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EVALUATING ARTIFICIAL INTELLIGENCE GOVERNANCE MODELS IN IMMIGRATION ADMINISTRATION: A RULE OF LAW BASED MULTI CRITERIA DECISION FRAMEWORK

AVALIANDO MODELOS DE GOVERNANÇA DE INTELIGÊNCIA ARTIFICIAL NA ADMINISTRAÇÃO DE IMIGRAÇÃO: UMA ESTRUTURA DE DECISÃO MULTICRITÉRIO BASEADA NO ESTADO DE DIREITO

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Abstract
The main problem addressed in this study is how states can integrate artificial intelligence into immigration procedures without undermining rule of law principles. The key issue that must be analyzed is the selection of the most appropriate governance model based on legally grounded criteria. The literature lacks structured and quantitative frameworks that systematically evaluate artificial intelligence governance alternatives in migration administration. This study proposes a novel multi criteria decision making model to fill this gap. The model combines stepwise weight assessment ratio analysis (SWARA) for weighting criteria, root assessment model (RAM) for ranking governance strategies, and interval valued q rung orthopair fuzzy sets to address uncertainty in expert judgments. The findings show that the positioning of decision-making authority and the obligation to provide reasoned decisions are the most influential criteria, and that the administrative support model is the most appropriate approach. The study contributes by integrating legal analysis with advanced decision tools. It recommends governance strategies that preserve human authority, ensure transparency, and limit artificial intelligence to supportive administrative functions.

Resumo
O principal problema abordado neste estudo é como os estados podem integrar a inteligência artificial nos procedimentos de imigração sem prejudicar os princípios do Estado de direito. A questão fundamental que deve ser analisada é a seleção do modelo de governação mais adequado com base em critérios legalmente fundamentados. A literatura carece de quadros estruturados e quantitativos que avaliem sistematicamente as alternativas de governação da inteligência artificial na administração da migração. Este estudo propõe um novo modelo de tomada de decisão multicritério para preencher essa lacuna. O modelo combina análise gradual da razão de avaliação de peso (SWARA) para critérios de ponderação, modelo de avaliação de raiz (RAM) para estratégias de governança de classificação e conjuntos fuzzy de ortopares de q degrau com valor de intervalo para lidar com a incerteza em julgamentos de especialistas. As conclusões mostram que o posicionamento da autoridade de tomada de decisão e a obrigação de fornecer decisões fundamentadas são os critérios mais influentes e que o modelo de apoio administrativo é a abordagem mais adequada. O estudo contribui ao integrar a análise jurídica com ferramentas avançadas de decisão. Recomenda estratégias

Keywords: Artificial Intelligence Governance. Immigration Administration. Rule of Law. Asylum. Border Control.

de governação que preservem a autoridade humana, garantam a transparência e limitem a inteligência artificial a funções administrativas de apoio.

Palavras-chave: *Governança de Inteligência Artificial. Administração de Imigração. Estado de Direito. Asilo. Controle de Fronteiras.*

1 INTRODUCTION

The use of artificial intelligence in managing immigration procedures can be considered a relevant policy option for modern states, especially in contexts where administrative capacity is limited and application volumes are high. Its importance lies in the potential to improve consistency, speed, and access to information within complex decision processes. However, the way artificial intelligence is integrated is decisive for its compatibility with the principles of the rule of law. Different governance approaches reflect varying levels of algorithmic influence and human control (Chartier-Edwards et al., 2025). In a factual automation and decision delegation model, artificial intelligence becomes the main determinant of outcomes, while human involvement is reduced to formal approval. A weak human oversight model retains human confirmation but leaves the algorithmic framework largely decisive. In contrast, a strong human oversight model treats artificial intelligence as an analytical tool, while legal qualification and final decisions remain with human officials. More limited approaches include administrative support models, where artificial intelligence is used for file management and procedural efficiency, and rights enhancing administrative support models, which focus on improving applicants' access to information, reasoning, and procedural safeguards (Saunders, 2025). Selecting among these approaches requires careful evaluation of their legal and institutional implications.

