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Implementation of Fuzzy-TOPSIS as the Basis for Decision-Making in Purchasing Production Equipment at Plywood Companies

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ABSTRACT

The decision-making process in a company should be based on a strong foundation. A robust decision-making basis is reflected in a methodology that can be accountable, especially in complex cases. Decision-making involving diverse criteria requires a proper methodology to achieve accurate results. Such issues often occur in small or micro-enterprises (SMEs). This study focused on plywood processing companies. The issue at hand was the absence of a standardized method for determining the purchase of production equipment. Therefore, a systematic decision-making tool becomes crucial to reduce the subjectivity among stakeholders. The most crucial production tool in the plywood industry is the press machine. The implementation of Fuzzy TOPSIS successfully provided an objective recommendation. These recommendations are in the form of rankings that inform the highest to lowest recommendations. The Cold Press Machine AKS - IR50T obtained the highest Cci value of 0.75, which can serve as the basis for decision-making in purchasing production equipment.

Keywords: Fuzzy, MCDM, SMEs, Systematic Decision-Making, TOPSIS

INTRODUCTION

The wood industry is one of the sectors with significant potential in Indonesia, evident from its substantial economic value. The export value of wood in Indonesia reached $11.6 billion in 2019 (Anugrah, 2020). In the same year, Indonesia was noted as the world's largest wood exporter (Lingga & Setiawan, 2019). Wood products generate roughly 10% of total exports in most deforested countries (Sakinah & Wibowo, 2021). Among various wood processing industries, plywood stands out as one of the most popular products.

Recent years have witnessed a considerable increase in wood exports, notably in 2021, where there was a significant surge of 44%. The plywood export value in 2021 was $1.744 billion, escalating to $2.513 billion in 2022 (AgroIndonesia, 2022). These statistics indicate a positive trend in the development of the plywood business for the upcoming years.

The players in Indonesia's plywood industry are quite diverse, ranging from small to large-scale businesses. Larger businesses generally possess adequate management and resources, thereby incorporating proper data and methodologies into their decision-making processes. In contrast, small-scale businesses (MSMEs) often lack robust managerial capabilities, necessitating simple analytical tools to aid their business decisions.

Fuzzy TOPSIS is a multi-criteria analysis tool utilized to select ideal solutions in multi-dimensional problems. Syahputra, in his research, employed Fuzzy TOPSIS as a decision-making tool in housing selection (Syahputra, 2014). Fuzzy TOPSIS isn't limited to evaluations related to non-physical resources. Perwira et al. used Fuzzy TOPSIS to screen production well operators at PT Geotama Energi. They ranked potential employees with competencies suitable for their positions using Fuzzy TOPSIS.

Considering the advantages of Fuzzy TOPSIS, this research aims to apply this decision-making tool to the issue of selecting production equipment in the plywood industry. The chosen production tool is the plywood pressing machine, which is a typical machine in the plywood industry. Utilizing the Fuzzy TOPSIS method, operational managers or those responsible for purchasing can rank and select the most optimal plywood pressing machine.

LITERATURE REVIEW

Fuzzy-TOPSIS

Fuzzy TOPSIS is a multi-attribute decision-making method that involves ranking to identify the most ideal positive and negative solutions (Nojavan, Heidari, & Mohammaditabar, 2021). It is highly beneficial in business, such as determining investment in production equipment, where quality parameters are diverse or multi-attribute. In such cases, attributes like machine speed, price, delivery time, and after-sales service must be transformed into similar attributes for more accurate measurement.

The evolution of Fuzzy TOPSIS has extended to material selection in production processes and supplier selection aimed at achieving consumer satisfaction (Kiraci & Akan, 2020). This method has experienced rapid development and is believed to aid in business decision-making in a measurable and replicable manner due to its mathematical approach.

Fuzzy TOPSIS is employed not only in for-profit organizations but also in non-profit sectors. It assists in decision-making regarding success factors in educational organizations like universities, using data-driven approaches to rank varied attributes (Conejero, Preciado, Prieto, Bas, & Bolós, 2021). Such data diversity necessitates tools or methods for standardization to ensure accurate measurements, and researchers have found Fuzzy TOPSIS to be a solution.

Fuzzy TOPSIS is a decision-making tool that considers human touch or expert subjectivity (Elibal & Özceylan, 2022). This addresses the issue in the business world that mathematical analyses still need expert observations for more comprehensive results. Hence, Fuzzy TOPSIS remains relevant as a decision-making method, particularly when analyzing factors with different parameters.

