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Applying IROC Method in Patent Submission Evaluation in Indonesia: A Comparison with MAGIQ and AHP

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Abstract

This study applies the Improved Rank Order Centroid (IROC) to the Indonesian patent submission process within a Multi-Criteria Decision Making (MCDM) framework. The study evaluates four primary elements in patent assessment: "Patent Description," "Illustration," "Inventor's Ownership Statement," and "Rights Assignment Declaration." Preliminary findings indicate the importance of "Patent Description," followed by the other elements in descending order of significance. The evaluation also encompasses three applicant alternatives, with the Second Applicant emerging as the most favorable. The study further contrasts IROC outcomes with MAGIQ and AHP methodologies. While rank-based techniques like ROC and IROC generally produce similar weight distributions, the AHP method, which employs pairwise comparisons, often displays variations. The research underscores the potential of IROC in determining criterion weights, its comparison within the MAGIQ framework, and its validation through AHP. These insights aim to deepen our understanding of decision-making processes and analysis. The conclusion from comparing IROC results with MAGIQ and AHP indicates that the applicant rankings remain consistent. Therefore, further research is needed to understand the differences between evaluation methods and their impacts and explore the influence of cultural or regional factors in the patent submission process.

Keywords: MCDM; IROC; ROC; AHP; Weighting

1. INTRODUCTION

Multiple Criteria Decision Making (MCDM) is an essential methodological framework that aids in selecting the most suitable alternatives based on distinct criteria. These criteria consist of measurements, rules, and standards for decision-making. Within MCDM, several methodologies, including the Analytical Hierarchy Process (AHP), address its challenges. Utilizing these methodologies ensures a structured and systematic decision-making process based on what is determined by the decision maker (DM).

Weighting is a central aspect of MCDM, as evidenced by various scholarly works. For instance, a study [1] highlighted the use of TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) in creating an effective decision-support mechanism for determining the best coffee shop. The research began by constructing a decision matrix from the available data and normalizing it. Criteria such as Price, service, flavor, facility, and location were assigned weights based on significance. Each criterion was considered beneficial, with a focus on higher values. The study used the Euclidean distance metric to gauge the proximity of each coffee shop to both ideal solutions. The result was that the coffee shop labeled "A04" emerged as the top choice with a score of 0.9911, emphasizing the role of weight allocation in MCDM.

Another research [2], highlighted the importance of the WASPAS (Weighted Aggregated Sum Product Assessment) method in multi-criteria decision-making. This method combines the strengths of various models. The study began by defining criteria and assigning weights based on their relevance. In a study on webcam selection, attributes such as Camera Resolution, FPS, Viewing Angle, and Price for decision-making received specific criteria. After normalizing the scores, they were weighted to reflect the significance of each criterion. The WASPAS method then averaged the results of different models. Following this, alternatives were ranked, with "NYK Nemesis A96" emerging as the top choice with a score of 0.7053.

Comparatively, the AHP method, which necessitates initial weight assignment through its inherent consistency mechanism, is assessed using the Consistency Index. It highlights AHP's robust consistency, showcasing its ability to derive optimal solutions. Due to AHP's continued relevance, the MAGIQ methodology emerged, as indicated by [3].

A study by [4] explored the efficacy of Parental Control Applications in protecting children from online threats. Central to this research was the MAGIQ (Multi-Attribute Global Inference of Quality) approach, which, like AHP, uses Rank Order Centroids (ROC) to assign weights. The study identified critical criteria through questionnaires and used the ROC formula to determine weights. Feedback from parents in Indonesia's Jabodetabek region prioritized "Operability." The MAGIQ method assigned weights to each criterion, revealing rankings for various metrics. The study concluded that while Parental Control Applications are essential, active parental engagement and open communication with children remain crucial.

The ROC method stands as a notable technique in the realm of decision-making. This method enables decision-makers to prioritize criteria via a structured ranking process, subsequently converting these rankings into quantifiable weights. Additionally, several other methodologies, such as equal weights, rank sum, rank exponent, and rank reciprocal, are available, enhancing the versatility and rigor of decision-making across different scenarios [5].