The selection of appropriate governance strategies for artificial intelligence in immigration procedures requires the consideration of multiple legal and administrative criteria. The positioning of decision-making authority is central, as it determines whether public power remains with accountable human actors. Closely related to this is the issue of accountability and legal responsibility, which must remain clearly identifiable in case of unlawful decisions. Individualized assessment obligations are also essential, as migration decisions directly affect fundamental rights and cannot rely solely on generalized patterns (Tomasev et al., 2025). The duty to provide reasoned decisions supports transparency and enables effective judicial review. Effective legal remedies must be preserved so that applicants can challenge adverse outcomes in a meaningful way. Personal data protection and purpose limitation obligations are particularly relevant given the sensitive nature of migration data. The principle of non-transferability of public authority requires that core sovereign powers are not fully delegated to automated systems (Memon et al., 2024). Finally, procedural safeguards must remain continuous even under crisis conditions, such as mass migration or emergency situations, to prevent the normalization of reduced legal protections.

Determining the governance approach that is most compatible with the rule of law in the use of artificial intelligence for immigration procedures is a critical task for states. This determination directly affects the ability of public administrations to implement appropriate actions in a timely manner. When unsuitable approaches are adopted, states may face significant financial costs due to legal disputes, system redesigns, and administrative inefficiencies. These costs can negatively affect the financial performance of public institutions and reduce overall policy effectiveness. Beyond financial impacts, improper use of artificial intelligence in migration governance can also generate social consequences, including loss of public trust and increased perceptions of injustice among affected communities. Despite these risks, existing academic studies that systematically identify and prioritize the most relevant legal and governance criteria remain limited. This scarcity creates a significant research gap in the literature (Csatlós, 2024). As a result, policymakers often lack structured decision support when choosing among alternative governance models. The absence of such guidance increases the likelihood of fragmented practices and inconsistent legal standards across jurisdictions.

This study aims to develop a governance approach for the use of artificial intelligence in state immigration procedures that is highly compatible with the principles of the rule of law. The motivation of the study arises from the need for a structured and transparent decision-making framework that can guide public authorities. To achieve this goal, a new decision-making model is proposed. Based on an extensive literature review, a set of evaluation criteria and governance alternatives is identified. Opinions are collected from ten experts with relevant legal and administrative backgrounds. The SWARA technique is applied to calculate the importance weights of the criteria. Subsequently, the RAM approach is used to rank the governance strategies. Interval valued q rung orthopair fuzzy sets are integrated into the model to better capture uncertainty and expert hesitation. The study seeks to answer the following research questions. (1) Which governance approach for artificial intelligence in immigration procedures is most compatible with rule of law principles. (2) Which legal and institutional criteria play the most significant role in this evaluation. (3) How can advanced fuzzy decision-making tools improve the robustness of governance selection processes.

This study contributes to the literature by providing a structured and legally grounded decision-making framework for artificial intelligence governance in immigration procedures. It also addresses an underexplored intersection between migration law and multi criteria decision analysis. The proposed model demonstrates several advantages over previously developed approaches. (1) The use of interval valued q rung orthopair fuzzy sets offers significant benefits, as these sets allow a wider representation of uncertainty, reduce information loss, and provide greater flexibility than traditional fuzzy and intuitionistic fuzzy sets. This is particularly useful when expert judgments are imprecise or hesitant. (2) The application of the SWARA technique for weighting criteria is another advantage, as it relies on expert driven stepwise comparison and reduces cognitive burden. It is well suited to legal evaluations where relative importance is easier to express sequentially rather than through pairwise matrices. (3) The use of the RAM technique for ranking strategies enhances the model, as it focuses on reference-based comparison and produces stable rankings. This makes it especially appropriate for governance evaluations involving qualitative and normative considerations.

This study is organized as follows. The introduction presents the research problem, motivation, and objectives of the study. The literature review examines existing studies on artificial intelligence governance, immigration procedures, and related decision-making models. The proposed methodology section explains the structure of the decision-making model, including the criteria, alternatives, and applied techniques. The analysis results section reports the findings obtained from the model implementation. The discussion section interprets these results considering legal and policy implications. Finally, the conclusion summarizes the main contributions of the study and outlines potential directions for future research.