Fuzzy and TOPSIS are originally two distinct analysis tools. TOPSIS, developed by Hwang and Yoon, stands for The Technique for Order of Preference by Similarity to Ideal Solution. It aims to find solutions for multi-criteria problems that require different treatments in analysis. The results of TOPSIS analysis yield positive and negative ideal solutions that form a ranking (Kilic & Yalcin, 2021). The highest ranking represents the ideal solution produced.

TOPSIS is one of the analytical tools in multiple criteria decision-making (MCDM) methods. It is considered valid in achieving solutions for various issues (Marchetti & Wanke, 2020). Apart from direct business processes in companies, TOPSIS is also highly effective in finding solutions for other problems, such as prioritizing states requiring assistance.

TOPSIS is robust in analyzing multi-dimensional parameter problems. In a study by (Chen, Li, & Yi, 2020), the technology capabilities of several provinces in China were evaluated using TOPSIS. The dynamic use of TOPSIS successfully provided evaluation results used for subsequent decision-making.

Ideal decision-making aims to achieve the most optimal solution from all alternatives. At times, decision-making receives subjectively inclined solutions. Fuzzy logic is then required to mitigate this issue (Malakouti, Faizi, Hosseini, & Norouzian-Maleki, 2019). Fuzzy is used to minimize subjectivity, followed by TOPSIS calculations for solution ranking to find the best solution from the problem at hand.

Fuzzy TOPSIS is valuable for complex issues. Conducted research on solid waste solutions, a prevalent problem in developing countries (Kharat et al., 2019). Fuzzy TOPSIS was employed to determine solutions for complex multi-criteria issues, providing optimal alternative solutions. Enhancing services is crucial for organizational sustainability, particularly in terms of customer or service user satisfaction. Fuzzy TOPSIS can be used to analyze the best service needs (Bostanci & Erdem, 2020). This was shown in research analyzing the satisfaction of information technology users in city administration services. Fuzzy TOPSIS was used to rank the most desired services by customers.

In another study, Fuzzy TOPSIS was used for material selection in plastic waste recycling (Soni, Chakraborty, Das, & Saha, 2023). The study evaluated Fuzzy TOPSIS as a multiple-criteria decision analysis tool (MCDM), and among the tools tested, Fuzzy TOPSIS obtained the highest value, signifying high accuracy. Furthermore, Fuzzy TOPSIS has proved to be beneficial in public sector management problems (Cuoghi, Leoneti, & Passador, 2022). In a study determining the best hospital services in Brazil, Cuoghi, Leoneti, and Passador (2022) utilized Fuzzy TOPSIS. The service management

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analysis was divided into private and public services based on public perception and expert opinions. Rehman and Ali (2021) conducted an analysis on oil import decision-making, focusing on China. China largely imports oil to meet its energy requirements. Many considerations need to be made to determine the best route for optimal benefits, including security, political, and cost aspects. Using Fuzzy TOPSIS, the researchers provided a ranking of proposed solutions for the best or optimal decision-making (Rehman & Ali, 2021).

Fuzzy TOPSIS can generate ideal solutions for multi-dimensional problems. Research by Irfan et al. (2022) showed that the technique can analyze key factors in the biomass industry in India (Irfan et al., 2022). The study explained India's desire to enhance its energy sustainability by strengthening the biomass industry. A multidimensional analysis was conducted on key factors for the industry, such as political, economic, cultural, and meteorological factors. The Fuzzy or Grey TOPSIS analysis recommended consistent and coherent actions by policymakers, stakeholders, and government agencies to ensure sufficient availability, subsidies, raw material supply, and local training for the advancement of India's biomass industry. Fuzzy TOPSIS is an extremely useful MCDM tool. In Sharma et al.'s study, Fuzzy TOPSIS was suggested for solving logistics issues, particularly in Reverse Logistics (RL). RL is a crucial topic related to the environment and sustainability. Fuzzy TOPSIS was used to analyze and rank the best retailers in RL practices. The performance of the best retailers can then serve as a benchmark for the adoption of optimal work practices in RL implementation by other retailers.

RESEARCH METHOD

The methodology applied in the study is Fuzzy TOPSIS, an approach used for multi-attribute decision-making. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) assesses alternatives by comparing them to ideal positive and negative solutions to determine their rankings. Sadi-Nezhad and Damghani introduced a fuzzy distance measurement method into the fuzzy TOPSIS calculation process. The steps involved in this fuzzy approach within the TOPSIS method include:

Determination of the Fuzzy Decision Matrix and Weights of Criteria

The first step is to create fuzzy criteria to perform weighting. The weighting is adapted from the concept of Triangular Fuzzy Numbers (TFN), which will be used as a Fuzzy Decision Matrix. These criteria weights will be combined with the TOPSIS calculation. The following TFN used in this study is more comprehensively presented in Table 1.