The simplicity of the ROC calculation makes it easily understandable, leading to its widespread application in decision-making research. For instance, research [6] employed ROC to enhance the performance of the K-Means algorithm. In contrast, a study [7] integrated ROC as a weighting mechanism within the Simple Additive Weighting

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(SAW) to achieve effectiveness. Furthermore, research [8] demonstrated that the ROC method effectively determines the most favored type of Betta fish based on predefined criteria. By implementing this method, the public can effortlessly select popular Betta fish with significant market value. This assertion regarding ROC is further reinforced by a study [9], indicating that ROC offers a more straightforward approach, potentially facilitating its application in specific cases, especially when emphasizing particular criteria.

However, The ROC approach exhibits notable limitations, including its heavy reliance on preference collection methods that can lead to inconsistent outcomes. Additionally, it faces challenges in achieving group decision-making consensus, accurately gauging subjective evaluations, and assigning precise numerical values. In response to these challenges, [10] introduced an innovative technique termed Improved ROC (IROC). By utilizing the Criteria Breakdown Structure (CBS) for criteria categorization, IROC endeavors to augment the ROC method's accuracy and consistency. The overarching objective is to derive weights that are more reliable and consistently superior.

Therefore, To shed light on the efficacy of the Improved Rank Order Centroid (IROC) when determining specific criterion weights, this study has integrated these weights into the MAGIQ methodology. Subsequently, we have compared the results obtained using the Rank Order Centroid (ROC) within MAGIQ and those obtained by employing the Analytic Hierarchy Process (AHP) with eigenvalue-based weightings to validate the results. The anticipated outcomes of this study encompass three key elements: a demonstration of the superior efficacy of IROC in determining criterion weights, a significant comparison between IROC and ROC as applied within the MAGIQ framework, and lastly, the validation of IROC's effectiveness via the AHP. The purpose of the analysis is to analyze the accuracy of the weights. Moreover, these findings enhance our comprehension of decision-making and decision analysis.

2. RESEARCH METHODOLOGY

2.1 Rank Order Centroid (ROC)

The Rank Order Centroid (ROC) methodology provides an efficient and direct technique to ascertain the weights of criteria based on their prioritization [11]. As fundamental, ROC's principle is to allocate weights following the significance order of the requirements. The ROC of equation (1) as follows [12]–[14]:

$$\omega_i = \frac{1}{n} \sum_{j=i}^{n} \frac{1}{j} \tag{1}$$

We can describe formula (1) as follows: ω_i denotes the criterion's weight at the i^{th} rank, n signifies the cumulative number of measures, and j serves as the iterative index ranging from i to n

By employing the earlier formula, deducing the weight corresponding to each criterion's rank is feasible. Notably, a measure at the apex (1st rank) will inherently possess a weight surpassing those of lower-ranked standards. To illustrate, given three criteria where the first is ranked paramount, followed by the second, and the third is the least prioritized, the ROC formula can compute the respective weights for each criterion.

2.2 Improved Rank Order Centroid (IROC)

The Improved Rank Order Centroid (IROC) method determines criteria weights in decision-making processes. This method advances the Rank Order Centroid (ROC) method, characterized by modifications in the coefficients utilized.

2.2.1 Theoretical Foundation

In the ROC method, a constant coefficient, 1/n, is employed. However, in the IROC method, this constant coefficient is substituted with a variable coefficient (φ_j^n), derived from systematic simulations.

2.2.2 IROC Formula

The weights of criteria in the IROC method are computed using the following formula [10]:

$$w_j = \sum_{r=j}^{n} (\varphi_{rn}/r) \tag{2}$$

The difference between IROC and ROC lies in their coefficient, which is explained as follows: ωj denotes the weight of the j-th criterion. φrn represents a constant associated with the ranking r and the number of criteria n. r signifies the rank of a specific criterion, ranging from 1 to n, with one being the most important and n being the least important. n is the total number of criteria.