2 LITERATURE REVIEW

The most rule-of-law-compliant governance approach to the use of artificial intelligence in immigration processes by states should be defined as a multi-layered and human rights-focused strategy. Artificial intelligence has become a tool taken for granted by both public and private actors in border management, as it has in many areas of social, political, and economic governance. This widespread acceptance has led to a strong belief that artificial intelligence will make borders more secure, fill information gaps, accelerate decision-making processes, and make interventions more accurate (Aradau, 2023). Licata (2025) argues that there is a significant asymmetry in information and expertise between public authorities and private suppliers, and that public institutions often lack the technical capacity to develop these systems autonomously. He suggests that this technical dependence exposes public buyers to the risk of "capture" by market actors who set standards and technical documentation, effectively transferring public power to technical parameters and market-oriented standards determined by the private sector, making it difficult for the state to maintain its sovereign authority. Therefore, when purchasing AI systems, states should focus not only on technical efficiency but also on specifications that incorporate democratic values into the system's design. La Spina (2024) also argues that the role of AI in migration management is not merely a matter of technical efficiency, but a profound legal shift that alters the nature of sovereign authority. Primarily, migration management has become a massive data laboratory for AI systems. While the system decides what to filter out as “noise data” or what to flag as a “security threat,” the official’s concrete judgment in the individual case lags these technical parameters. This situation leads to public power being exercised through hidden administrative rules determined by those who write the code or select the datasets (mostly the private sector). Tomasev et al. (2025) argue that it’s not just the transfer of public power to a company or algorithm, but also the risk of surrendering to a biased ideology that codes a segment of society as “outsiders to be systematically excluded.” The authors argue that artificial intelligence systems automate xenophobia in the form of “civic ostracism”. Bélanger et al. (2025) state in their study that decision-making authority (discretion) is no longer solely held by frontline officials; it is distributed and displaced to software designers, managers who set triage rules, and those who manage risk indicators. Chartier-Edwards et al. (2025) describe this distribution of decision-making authority through technological systems as "anarchitecture," analyzing that it creates a blurred, fragmented, and sometimes inconsistent mode of government instead of a monolithic state structure, and that decision-making authority is no longer a matter of policy but a cybernetic process of "steering and acceleration" technology. Brunner et al. (2024) also argue that the state's decision-making authority is shifting towards a hybrid structure where algorithmic systems guide human reasoning or are directly decisive in some routine tasks.

Kinchin (2024) argues that asylum law, by its very nature, necessitates a form of reasoning based on “abductive reasoning,” that is, choosing the best explanation from among the incomplete and flawed evidence at hand. He states that asylum decisions are not a mechanical evaluation of individual pieces of evidence, but rather an assessment process where risks are weighed holistically and the “most plausible” outcome is preferred. In contrast, he argues that artificial intelligence systems essentially operate through inductive correlations based on statistical similarities in past data; this approach reduces the asylum seeker’s unique narrative to superficial similarities found within large datasets, rather than understanding it based on world knowledge and common sense, thus undermining the principle of individualization in the decision-making process. Saunders (2025) also analyzes the burden of individual assessment through the ontological condition of the individual and the integrity of the data, proposing the concept of the “dividual” (fragmented/fragmented individual) and centering on the individual’s right to be seen as a “whole” in law. In this context, it is argued that AI-powered digital border systems treat the individual not as a singular and concrete human being, but as a fragmented entity composed of bits and digits scattered across different databases. Decision-making processes are based not on the individual themselves, but on a "data double" (data twin/fiction) created by the reassembly of scattered data fragments by algorithms. As a result, the link between the refugee's real personality and this digitally constructed fiction is broken; this break creates a structural violation that undermines the essence of the right to individual assessment. Amoroso (2024) also grounds the criterion of individual assessment on the "subjective element" at the heart of asylum law, namely the concept of fear, and emphasizes that the individual's inner world, emotional experiences, and perceptions cannot be fully measured with objective data. From this perspective, while AI systems can analyze external and objectifiable elements such as the risk of persecution through data sets, they are structurally inadequate in grasping the personal, emotional, and contextual nuances that constitute the refugee's "fear of persecution." According to Amoroso, a decision-making process devoid of human interaction—that is, an assessment made “looking into someone’s eyes”—cannot reflect the refugee’s true situation; this emotional blindness effectively makes individual assessment impossible, leading to discriminatory outcomes. Biswas (2025) addresses the issue from a socio-technical perspective, examining how technology anonymizes individuals under the guise of neutrality through the “smartness mandate.” The clustering process of artificial intelligence defines the individual solely by the characteristics of the group to which they are assumed to belong (e.g., a specific nationality or “risk profile”). As a result, the refugee is treated not as a unique individual, but as part of a “fabricated group” produced by the system, leading to the disregard of individual nuances and the reinforcement of stereotypes.