Table 1. Triangular Fuzzy Numbers (TFN)

Linguistic Value	*Fuzzy Numbers*
Very Low (VL)	(0, 0, 0.2)
Low (L)	(0, 0.2, 0,4)
Medium (M)	(0.2, 0.4, 0.6)
High (H)	(0.4, 0.6, 0.8)
Very High (VH)	(0.6, 0.8, 1)
Excellent (E)	(0.8, 1, 1)

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Figure 1. Research Methods

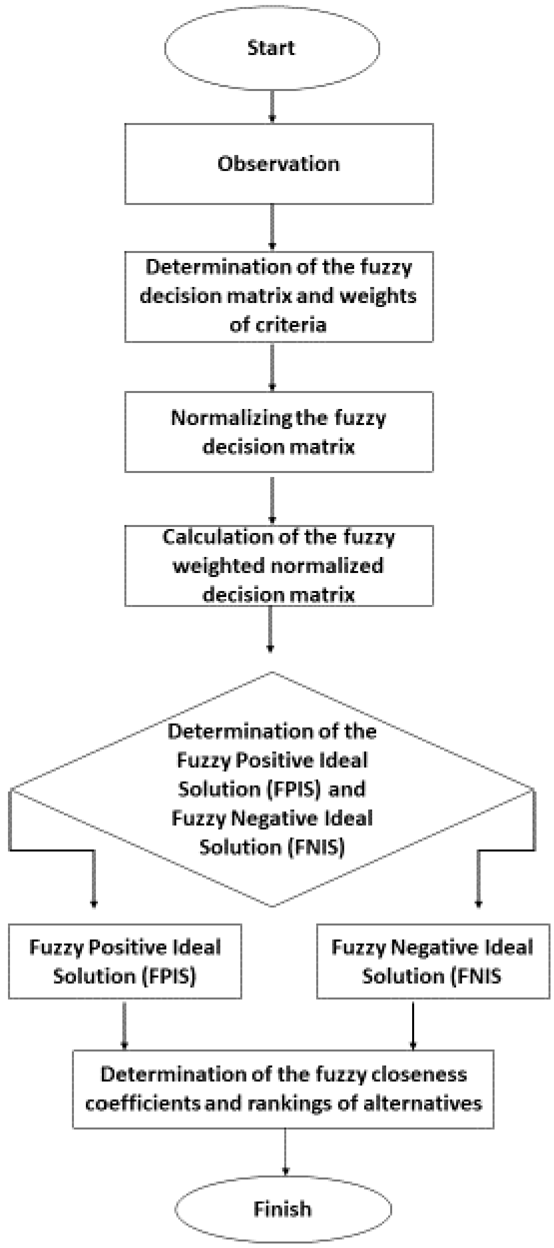
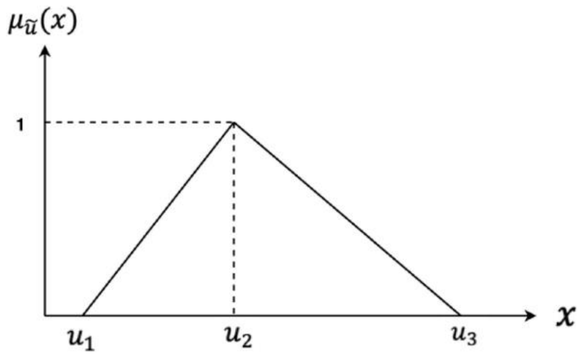


Figure 2. Triangular Fuzzy Numbers



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Normalizing the Fuzzy Decision Matrix