2.2.3 Coefficient Table

The coefficients φ_j^n, for each n are presented in Table 1 below:

Table 1. The Coefficient Table

n	the coefficients φ_{jn} (1, 2, 3,…, n)
2	0.51150,0.48850
3	0.32415,0.35529,0.32056

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n	the coefficients φ_{jn} (1, 2, 3,…, n)
4	0.23236,0.26888,0.26293,0.23583
5	0.17918,0.21316,0.21710,0.20416,0.18639
…	...
25	0.02702,0.03286,0.03681,0.03932,0.04108,…,0.03556

Table 1 is the coefficient table which used in formula (1). Central to this framework is the variable 'n,' which denotes the total number of criteria involved. This variable is pivotal as each row in the table adapts to represent different scenarios, each distinguished by the number of criteria it encompasses. The coefficients, expressed as φjn (1, 2, 3,..., n), have a crucial role in determining the weight of each criterion, directly linked to its rank in the overall analysis.

For instance, in Table 1, in a scenario where n=2, the coefficient for the first criterion is 0.51150, while 0.48850 for the second. This pattern extends to scenarios with more criteria, such as n=3, where the coefficients are 0.32415, 0.35529, and 0.32056 for the first, second, and third criteria, respectively. These coefficients are integral to the IROC formula, facilitating the calculation of each criterion's relative weight. Such weights are then instrumental in evaluating various options within the decision-making process. A notable aspect of this system is the variation in coefficient values with different 'n,' ensuring that each criterion's weight accurately reflects its relative importance in the context of the total number of criteria.

2.2.4 IROC Algorithm

To ensure a comprehensive analysis, we must juxtapose the Improved Rank Order Centroid (IROC) method with other prevailing techniques, such as the MAGIQ approach. Leveraging data from established sources, in this case, reference [15], provides credibility and a foundation for the comparison. Implementation Steps for IROC Algorithm:

a. Determination of Criteria Count: First, one must determine the total number of criteria at hand, denoted as n.
b. Coefficient Retrieval from the Table: Based on the determined number of criteria n, the corresponding coefficients from the provided table should be extracted.
c. Criteria Assessment by DM: The Decision Maker (DM) should be solicited to rank each criterion. The most significant criterion receives a rank of 1, followed by the next in importance with a level of 2, and so forth.
d. Weight Calculation using the IROC Formula: By employing the ranks given by the DM and the coefficients from Table 1, the weights for each criterion are computed using the IROC formula.
e. Application of Weights in the Decision Model: After determining the weights for each criterion, these weights should be incorporated into the decision-making model.
f. Result Analysis: The outcomes from the decision model, which utilizes IROC weights, should be compared against results from other methodologies or against the DM's intuition to validate the accuracy and consistency of the decisions.

2.3 Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a decision-making method that decomposes complex problems into simpler components and organizes these components hierarchically. Within AHP, the eigenvalue of the pairwise comparison matrix is utilized to determine the relative weights of each criterion or alternative and to assess the consistency of these pairwise comparisons [16]–[20]. However, the study does not delve into the detailed calculations of AHP but compares the results with those presented in reference [15].

3. RESULT AND DISCUSSION

For comparison with IROC, this study employs a case study of the patent application process in Indonesia. The MCDM framework has four criteria and three alternatives, as illustrated in Table 2.

Table 2. Decision Determining Factor of the MAGIQ

Criteria	Alternatives
Patent Description (1)	First Applicant (1)
Illustration (4)	Second Applicant (2)
Inventor's Ownership Statement (2)	Third Applicant (3)
Declaration of Rights Assignment (3)	

Per the data in Table 2, rankings are systematically allocated to both criteria and alternatives to enable accurate computation of associated coefficients. For the criteria, with a coefficient of n = 4, the values are φ_{14} = 0.23236, φ_{24} = 0.26888, φ_{34} = 0.26293, φ_{44} = 0.23583. Corresponding ranks derived from the coefficients are detailed in Table 3.

