specific needs.

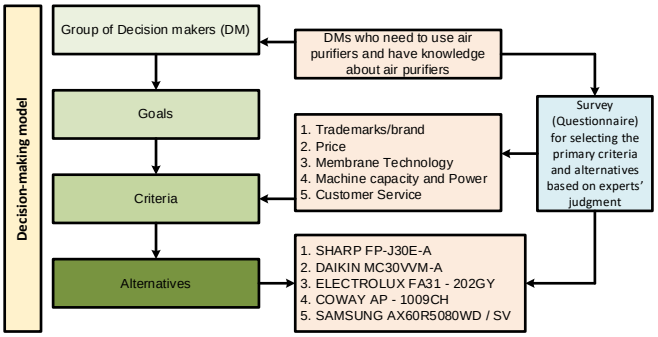

Fig. 1. Decision-making model for selecting the best air purifier

A. Entropy method

While entropy traditionally refers to the uncertainty in random events or information content in messages [5], the Entropy Method applies this concept to decision-making. It analyzes the dispersion of values within each criterion in a payoff matrix. Criteria with more varied data, indicating greater information content, are assigned higher weights. Conversely, those with less variation receive lower weights. This data-driven approach aims to remove decision-maker bias by objectively weighting criteria based on the inherent level of information they provide. In essence, the Entropy Method leverages entropy as a measure of informativeness to guide a more balanced selection of the best option, highlighting the importance of contrasting data sets within the decision [6].

In the realm of multi-criteria decision-making, the Entropy Method (EM) offers a data-driven approach for assigning weights to different evaluation factors. This method leverages the concept of entropy, a measure of uncertainty, to assess the information content within each factor. Criteria with greater dispersion in their values, indicating they provide more unique

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information for the decision, are assigned higher weights. Conversely, factors with less variation receive lower weights. The EM aims to achieve a balanced weighting system based on the inherent informativeness of each criterion, aiding in a more objective selection of the best option.

First, there should be a table of survey results answering questions posed to customers who require buying an air purifier. From that questionnaire identify the most important criterion and find the weight. There are two ways to find weight: Entropy [7-9], Analytic Hierarchy Process (AHP) [10-13], and Analytic Network Process (ANP) [14, 15]. However, this paper will use the ENTROPY method. The Entropy Method is a decision-making tool that allows for the evaluation and comparison of different options based on uncertainty and the information they provide. By applying this method, decision-makers can optimize their decisions and make the best choices based on information theory.

The number of survey questions is determined by the formula n(n−1)/2, where n is the number of criteria. The report will examine five criteria, which are equivalent to ten questions. These questions are:

- What brand of air purifier are you interested in? Where did you hear about this brand?
- (through advertising campaigns, previous use, etc.)
- What is your budget for a suitable air purifier? (Low and medium range below 10 million VNĐ, high range above 10 million VNĐ)
- What filter technology and machine capacity do you prioritize when choosing to serve user needs?
- What are your design requirements for the machine or what do you want the air purifier to look like in terms of size, color, and mobility?
- Lastly, what standout features are offered that are appropriate for the era? The device has a humidification mode and generates healthy ions. It also has a function for catching mosquitoes and insects, as well as smart connectivity with smartphones. Additionally, it is equipped with sensors that accurately check the air status.
- As for customer service, please provide information on troubleshooting procedures and the warranty policy. As for customer service, please provide information on troubleshooting procedures and the warranty policy. As for customer service, please provide information on troubleshooting procedures and the warranty policy. It would also be helpful to know about the staff's attitude.
- Do air purifier filters have a long lifespan? Estimate maintenance costs so that the machine always works well for a long time.
- How often should the filter be cleaned or replaced? Are replacement parts easy to find?
- What is the power consumption of the air purifier? In other words, does the machine save any money on the electricity bill each month?
- Vietnamese people are very interested in a discounted item or a gift included with the item they are about to buy. So, what is the preferential policy when buying an air purifier?

The Entropy method has been explained in the following steps [5, 16, 17]:

Step 1: For the given normalized payoff matrix, p_{ij} entropy E_j of the set of alternatives for the criterion j is

$$E_j = -\frac{1}{\ln(m)} \sum_{i=1}^{m} p_{ij} \ln\left(p_{ij}\right) \qquad \text{for } j = 1, \ldots, J \qquad (1)$$

where m is the number of alternatives and j is the number of criteria.