Given that each criterion is assessed on a diverse scale, normalization within the decision matrix is pivotal. Hence, the normalization process is employed on the fuzzy decision matrix using a linear scale. The computation for the normalized elements of the fuzzy decision matrix is carried out as follows:

$$\bar{r}_{ij} = \left(r_{ij}^{l}, r_{ij}^{m}, r_{ij}^{u}\right) = \left(\frac{a_{ij}^{l}}{a_{j}^{l}} + \frac{a_{ij}^{m}}{a_{j}^{m}} + \frac{a_{ij}^{u}}{a_{j}^{u}}\right) \quad (1)$$

$$\bar{r}_{ij} = max_i\left(a_{ij}^{u}\right) \mathrm{j} \in \mathrm{B}\,;\ \mathrm{I} = 1,\ldots,\mathrm{m} \quad (2)$$

$$\bar{r}_{ij} = \left(r_{ij}^{l}, r_{ij}^{m}, r_{ij}^{u}\right) = \left(\frac{a_{j}^{-}}{a_{ij}^{u}} + \frac{a_{j}^{-}}{a_{ij}^{m}} + \frac{a_{j}^{-}}{a_{ij}^{l}}\right) \quad (3)$$

$$\tilde{a}_{ij} = \min i\ \left(a_{ij}^{1}\right) j \in \mathrm{C}\,;\mathrm{i} = ,\ldots,\mathrm{m} \quad (4)$$

Where $\bar{a}_{j}^{-} = a_{ij}^{l} + a_{ij}^{m} + a_{ij}^{u}$ s the fuzzy score of alternative I (i = 1,…, m) in criterion j (j = 1,…, m). B and C are sets of benefit and cost criteria, respectively.

Calculation of the Fuzzy Weighted Normalized Decision Matrix

In step 3, the normalized weighted fuzzy decision matrix is calculated using the following equation:

$$\tilde{v} = \left(v_{ij}^{l}, v_{ij}^{m}, v_{ij}^{u}\right) = \left(\left(w_{j}^{l}, r_{ij}^{l}\right), \left(w_{j}^{m}, r_{ij}^{m}\right), \left(w_{j}^{u}, r_{ij}^{u}\right)\right)\ \forall\, \mathrm{i,j} \quad (5)$$

Where $\tilde{v} = \left(v_{ij}^{l}, v_{ij}^{m}, v_{ij}^{u}\right) = \left(\left(w_{j}^{l}, r_{ij}^{l}\right), \left(w_{j}^{m}, r_{ij}^{m}\right), \left(w_{j}^{u}, r_{ij}^{u}\right)\right) \forall\, \mathrm{i,j}$ is the fuzzy weight of the j-th criterion.

Determination of the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS).

S^+=(v ̃_1^+,…,v ̃_N^+) (6)

v ̃_J^+=((v ̃_J^(+l),v ̃_J^(+m),v ̃_J^(+u)))= 〖(max〗 _l (v ̃_iJ^l), 〖max〗 _m (v ̃_iJ^m max〗 _u (v ̃_iJ^u)) ∀J (7)

S^-=(v ̃_1^-,…,v ̃_N^-) (8)

v ̃_J^-=((v ̃_J^(-l),v ̃_J^(-m),v ̃_J^(-u)))= 〖(min〗 _l (v ̃_iJ^l), 〖min〗 _m (v ̃_iJ^m), 〖min〗 _u (v ̃_iJ^u)) ∀J (9)

The fuzzy distances of each alternative from the FPIS and FNIS (fPFi and fNFi respectively).

The calculation of the fuzzy distance between FPIS and FNIS can be performed using the following formula:

$$\widetilde{PF}_i = \sum_{j=1}^{n} \tilde{d} = \left(\tilde{v}_{ij}, \tilde{v}_{j}^{+}\right)\ \forall i \quad (10)$$

$$\widetilde{NF}_i = \sum_{j=1}^{n} \tilde{d} = \left(\tilde{v}_{ij}, \tilde{v}_{J}^{-}\right)\ \forall i \quad (11)$$

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Where $\tilde{d} = (\tilde{v}_{ij}, \tilde{v}_J^+)$ dan $\tilde{d} = (\tilde{v}_{ij}, \tilde{v}_J^-)$ is fuzzy distance from alternative i to criterion j from both FPIS and FNIS is respectively calculated using the equation:

$$\tilde{d}(\tilde{v}_{ij}, \tilde{v}_J^+) = (d_{ij}^{+l}, d_{ij}^{+m}, d_{ij}^{+u}) \quad (12)$$

$$= (\max\left\{0, \frac{(v_J^{+l} - v_{ij}^{u}) + (v_J^{+m} - v_{ij}^{m})}{2}\right\}, v_J^{+m} - v_J^{m}, \frac{(v_J^{+u} - v_{ij}^{l}) + (v_J^{+m} - v_{ij}^{m})}{2}) \ \forall i, j \quad (13)$$

$$\tilde{d}(\tilde{v}_{ij}, \tilde{v}_J^-) = (d_{ij}^{-l}, d_{ij}^{-m}, d_{ij}^{-u}) \quad (14)$$

$$= (\max\left\{0, \frac{(v_J^{-l} - v_{ij}^{-u}) + (v_J^{m} - v_{ij}^{-m})}{2}\right\}, \quad (v_J^{m} - v_J^{-m}), \frac{(v_{ij}^{u} - v_{ij}^{-l}) + (v_{ij}^{m} - v_J^{-m})}{2}) \ \forall i, j \quad (15)$$

Where numerous positive value is added to the fuzzy PFi and NFi if their left extreme value equals zero.