Table 3. IROC for Criteria

Criteria	Rank	Coefficient	IROC
Patent Description	1	(0.23236/1)+(0.26888/2)+(0.26293/3)+(0.23583/4)	0.513401
Illustration	4	(0.23583/4)	0.058958

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Criteria	Rank	Coefficient	IROC
Inventor's Ownership Statement	2	(0.26888/2)+(0.26293/3)+(0.23583/4)	0.281041
Declaration of Rights Assignment	3	(0.26293/3)+(0.23583/4)	0.146601

In patent evaluation, four key elements are paramount: the "Patent Description," the "Illustration," the "Inventor's Ownership Statement," and the "Rights Assignment Declaration." IROC quantifies the importance or priority of each of these components. The "Patent Description" holds the highest significance, as indicated by its leading IROC value of 0.513401. We suggest that any evaluation based on this table should prioritize the "Patent Description." The "Inventor's Ownership Statement" follows with an IROC value of 0.281041. While it does not surpass the "Patent Description" in importance, it remains a significant factor in the assessment. The "Rights Assignment Declaration" has an IROC value of 0.146601, ranking it below both the "Patent Description" and the "Inventor's Ownership Statement" in terms of importance. However, the "Illustration" carries the least priority, reflected by its IROC value of 0.058958. After the primary three elements, the "Illustration" is an ancillary consideration in this evaluation framework. In summary, the optimal approach would prioritize the "Patent Description," followed by the "Inventor's Ownership Statement," then the "Rights Assignment Declaration," and lastly, the "Illustration."

The study analyzes three alternatives (First applicant, Second Applicant, and Third Applicant) for which the values are $\varphi_{13} = 0.32415$, $\varphi_{23} = 0.35529$, and $\varphi_{33} = 0.32056$. Table 4 showcases the IROC-level calculations for these alternatives.

Table 4. IROC Level for Three Alternatives

Rank	Coefficient	IROC
1	(0.32415/1)+(0.35529/2)+(0.32056/3)	0.608648
2	(0.35529/2)+(0.32056/3)	0.284498
3	(0.32056/3)	0.106853

The values of three alternatives based on Table 4 are cumulative coefficients with each rank. For example, Rank 1's IROC value of 0.608648 is the total sum of its coefficients (0.32415/1)+(0.35529/2)+(0.32056/3), indicating a comprehensive score. Similarly, Rank 2's IROC value (0.284498) is the sum of φ23 and φ33 coefficients (0.35529/2)+(0.32056/3), and Rank 3's IROC value (0.106853) is φ33 coefficient ((0.32056/3). This ranking system prioritizes values in Rank 1, gradually decreasing the contribution of each coefficient as the rank lowers, which we obtained from formula (1). Subsequently, the IROC values for the alternatives are incorporated into each criterion, as illustrated in Table 5.

Table 5. IROC for Each Alternative

Criteria/Alternatives	Rank	IROC
Patent Description:		
First Applicant	2	0.284498
Second Applicant	1	0.608648
Third Applicant	3	0.106853
Illustration:		
First Applicant	1	0.608648
Second Applicant	2	0.284498
Third Applicant	3	0.106853
Inventor's Ownership Statement:		
First Applicant	2	0.284498
Second Applicant	3	0.106853
Third Applicant	1	0.608648
Declaration of Rights Assignment:		
First Applicant	3	0.106853
Second Applicant	1	0.608648
Third Applicant	2	0.284498

Based on Table 5, we can interpret each alternative as follows:

a. For the "Patent Description" criterion:
   1. The Second Applicant secured the top position with an IROC value of 0.608648, indicating a predominant contribution.
   2. The First Applicant followed closely in the second rank with an IROC value of 0.284498.
   3. The Third Applicant held the last rank, having an IROC value of 0.106853, suggesting a lesser contribution than the other two.