The Obligation to Provide Reasoned Decisions refers to the requirement that AI-powered systems in migration and asylum processes clearly and verifiably demonstrate the specific data and legal grounds upon which their decisions are based; this obligation is a fundamental procedural safeguard that prevents arbitrariness in decisions and enables the individual's right to an effective appeal. Csatlós (2024) defines justification as the "heart" of an administrative decision and states that this obligation both proves the legality of the administration and provides the individual with the opportunity to seek redress. In his study, Stewart (2024a) addresses the obligation to provide reasoned decisions through the lens of the asylum seeker's right to meaningful participation in the process and argues that the "black box" nature of AI leads to the inability to explain the logic of the decision, thus excluding the individual from the process that determines their own fate. Therefore, justification is not only a procedural obligation but also a prerequisite for protecting the individual's dignity and enabling them to effectively appeal the decision, because a genuine defence against a decision whose reasoning is not explained will not be possible. Memon et al. (2024) argues that the "similarity scoring" used by artificial intelligence in the justification process creates a structural contradiction. Using the Casematcher example from the Netherlands, they show that an asylum seeker's narrative can be rejected as "fabricated" if it is found to be very similar to past decisions, and as "illogical" if it is found to be very different. This situation reveals that the obligation to provide reasoned decisions risks squeezing the individual's unique narrative into statistical patterns instead of understanding it and undermines the reliability of the decisions.

These discussions bring the issue to the protection of personal data and the obligation of purpose limitation upon which these decisions are based. Poyares (2025) criticizes the fact that data collected within the scope of humanitarian aid or asylum applications are diverted from their intended purpose through “compulsory consent” mechanisms and transformed into a profitable source of “behavioral surplus” for technology companies. In this context, the indefinite use of migrant data not only for identification purposes but also for behavioral prediction and algorithm training is discussed within the framework of the concept of “migrant data extractivism”. The study also states that the indefinite storage of biometric and genetic data collected from migrants and their sharing with forensic databases fundamentally undermines the principle of data protection and purpose limitation. Therefore, Phang et al. (2025) argue that, in line with the principle of data minimization, personal data should be limited and processed only for specific, legitimate, and clearly defined purposes, and that a fundamental protection mechanism should be established against the risk of "purpose creep," which is frequently encountered in artificial intelligence and big data analytics processes and means that data is used beyond its original purpose of collection. Bergh et al. (2022) emphasize in their study that there is no public oversight of how security agencies and private sector partners manage this data, and that this institutional "opaque" effectively renders data protection principles ineffective.

The governance of immigration procedures during crises such as war, natural disasters, and epidemics becomes an area requiring far greater attention than in normal times. This is because, under such extraordinary circumstances, migration ceases to be an individual or family phenomenon and reaches the scale of a mass influx. Resolution 2628 (2025), adopted by the Parliamentary Assembly of the Council of Europe, emphasizes that regardless of the administrative burden created by crises, artificial intelligence systems should under no circumstances replace human decision-makers, but should only be used to support decision-making processes (“support – not replace”). It clearly states that even under crisis conditions, bypassing international protection obligations, particularly the prohibition of return (non-refoulement) and the right to asylum, is not permitted. Ineli-Ciger et al. (2025) argues that, addressing crisis conditions through the lens of mass influx situations where asylum systems are "overwhelmed," inclusion decisions (e.g., automatically granting refugee status to a group of a specific nationality) can be delegated to autonomous systems to increase efficiency during crises, but all exclusion or decisions with negative consequences must remain under absolute human control. Thus, technological speed is used only to facilitate access to rights, while the risk of loss of rights is prevented by human judgment. Mozumder (2024) considers crisis conditions, especially after climate disasters, as processes where refugees are traumatized and pressured to make "hasty decisions." In this context, he argues that artificial intelligence should function not as an obstacle or an accelerating filter, but as a "human window" that supports refugees' problem-solving capacities and facilitates access to information and services. Abbas (2026) argues that technology-supported and transparent governance during times of crisis constitutes a necessary infrastructure for the state to protect its political and economic sovereignty. However, empirical data shows that technological solutions do not produce the same results in every country. Accordingly, low-income countries are more responsive and generally more positive towards digital innovations and diaspora support during times of crisis, while lower-middle-income economies exhibit a relatively more resistant attitude towards such innovations. These findings suggest that crisis management models should be tailored to the economic development level of each country.