The process involves determining the fuzzy closeness coefficients and rankings of alternatives. Within this step, the fuzzy proximity coefficient to the ideal solution $\widetilde{CC}_i$)is calculated for each alternative using the provided equation.

$$\widetilde{CC}_i = (CC_i^l + CC_i^m + CC_i^u) = \frac{\widetilde{NF}_i}{\widetilde{NF}_i + \widetilde{PF}_i} \ \forall i \quad (16)$$

The calculated fuzzy proximity coefficients must be converted to crisp in order to determine the ranking of alternatives. In this case, the Center of Gravity method can be used as follows:

$$\widetilde{CC}_i = \frac{CC_i^l + CC_i^m + CC_i^u}{3} \ \forall i \quad (17)$$

RESULTS

Observation

The initial step in Fuzzy-TOPSIS analysis involves observing the phenomenon. Observation holds paramount significance as it aids in comprehending the challenges encountered by a corporation or organization. This method allows for comprehensive consideration of multiple factors, balancing varying priorities to arrive at a more informed decision. The observational data results indicate several plywood press machines for small-scale business. For further clarification, please refer to Table 2.

Table 2. Assessment Criteria for Press Machines

No.	Brand/Type	Price	Weight	Compression Force	Warranty
1	Cold Press Machine AKS - IR50T	Rp 99.000.900	1,9 Ton	51 Ton	12 Month
2	Cold Press Machine AKS - IR1225	Rp 24.750.780	3 Ton	10 Ton	12 Month
3	Cold Press Hydraulic Machine AKS - KX100T	Rp 20.625.000	3,6 Ton	10 Ton	12 Month
4	Hydraulic Cold Press Machine Type AKS - SG50T	Rp 94.605.300	1,9 Ton	51 Ton	12 Month

Determining the Fuzzy Decision Matrix and Criteria Weights

This stage holds paramount importance in quantitative decision-making calculations using Fuzzy-TOPSIS methodology. The initial weighting step significantly influences the ultimate outcome in determining the most favourable decision. In this step, the fuzzy decision matrix and criteria weights need to be determined for each criterion used. A more detailed explanation is provided in tables 4.2 and 4.3 as follows.

Table 3. Decision Matrix

No.	Brand/Type	Price	Weight	Compression Force	Warranty
1	Cold Press Machine AKS - IR50T	Rp 99.000.900	1.9 Ton	51 Ton	12 Month
2	Cold Press Machine AKS - IR1225	Rp 24.750.780	3 Ton	10 Ton	12 Month
3	Cold Press Hydraulic Machine AKS - KX100T	Rp 20.625.000	3.6 Ton	10 Ton	12 Month
4	Hydraulic Cold Press Machine AKS - SG50T	Rp 94.605.300	1.9 Ton	51 Ton	12 Month

Table 3 represents the decision matrix to be used as a source of analysis using Fuzzy TOPSIS. The matrix includes 4 criteria, namely price, weight, compression force, and warranty. These criteria will be the basis for decision-making in Fuzzy TOPSIS analysis. In addition to the basic decision matrix for Fuzzy analysis using Triangular Fuzzy Numbers (TFN), which can be observed in Table 4.

Tabel 4. *Fuzzy* Criteria Weights

Criteria	Linguistic Value	Fuzzy Numbers		
		L	M	U
Price	H	0.4	0.6	0.8
Weight	M	0.2	0.4	0.6
Compression Force	VH	0.6	0.8	1
Warranty	L	0	0.2	0.4

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Weighting is required to assign values to each criterion. The criteria above are given linguistic values as weights. Each linguistic value has a fuzzy value, starting in sequence from low, medium, and high.