b. Regarding the "Illustration" criterion:
   1. The First Applicant excelled with the highest IROC value of 0.608648.
   2. The Second Applicant came next, achieving an IROC of 0.284498.
   3. The Third Applicant took the third position with an IROC value of 0.106853.

c. In the "Inventor's Ownership Statement" criterion:

1. The Third Applicant led an IROC score of 0.608648.
2. The First Applicant ranked second, registering an IROC of 0.284498.
3. The Second Applicant, with an IROC value of 0.106853, was ranked third.

d. For the "Declaration of Rights Assignment" criterion:
1. The Second Applicant emerged as the top contender, boasting an IROC value of 0.608648.
2. The Third Applicant was ranked second with an IROC of 0.284498.
3. Having secured an IROC value of 0.106853, the First Applicant occupied the third rank.

The IROC methodology provided a nuanced understanding of each applicant's relative contribution or qualification across four pivotal criteria. The IROC values are a quantifiable metric to rank the applicants, ensuring a systematic and objective evaluation.

Table 6. The result of MAGIQ Calculation

	Patent Description	Illustration	Inventor's Ownership Statement	Declaration of Rights Assignment	Overall	Rank
	0.513401	0.058958	0.281041	0.146601		
First Applicant	0.284498	0.608648	0.284498	0.106853	0.2775665	2
Second Applicant	0.608648	0.284498	0.106853	0.608648	0.4485124	1
Third Applicant	0.106853	0.106853	0.608648	0.284498	0.2739211	3
				Sum	1	

Table 6 showcases the results of the MAGIQ calculation for three applicants across distinct criteria. Upon aggregating the scores for each criterion, the overall MAGIQ scores were derived. The Second Applicant achieved the pinnacle with an impressive score of 0.4485124. Closely following was the First Applicant with an overall tally of 0.2775665. The Third Applicant, while competitive, secured the lowest combined score of 0.2739211. The summed score, reaching a total of 1, confirms the normalization of the scores, ensuring that the results are proportionally representative of each applicant's contributions.

The rankings, derived from these overall scores, clearly illustrate the relative standing of each applicant. The Second Applicant's top rank signifies their superior performance or contribution across the evaluated criteria. Meanwhile, the close scores between the First and Third Applicants, resulting in their respective second and third rankings, suggest competitive performance with marginal differences. It is essential to note that even minor variations in overall scores can influence the rankings, underlining the precision and sensitivity of the MAGIQ evaluation.

3.1 Discussion

We can compare the results obtained using MAGIQ with IROC calculations with a study's MAGIQ and AHP outcomes [15]. We can also validate that the rankings from IROC align with those from AHP. Consequently, the discussion concerning comparing these three methods can be segmented into the following sections.

3.1.1 Ranking Comparison of IROC-MAGIQ, ROC-MAGIQ, and Eigenvalue-AHP

The First Applicant (P1) consistently secures the second spot in every evaluation, demonstrating a commendable but not outstanding performance or contribution compared to the other candidates. Their overall scores in each table are close to each other, indicating a moderate level of competence or input.

However, the Second Applicant (P2) consistently dominates all three assessments, surpassing the other contenders with unwavering excellence. The methodologies unanimously attest to the Second Applicant's performance or contribution superiority.

Meanwhile, the Third Applicant (P3) consistently finds themselves in the third position across all tables. Their scores across the various evaluation techniques show a relative proximity, signifying that their performance or contribution ranks lowest among the three applicants.

In summary, regardless of the evaluation method employed, whether IROC-MAGIQ, ROC-MAGIQ, or Eigenvalue-AHP, the ranking of the applicants remains consistent. The Second Applicant consistently emerges as the top performer, with the First Applicant following closely behind, while the Third Applicant consistently settles into the last spot. This unwavering pattern across different evaluation methodologies underscores the results' robustness and solidifies the applicants' relative standings.