Step 2: Degree of diversification of the information provided by the outcomes of the criterion j is:

$$D_j = 1 - E_j \quad \text{for } j = 1, \ldots, J \qquad (2)$$

Step 3: Normalized weights of the criterion are:

$$w_i = \frac{D_j}{\sum_{j=1}^{J} D_j} \qquad (3)$$

The Entropy method assigns weights based on the level of information each criterion offers. A high entropy value signifies high uncertainty in the criterion's data (step 1), meaning the information it provides is less diverse (step 2). Consequently, such criteria receive lower importance (step 3). This method is particularly beneficial for complex decisions with many criteria, as it reduces the burden of assigning weights manually. Additionally, it can serve as an impartial solution when group consensus on weighting is elusive. However, it's important to acknowledge that the decision-maker role is more limited in weight estimation compared to traditional methods [17].

After receiving the user's answer sheet, we will create a decision matrix payoff and a normalized payoff matrix to aid in our decision-making process.

B. TOPSIS method

In the world of multi-criteria decision-making, TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) stands out for its approach to identifying the best option. TOPSIS works by conceptualizing an ideal solution that embodies the best possible performance across all criteria. It then analyzes each alternative solution's distance from this ideal and a negative ideal solution, representing the worst possible performance. The option closest to the ideal and farthest from the negative ideal is considered the most favorable choice. By balancing proximity to the best and distance from the worst, TOPSIS helps decision-makers reach well-rounded conclusions. In recent years, TOPSIS has been applied to making a successful decision in many fields [18-25].

TOPSIS is based on the principle that the chosen alternative should have the shortest distance from the ideal solution and the farthest distance from the negative ideal solution. This methodology consists of the following steps [17, 26, 27]:

- Step 1: Computation of weighted normalized payoff matrix.
- Step 2: Determine the ideal f_j^* value and negative ideal f_j^{**} value for each criterion j.
- Step 3: Calculate separation measures D_a^+, D_a^- in J-dimensional Euclidean distance for each alternative.

(a) TOPSIS evaluates alternatives by their closeness to a hypothetical ideal solution and distance from a worst-case

scenario. This ideal solution reflects the best possible outcome on each criterion. TOPSIS calculates a separation measure for each alternative a. This measure is the sum of the distances between the alternative's performance on each criterion and the corresponding value in the ideal solution. In other words, it captures the total deviation from the ideal across all criteria for a particular alternative.

$$D_a^+ = \sqrt{\sum_{j=1}^{J} \left[f_j(a) - f_j^* \right]^2} \quad (4)$$

(b) TOPSIS also considers how far each alternative *a* is from the worst possible outcome. This "negative ideal solution" reflects the least desirable performance on each criterion. Similar to the ideal solution, TOPSIS calculates a distance for each alternative. This distance represents the total deviation from the worst-case scenario across all criteria for a particular alternative.

$$D_a^- = \sqrt{\sum_{j=1}^{J} \left[f_j(a) - f_j^{**} \right]^2} \quad (5)$$

Step 4: Determination of relative similarity or closeness of each alternative *a* concerning the worst possible scenario (negative ideal) measure D_a^- is:

$$C_a = \frac{D_a^-}{D_a^- + D_a^+} \quad (6)$$

Step 5: Determination of the ranking of the alternatives based on the C_a values. The higher the value C_a, the better the alternative.

Starting from the decision matrix payoff, we move on to the Normalized matrix payoff step, followed by the Weighted normalized payoff matrix. We define the ideal criteria values and non-ideal criteria values as Positive Idea Solution (PIS) and Negative Idea Solution (NIS), respectively, denoted by f_j^* and f_j^{**}. Using the weighted decision matrix, we determine the distance D_a^+ and D_a^- and rank the options from best to least best. In theory, a larger Ca indicates that an option is the best choice when making multi-criteria decisions. Based on the results, we can rank the options and select the air purifier option that should receive the most investment from multi-criteria decision-making.

V. Results and Discussion

To choose the optimal air purifier using Entropy and TOPSIS methods, we first need to gather data for a decision-making matrix (Table 1). This involves identifying several air purifier models as alternatives. Then, we define key criteria for evaluation, such as brand/trademarks, price, membrane technology, machine capacity and power, and customer care. Data on these criteria can be collected from manufacturer specifications, independent testing agencies, and consumer reviews. For the qualitative data of brand and customer care, four levels from 1-4 have been used; in particular, 1-No reputation, 2-Normal, 3-Good, and 4-Very reputation. This comprehensive data set is the foundation for the analysis using Entropy to objectively determine the criteria weights and TOPSIS to rank the air purifiers based on their performance against these weighted criteria.