Normalizing The Fuzzy Decision Matrix

The goal of normalization within Fuzzy TOPSIS is to ensure fair treatment of diverse criteria, preventing any criterion from dominating the decision solely due to its measurement scale or unit. By transforming the data into a common scale, the analysis allows for a comprehensive evaluation, facilitating a more informed decision-making process. Normalization step in Fuzzy-TOPSIS is pivotal, particularly in complex decision-making scenarios involving multiple criteria with varying measurement scales. It bridges the gap between diverse criteria, allowing for a more equitable comparison and facilitating a structured approach to arrive at a well-informed decision. This stage involves the normalization process for each criterion's values. Normalization is carried out because decision-making analysis requires equivalent values. Having equivalent values facilitates analysis and ranking.

Table 5. Normalizing The Fuzzy Decision Matrix

No.	Brand/Type	Price	Weight	Compression Force	Warranty
1	Cold Press Machine AKS - IR50T	0.70	0.35	0.69	0.5
2	Cold Press Machine AKS - IR1225	0.18	0.56	0.14	0.5
3	Cold Press Hydraulic Machine AKS - KX100T	0.15	0.67	0.14	0.5
4	Hydraulic Cold Press Machine AKS - SG50T	0.67	0.35	0.69	0.5

Table 5 represents the normalized matrix from Table 4, where the values in the matrix still have a diverse range. In this table, it can be observed that each value is relatively equivalent in fractional form.

Calculation of the Fuzzy Weighted Normalized Decision Matrix

After the data normalization process, the next step is to weight each criterion with the predetermined fuzzy values. The fuzzy values are determined in stage 2, where linguistic values are based on input from competent individuals in the plywood processing business. The weighting process involves multiplying the values by the fuzzy numbers for each linguistic value.

Table 6. Fuzzy Weighted Normalized Decision Matrix

No.	Machine Type	Criteria	Normalization with Fuzzy		
			l	*m*	*u*
1	Cold Press Machine AKS - IR50T	Price	0.28	0.42	0.56
		Weight	0.07	0.14	0.21
		Comperession Force	0.42	0.56	0.69
		Warranty	0.00	0.10	0.20
2	Cold Press Machine AKS - IR1225	Price	0.07	0.11	0.14
		Weight	0.20	0.40	0.60
		Comperession Force	0.08	0.11	0.14
		Warranty	0.00	0.10	0.20
3	Cold Press Machine AKS - KX100T	Price	0.40	0.60	0.80
		Weight	0.13	0.27	0.40
		Comperession Force	0.08	0.11	0.14
		Warranty	0.00	0.10	0.20
4	Cold Press Machine AKS - SG50T	Price	0.27	0.40	0.54
		Weight	0.07	0.14	0.21
		Comperession Force	0.42	0.56	0.69
		Warranty	0.00	0.10	0.20

Table 6 displays the results of fuzzy weighting. The weighting exhibits fuzzy values represented by three values: low, medium, and high.

Determination of the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS)

Fuzzy TOPSIS is certainly useful for finding solutions to MCDM problems. This stage involves a calculation process that yields FPIS and FNIS. This stage should be observed closely.

Table 7. FPIS And FNIS Matrix

Type Machine	Price			Weight			Compression Force			Waranty		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
Cold Press Machine AKS - IR50T	0.28	0.42	0.56	0.07	0.14	0.21	0.42	0.56	0.69	0.00	0.10	0.20
Cold Press Machine AKS - IR1225	0.07	0.11	0.14	0.20	0.40	0.60	0.08	0.11	0.14	0.00	0.10	0.20
Cold Press Machine AKS - KX100T	0.40	0.60	0.80	0.13	0.27	0.40	0.08	0.11	0.14	0.00	0.10	0.20
Cold Press Machine AKS - SG50T	0.27	0.40	0.54	0.07	0.14	0.21	0.42	0.56	0.69	0.00	0.10	0.20
FPIS (+)	0.07	0.11	0.14	0.07	0.14	0.21	0.42	0.56	0.69	0.00	0.10	0.20
FNIS (-)	0.40	0.60	0.80	0.20	0.40	0.60	0.08	0.11	0.14	0.00	0.10	0.20

Table 7 shows the calculation results of FPIS and FNIS. These results will be processed in the next stage as the basis for the solution ranking process.

The Fuzzy Distances of Each Alternative from the FPIS and FNIS (fPFi and fNFi Respectively)
This stage is the defuzzification process, which consolidates the values of low, medium, and high into a single value. Fuzzy distance is calculated for both solutions, namely FPIS and FNIS.