3.1.2 Difference of IROC, ROC, and Eigenvalue Weighting

Weighting is critical in making decisions, and the choice of method can significantly impact the results. This section explores the distinctions and implications of three prominent weighting techniques: IROC, ROC, and Eigenvalue. Through patent submission analysis, we scrutinize how these methods assign weights differently. Emphasis is placed on differential and precision analyses to highlight the unity and variances among the methods. Each subsection provides an in-depth look into their behavior, ensuring a holistic understanding of the intricacies involved in weightage distribution.

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3.1.2.1 Patent Description

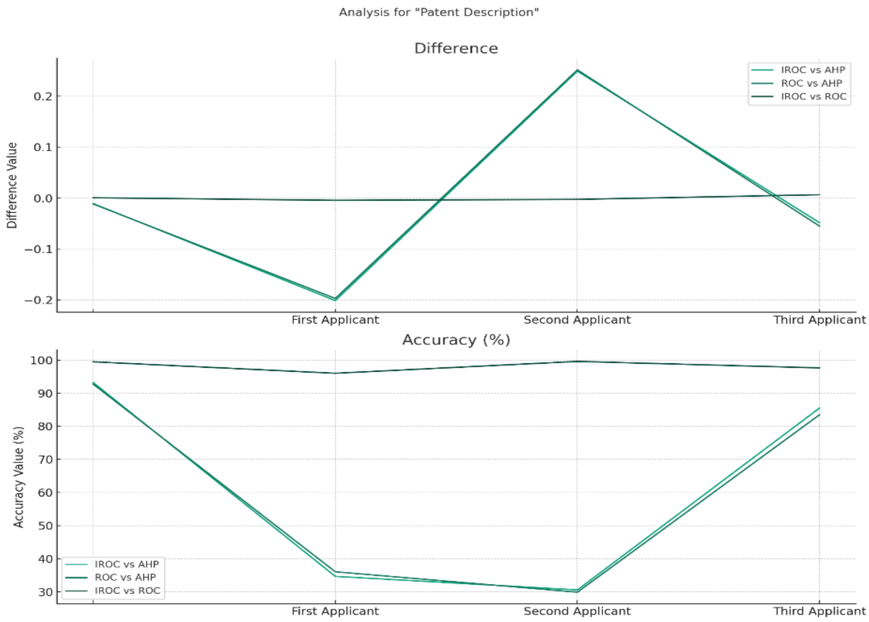

Figure 1. Difference and Accuracy Weight for Patent Description

a. Differential Analysis:
   1. The curve comparison between IROC and AHP reveals a pronounced disparity in the weightage assigned by the IROC method relative to AHP, particularly for the First and Fourth Applicants.
   2. The congruence between IROC and ROC curves demonstrates their aligned weightage derivations.

b. Precision Analysis:
   1. A high congruence percentage between IROC and ROC for all applicants indicates nearly identical outcomes between these methods.
   2. In contrast, the congruence between IROC (or ROC) and AHP is less pronounced, suggesting variations in the AHP method's weightage assignment.