Table 1. Decision support matrix

Alternatives of air purifiers	Trademarks /Brand	Price (VNĐ)	Membrane technology (layers)	Machine capacity and power (W)	Customer care
SHARP FP-J30E-A	Japan (4)	2,200,000	4	50	4
DAIKIN MC30VVM-A	Japan (4)	3,600,000	4	5.5 - 16.0	4
ELECTROLUX FA31 - 202GY	Sweden (3)	5,500,000	3	3.5 - 20	3
COWAY AP - 1009CH	Korea (2)	6,400,000	3	40	2
SAMSUNG AX60R5080WD/SV	Korea (4)	11,000,000	3	60	4

After obtaining the decision matrix in Table 1, we proceed to normalize the data and determine the weighted normalized decision matrix for five alternatives in Table 2.

Table 2. Weighted Normalized Decision Matrix

	C1	C2	C3	C4	C5
A1	0.022636	0.0325567	0.007656	0.094178	0.022636
A2	0.022636	0.0532746	0.007656	0.030137	0.022636
A3	0.016977	0.0813918	0.005742	0.037671	0.016977
A4	0.011318	0.0947105	0.005742	0.075342	0.011318
A5	0.022636	0.1627836	0.005742	0.113013	0.022636
f_j^*	0.022636	0.0325567	0.007656	0.113013	0.022636
f_j^{**}	0.011318	0.1627836	0.005742	0.030137	0.011318

From Table 2, we get the ranking of five alternatives based on the TOPSIS method in Table 3.

Table 3. Alternatives ranking based on the TOPSIS method

	D_a+	D_a-	C_a	Ranking
A1	0.018836	0.146014	0.885741	1
A2	0.085427	0.110689	0.564407	2
A3	0.090161	0.082131	0.476695	4
A4	0.074445	0.081716	0.52328	3
A5	0.130241	0.084408	0.393237	5

A. *Stability analysis of alternatives' ranking*

According to the normalized decision matrix of data and the ranking results of the alternatives, the ranking of potential options is based on the value of Ca. The higher the Ca, the higher the rating of the alternative. The rankings are as follows: A1 > A2 > A4 > A3 > A5 or

"SHARP FP-J30E-A > DAIKIN MC30VVM-A > COWAY AP-1009CH > ELECTROLUX FA31-202GY > SAMSUNG AX60R5080WD/SV".

It can be tentatively concluded that the SHARP air purifier option is the most optimal choice at this time. This is a provisional conclusion because a sensitivity analysis is necessary for a more accurate and reliable assessment of this alternative. When the weight changes slightly, it can cause a change in the rank of the alternatives.

To conduct a sensitivity analysis, we will keep four weights constantly and change one weight in turn by the remaining four weights. This will result in 20 new rankings of alternatives. Table 4 shows the weighted values and their corresponding rankings based on sensitivity analysis. The weights were adjusted 20 times to obtain the ranking results in Table 4.

After conducting a sensitivity analysis, we observed a significant change in the rankings. Additionally, the stability after 20 weighted changes of options is almost absolute, resulting in the new rankings of A1 > A5 > A4 > A3 > A2.

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TABLE 4. SENSITIVITY ANALYSIS OF ALTERNATIVES' RANKING

Case No.	A1	A2	A3	A4	A5
1	1	5	4	3	2
2	1	5	4	3	2
3	1	5	4	3	2
4	1	5	4	3	2
5	1	5	4	3	2
6	2	4	5	3	1
7	1	5	4	3	2
8	1	5	4	3	2
9	1	5	4	3	2
10	1	5	4	3	2
11	1	5	4	3	2
12	1	5	4	3	2
13	1	5	4	3	2
14	1	5	4	3	2
15	1	5	4	3	2
16	1	5	4	3	2
17	1	5	4	3	2
18	1	5	4	3	2
19	1	5	4	3	2
20	1	5	4	3	2

The initial rankings were A1 > A2 > A4 > A3 > A5, but now the positions of option 2 and option 5 have been swapped. Additionally, the stability after 20 weighted changes of options is almost absolute, resulting in the new rankings of A1 > A5 > A4 > A3 > A2. Additionally, the stability after 20 weighted changes of options is almost absolute, resulting in the new rankings of A1 > A5 > A4 > A3 > A2. However, after careful consideration and analysis, we have determined that option/alternative 1, the SHARP home air purifier, is the most reliable alternative available.