The criterion of ensuring effective legal recourse means that individuals can understand the logic behind algorithmic decisions made about them, challenge these decisions, and have the opportunity to seek redress before an independent judicial body. Horvath et al. (2023) demonstrate that the presence of an appeals mechanism in AI systems is the most fundamental element that increases individuals' perception of the system as procedurally fair and their likelihood of accepting it. The guarantee of effective legal recourse is an indispensable mechanism that prevents arbitrariness that may arise from the "black box" nature of AI and protects the democratic legitimacy of the state in the eyes of citizens when using public power. Stewart (2024b) argues that the recording of AI systems used in the field of immigration in non-public databases makes it difficult for individuals and civil society organizations to exercise their right to effective legal recourse. Even if the right to legal recourse is included in legislation, he suggests that due to technical closure, difficulties in accessing information, and lack of representation, oversight remains "in the shadows," rendering this right practically ineffective for people. Mégret (2024), while acknowledging the existence of judicial avenues against the illegality of visa systems, argues that appealing visa refusals from abroad is costly, lengthy, and virtually unsupervised, thus not offering an effective solution in practice. Consequently, although legal recourse mechanisms exist on paper, the technical complexity of the system and geographical distance make these safeguards inaccessible to applicants.

The Accountability and Legal Responsibility criterion addresses how responsibility for human rights violations arising from the use of artificial intelligence systems will be shared among the administration, developers, and other stakeholders, and how this responsibility will be monitored through effective oversight mechanisms. Ikkatai et al. (2025) emphasize that, within the framework of ethical, legal, and social issues, subjecting artificial intelligence to legal regulations is necessary due to its societal impacts. Khan et al. (2024) demonstrate that artificial intelligence used in immigration services is continuously refined through user feedback, and that the institution is directly responsible for this performance. However, they argue that legal regulations such as the Algorithmic Accountability Act are necessary to hold the private sector accountable for damages. In areas with extremely severe consequences, such as migration, they emphasize that algorithmic injustices cannot be seen merely as technical errors; regulations that hold institutions and private contractors legally responsible are vital. Peng et al. (2025) draw attention to the operational gap between legislation and implementation. They note that despite the existence of directives on risk self-assessment and transparency in the US, institutions fail to implement these obligations in practice, which weakens accountability. Forti (2024) argues that interconnected artificial intelligence structures make those responsible in migration management more ambiguous. They suggest that the network structure formed by interoperable systems such as SIS II, VIS, and Eurodac used in border management in European Union countries leads to a dispersion of responsibility. This structure makes it difficult to identify which actor entered erroneous or misleading data into the system, causing accountability to become ambiguous among multiple institutions instead of being concentrated in a single institution.