3.1.2.2 Illustration

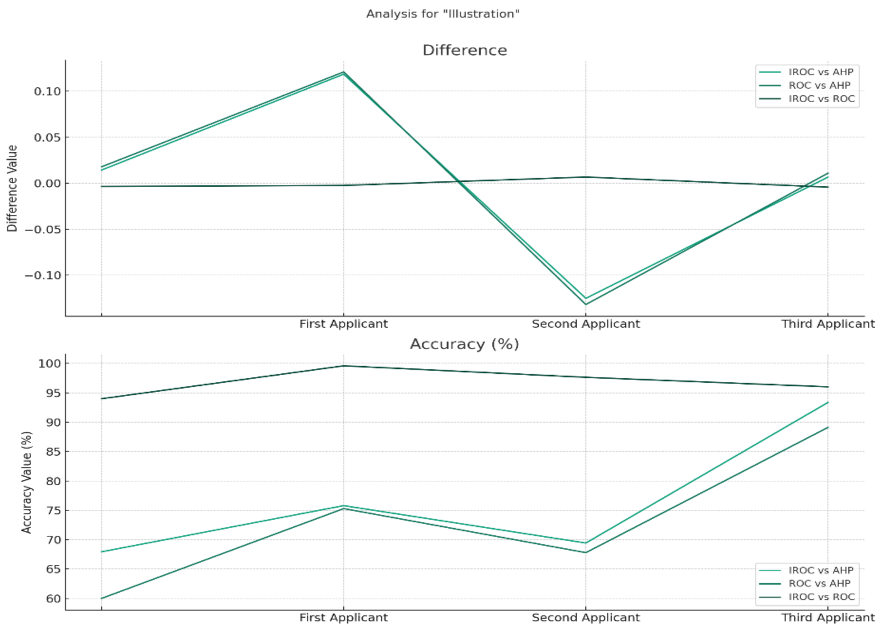

Figure 2. Difference and Accuracy Weight for Illustration

a. Differential Analysis:
   1. Negligible variations among the three methods in this category reflect consistent weightage assignments across methodologies.

b. Precision Analysis:

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1. The congruence between IROC and ROC remains consistent for all applicants, whereas the congruence between IROC (or ROC) and AHP exhibits more fluctuation, notably for the Second Applicant.

3.1.2.3 Inventor's Ownership Statement

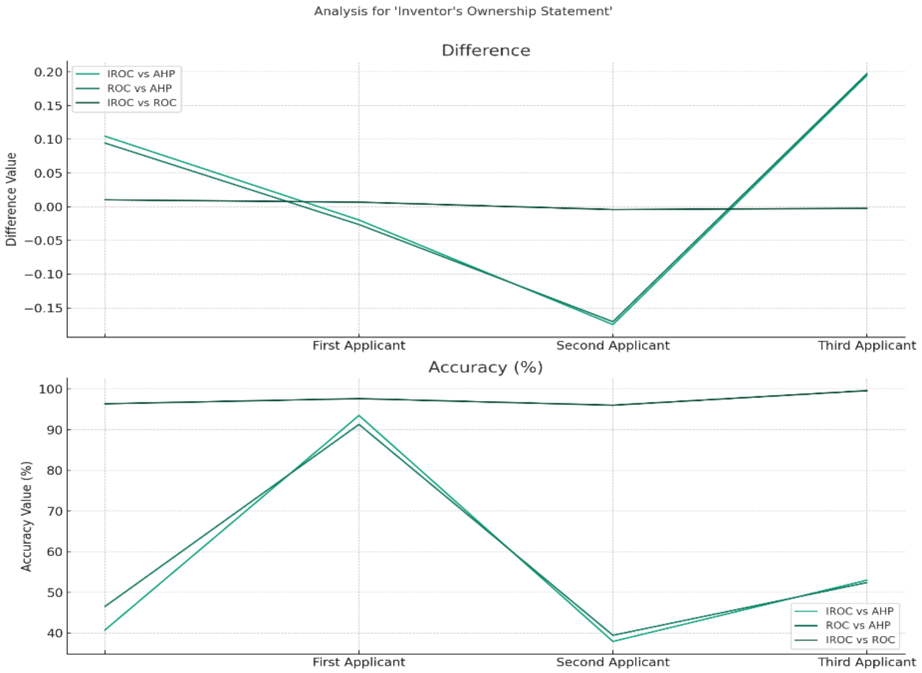

Figure 3. Difference and Accuracy Weight for Inventor's Ownership Statement

a. Differential Analysis:
   1. The data suggests analogous weightage distributions between IROC and ROC, with AHP presenting distinct variations, especially for the Third Applicant.

b. Precision Analysis:
   1. A nearly perfect congruence between IROC and ROC for all applicants emphasizes their methodological alignment in this category.
   2. A discernible reduction in congruence between IROC (or ROC) and AHP, especially for the Third Applicant, accentuates the divergent weightage distributions among these methods.