Tabel 8. Fuzzy Distance FPIS

	Machine Type	Criteria				*Si_+*
		P	W	CF	W	
FPIS	Cold Press Machine AKS - IR50T	0.33	0.00	0.00	0.00	0.33
	Cold Press Machine AKS - IR1225	0.00	0.28	0.46	0.00	0.74
	Cold Press Machine AKS - KX100T	0.51	0.14	0.46	0.00	1.10
	Cold Press Machine AKS - SG50T	0.31	0.00	0.00	0.00	0.31

The FPIS distance represents the positive ideal solution for each criterion. This will be further used for calculating the closest coefficient and ranking.

Tabel 9. Fuzzy Distance FNIS

	Machine Type	Criteria				*Si_-*
		P	W	CF	W	
FNIS	Cold Press Machine AKS - IR50T	0.18	0.28	0.46	0.00	0.92
	Cold Press Machine AKS - IR1225	0.51	0.00	0.00	0.00	0.51
	Cold Press Machine AKS - KX100T	0.00	0.14	0.00	0.00	0.14
	Cold Press Machine AKS - SG50T	0.20	0.28	0.46	0.00	0.94

The FNIS distance represents the negative ideal solution for each criterion. This will be further used for calculating the closest coefficient and ranking.

Determination of the Fuzzy Closeness Coefficients and Rankings of Alternatives
This stage is the final step of Fuzzy TOPSIS. This stage provides Cci values which will then be used for ranking from the highest to the lowest values.

Tabel 10. Fuzzy Closeness Coefficients and Rankings of Alternatives

Machine Type	*Cci*	Ranking
Cold Press Machine AKS - IR50T	0.74	2
Cold Press Machine AKS - IR1225	0.41	3
Cold Press Machine AKS - KX100T	0.12	4
Cold Press Machine AKS - SG50T	0.75	1

Table 10 shows the final results of the Fuzzy TOPSIS analysis. The highest Cci value, which represents the first rank, is for the machine AKS-SG50T. Meanwhile, the lowest Cci value is for the machine AKS-KX100T. The AKS-SG50T machine is the recommended machine for purchase by the plywood processing company. A high Cci value indicates the most optimal decision.

DISCUSSION

The initial step in Fuzzy-TOPSIS analysis involves observing the phenomenon. Observation holds paramount significance as it aids in comprehending the challenges encountered by a corporation or organization. This process involves collecting data directly from primary sources or utilizing secondary data available within the company. However, the data required must align with the method and purpose of the analysis, making primary data favorable due to its adaptability. In the context of this analysis, the researcher focuses on press machine criteria for wood companies. Key criteria under scrutiny encompass price, pressing power, machine weight, and warranty. Price correlates closely with a company's capacity to procure factory equipment. Its importance lies in each company's constrained budget. Company funds cater not only to machine procurement but also to overall management needs, such as employee wages, building rent, staff training, tax payments, raw materials, and more. Thus, the researcher opts to include price as a primary consideration in production equipment procurement decisions. Another criterion is pressing power, crucial in plywood processing. Machines with higher pressing power garner preference due to increased production flexibility when substantial strength is required. Typically, a machine's strength is accounted for during initial production design. Yet, in incidental scenarios, such as unexpected material hardness, machine strength becomes crucial in overcoming such challenges. Machine weight serves as another criterion. Machines vary in weight, ranging from very heavy to relatively light. Preference leans towards machines with relatively lighter weights due to their operational flexibility in layout changes, maintenance, and periodic repairs. Lighter machines are more easily relocated when operational layout adjustments are necessary. The final but equally significant criterion is warranty. A warranty acts as a financial instrument shielding a company from risks. Every corporate decision entail inherent risk, varying in magnitude. Thus, a warranty becomes critical in minimizing variable risks associated with machine uncertainty. Purchased machines are expected to perform as promised by the seller. However, numerous uncertainties require attention, such as potential breakdowns, specification discrepancies, or subpar performance. A robust warranty is crucial in mitigating such risks. The Fuzzy-TOPSIS methodology integrates these criteria to evaluate alternatives and rank them based on their closeness to an ideal solution. By assigning weights to these criteria, the analysis accounts for their relative importance. Subsequently, each alternative's performance is assessed against the established criteria, employing fuzzy numbers to handle uncertainty and imprecision in the evaluation process. Finally, the Fuzzy-TOPSIS approach, through observation and evaluation of criteria like price, pressing power, machine weight, and warranty, offers a systematic means to aid wood companies in decision-making regarding press machine procurement.