B. Analysis of Correlation coefficient

In statistics, Kendall's τ coefficient (after the Greek letter τ, tau) is a non-parametric statistic used to measure the ordinal alignment between two measured quantities. It is often referred to as Kendall's ranking correlation coefficient. The text goes on to describe a test for coefficient-based statistical dependence and the ranking of options by three decision-makers (DM1, DM2, DM3) using a data table. The Spearman correlation coefficient and the Kendall correlation coefficient will be calculated to analyze the strength of each decision-maker and determine a ranking for the products. The Spearman matrix will be reorganized to rank the reliability of the decision-makers (Table 5).

TABLE 5. SPEARMAN COEFFICIENT MATRIX AND ITS RANKING

	DM1	DM2	DM3	Ranking
DM1	-	0.9	0.8	1
DM2	0.9	-	0.55	2
DM3	0.8	0.55	-	3

Based on Table 5, it can be concluded that the ranking reliability of DM1 is higher than that of DM2 and DM3, and its correlation properties are also superior to those of DM2 and DM3.

C. Group decision making

Decision-making is a problem-solving activity with the ultimate goal of achieving an optimal or satisfactory solution for the problem at hand. It can be rational or irrational, depending on the approval or objections of decision-makers. The main content of decision-making involves analyzing a set of options described by different evaluation criteria. The decision maker's task is to rank the options objectively based on their decreasing attractiveness. This means that the more optimal an option is, the higher it will be ranked, making it the first priority when deciding or analyzing even more positives. We assume three decision makers in this paper and will calculate the option rankings using two rules: additive ranking and multiplication rank. It is important to maintain a clear and logical structure, avoiding biased language and filler words while adhering to style guides and ensuring grammatical correctness. According to Table 6, A1 has a higher rating and reliability than A5, A2, A3, and A4.

TABLE 6. THE FINAL RANKING OF ALTERNATIVES BASED ON GROUP DECISION-MAKING

	DM1	DM2	DM3	ADD	Rank	MULT	Rank
A1	1	2	2	1.67	1	1.58	1
A2	3	4	1	2.67	3	2.28	3
A3	4	3	5	4	4	3.91	4
A4	5	5	4	4.67	5	4.64	5
A5	2	1	3	2	2	1.81	2

In summary, the hybrid method of Entropy and TOPSIS bridges theory and practice. It enables decision-makers to select air cleaners based on a balanced evaluation of criteria, taking into account both practical constraints and theoretical principles. By using this hybrid approach, we improve the quality of our decisions and contribute to better indoor air quality. The hybrid approach allows us to assign appropriate weights to different criteria. In practice, this means we can emphasize critical factors such as trademark/brand, price, membrane technology, capacity and performance, and customer service. By understanding the relative importance of each criterion, decision-makers can make informed choices. In practice, the hybrid method helps decision-makers compare air purifiers based on multiple aspects. It allows them to consider trade-offs and make decisions that meet specific needs. In terms of theoretical implications, the theoretical foundations of entropy provide a principled way to assign weights. Entropy measures uncertainty or disorder in a system. By applying entropy to criteria weights, we ensure that the most influential factors receive greater weight. Theoretical rigor ensures consistency and fairness in the decision process. Rooted in decision science, TOPSIS introduces the concepts of ideal and worst solutions. The ideal solution represents the best performance across all criteria, while the worst solution represents the least desirable solution. A theoretical understanding of these concepts helps decision-makers evaluate alternatives objectively. The hybrid method takes advantage of the strengths of both approaches. Entropy captures the relative importance of criteria, while TOPSIS ranks alternatives based on their proximity to ideal solutions. By combining them, we create a robust decision framework that considers both importance and performance. Theoretical implications remind us to take a holistic view. Decision-making isn't just about numbers; it's about understanding context, user preferences, and system dynamics. The hybrid method promotes a comprehensive assessment.

VI. CONCLUSION

This research aims to assist consumers in making multi-criteria decisions when selecting an air purifier for their homes. The research could also be expanded to cover other multi-objective decision-making for selecting the best air purifiers. The flow of this research is clearly presented, starting with criteria, followed by solutions, models, and methods of multiple criteria decision-making. The flowchart and ENTROPY and TOPSIS methods are well-applied here. Additionally, this research aims to assist people in selecting an air purifier that is both durable and stable, thereby safeguarding consumer health. To achieve this, sensitivity analysis was applied to determine the stability of the available options. Finally, the correlation coefficient and group decision-making were also discussed as confidence

coefficients. This research has been addressed by ranking five alternatives in a clear, objective, and reliable manner

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