3.1.2.4 Declaration of Rights Assignment

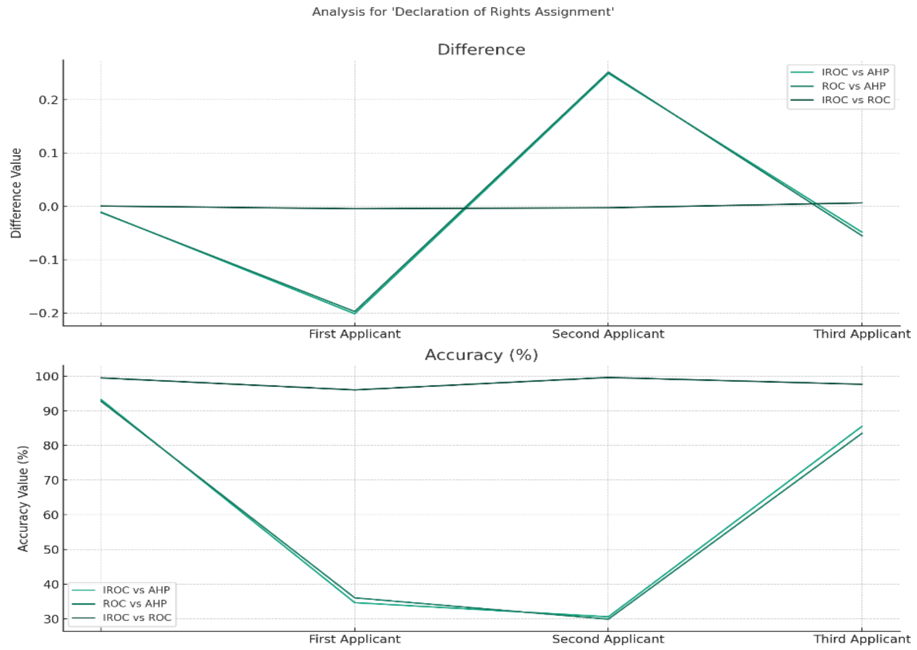

Figure 4. Difference and Accuracy Weight for Declaration of Rights Assignment

a. Differential Analysis:
   1. The closely aligned curves in this category indicate minimal weightage distribution differences across the three methods.
b. Precision Analysis:
   1. The congruence between IROC and ROC remains consistently high for all applicants, while the congruence with AHP varies more.

Rank-based methods, such as ROC and IROC, generally produce analogous weightage distributions across most categories. In contrast, the AHP method, which employs pairwise comparisons, often diverges, especially in categories like "Patent Description" and "Inventor's Ownership Statement." The observed disparities arise from the intrinsic differences between rank-based and pairwise comparison techniques. The nature of the decision-making problem and the foundational data should guide the selection of an appropriate method.

4. CONCLUSION

The study contrasts the patent submission process in Indonesia with the IROC through an MCDM approach. Four pivotal elements in patent evaluation, namely "Patent Description," "Illustration," "Inventor's Ownership Statement," and "Rights Assignment Declaration," undergo assessment based on their significance via IROC values. The "Patent Description" emerges as the most crucial, followed by the "Inventor's Ownership Statement," "Rights Assignment Declaration," and "Illustration." Additionally, the evaluation assesses three applicant alternatives, with the Second Applicant prevailing in the overall assessment. The evaluation also juxtaposes IROC results with those from MAGIQ and AHP. Regardless of the chosen evaluation method, the applicant rankings remain steadfast. While rank-based methods like ROC and IROC typically yield analogous weightage distributions, the AHP method often exhibits variations, employing pairwise comparisons to have eigenvalue. Future research should contemplate incorporating additional empirical data to offer deeper insights into the relationships between criteria and applicant alternatives. Given the observed discrepancies between AHP, ROC, and IROC, delving deeper into the factors influencing these differences is recommended. We might also consider how other evaluation methods could impact rankings and outcomes beyond this study's analysis. Understanding the ramifications of cultural or regional disparities in the patent submission process presents an intriguing avenue for exploration.

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