Further, the next stage holds paramount importance in quantitative decision-making calculations using Fuzzy-TOPSIS methodology. The initial weighting step significantly influences the ultimate outcome in determining the most favourable decision. Weighting, within this context, involves assessing criteria such as price, machine weight, pressing power, and warranty against each other. While it may be straightforward to decide the best option when considering a single criterion, the complexity arises when dealing with four interlinked criteria present in the machines. Consequently, the subsequent normalization step becomes crucial to ensure an equitable assessment of these various criteria. Beyond weighting, this second stage introduces the application of fuzzy numbers. While TOPSIS analysis traditionally addresses multi-criteria decision-making, this method amalgamates fuzzy logic with the TOPSIS approach. This integration involves the incorporation of TOPSIS theory into the calculations, where triangular fuzzy numbers assume a central role as adjustment variables for each criterion. This process is integral as it facilitates a more comprehensive and nuanced assessment, considering multiple criteria and their respective weights through the integration of fuzzy logic and TOPSIS methodology. This fusion allows for a more refined decision-making process, particularly in situations where multiple criteria necessitate meticulous evaluation to arrive at an optimal decision.

The third step in the Fuzzy-TOPSIS methodology involves normalization, a critical aspect in the realm of Multiple Criteria Decision Making (MCDM). MCDM encompasses a set of techniques used to evaluate and prioritize among multiple conflicting criteria in decision-making scenarios. These methods aim to facilitate rational and structured decision-making processes when faced with complex, multi-dimensional problems. In intricate decision-making processes, especially those involving various criteria with diverse measurement scales or units, normalization becomes essential. It aims to bring disparate criteria onto a comparable scale, enabling fair and accurate assessments. The normalization process within TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) ensures that each criterion's values are standardized and do not exert disproportionate influence due to differences in their measurement units or scales. Consider a scenario where a decision involves factors like price, pressing power, machine weight, and warranty for machinery selection. These criteria inherently possess varying measurement ranges, making direct comparisons challenging. For instance, the price might be measured in currency units, while pressing power could be denoted by a different numerical scale. Normalization aids in resolving these disparities by transforming the values of each criterion into a comparable range, often between 0 and 1, ensuring uniformity in their evaluation. Fuzzy TOPSIS, a hybrid approach combining Fuzzy Logic principles with the TOPSIS technique, proves advantageous in such cases. Fuzzy Logic deals with uncertainty and imprecision in decision-making, accommodating the vagueness often encountered in real-world data. It allows for a more flexible representation of information, particularly useful when dealing with subjective or ambiguous criteria assessments. Implementing normalization in Fuzzy TOPSIS involves several steps. Initially, each criterion's values for all alternatives are normalized to eliminate the influence of measurement units. This normalization typically involves linear scaling or transformation techniques, ensuring that the values are proportionately comparable across criteria. Subsequently, weights or importance assigned to each criterion are considered to reflect their relative significance in the decision-making process.

CONCLUSION

Fuzzy TOPSIS, as one of the Multiple Criteria Decision Making (MCDM) tools, can serve as a decision support system in purchasing production equipment, specifically plywood press machines in wood processing companies.

The press machine with the highest value is AKS-SG50T, scoring 0.75, while the lowest recommendation is for the AKS-KX100T machine, scoring 0.12. From the ranking values in Cci, it can be concluded that purchasing the AKS-SG50T machine is the best decision based on the Fuzzy TOPSIS method.

The implementation of Fuzzy TOPSIS in decision-making processes presents a notably objective approach, offering a systematic method to evaluate alternatives and aid in arriving at informed choices. While it may not solely dictate the final decision, it serves as a crucial reference point that bolsters decision-makers' confidence by providing quantifiable justifications. In the realm of decision-making, especially within business contexts, the need for objective and accountable assessments is paramount. Fuzzy TOPSIS, a methodology integrating Fuzzy Logic principles with the TOPSIS technique, stands as a robust tool in this regard. It facilitates the evaluation and comparison of various alternatives by considering multiple criteria simultaneously. This method not only assists in identifying the best-suited option but also provides a structured approach to assess the pros and cons of each alternative systematically. By employing Fuzzy TOPSIS, decision-makers are equipped with quantitative assessments that are grounded in a systematic evaluation of criteria such as price, pressing power, machine weight, and warranty, among others. These objective assessments become valuable points of reference, enabling decision-makers to comprehend the relative strengths and weaknesses of each alternative.

Due to research limitations, it is recommended that when assigning linguistic values, multiple respondents should be involved to reduce the subjectivity of linguistic assessments.

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DECLARATION OF CONFLICTING INTERESTS
In this research, there are no conflicts of interest. The study is purely aimed at applying theory to practical aspects and hopefully can be used as a reference for decision-making in the field of MCDM business matters.

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