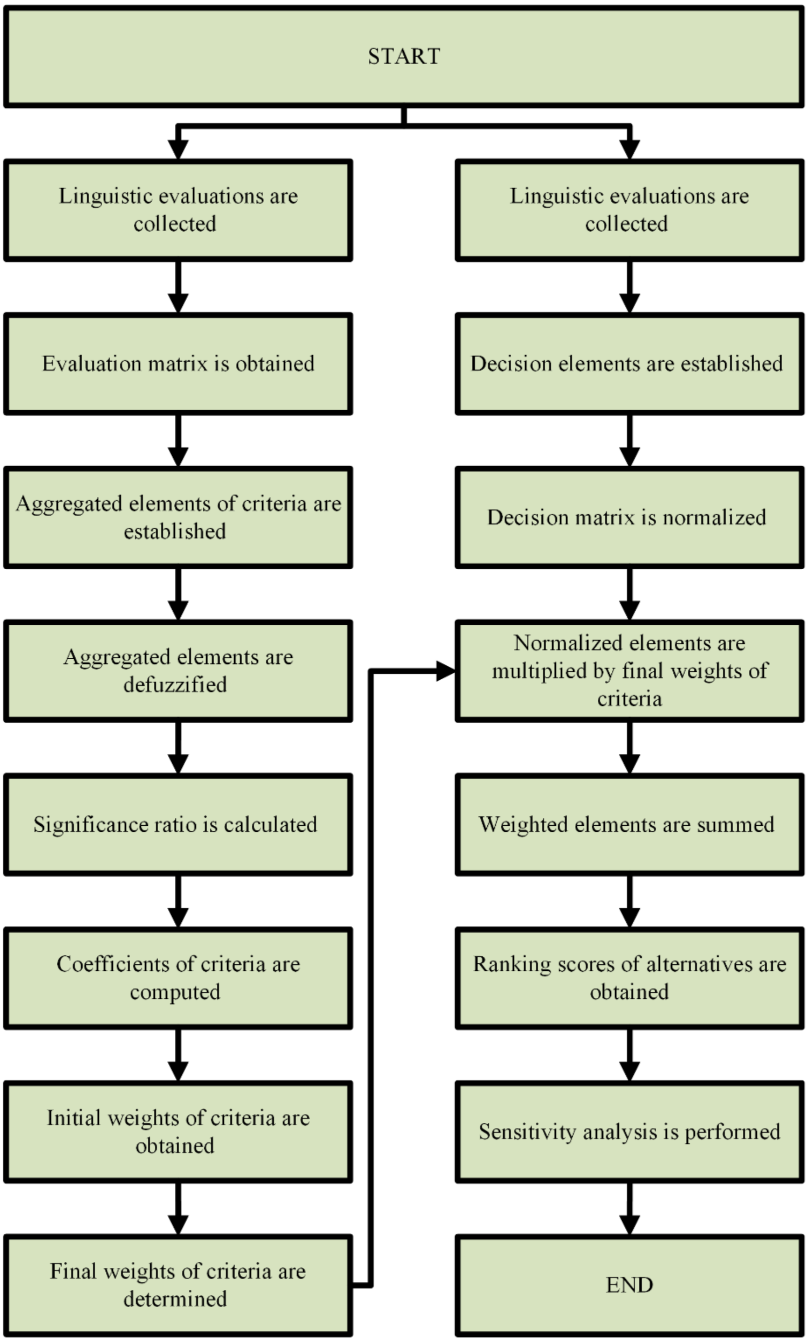
When the findings in the literature regarding the use of artificial intelligence by states in the areas of immigration, visas, asylum, and border control are considered together, it becomes clear that in order to prioritize the principles of the rule of law, technology should be conceived not merely as a tool to increase administrative efficiency, but as a "legal infrastructure" that guarantees human rights. The existing literature analyzes the erosive effects of the use of artificial intelligence by states in these areas on the principles of the rule of law in a multifaceted way. Studies detail the distribution of decision-making authority through algorithmic systems, the weakening of the obligation for individualized assessment, the ineffectiveness of reasoned decisions and effective legal remedies due to technical ambiguity, and the de facto transfer of public power in favor of private actors. However, the clear definition of the legal status of artificial intelligence within the administrative decision-making process regarding individual applications, the systematic separation of the relationship between algorithmic outputs and legal justification, and the structuring of human oversight as a meaningful legal reasoning process beyond a purely formal "human-in-the-loop" approach have not been sufficiently discussed in the literature. Artificial intelligence can generate information by establishing patterns and probability relationships between data; however, it cannot perform normative reasoning regarding how this information should be interpreted within the framework of legal norms, values, and responsibility. Therefore, the information produced by artificial intelligence (algorithmic output) alone cannot be the justification for a legal decision; it can only become part of the justification when reinterpreted by humans through legal reasoning. Consequently, it is essential for decision-makers to subject algorithmic outputs to critical evaluation. In this context, oversight should not be limited to a mere formal check; it should be designed as a meaningful process in which the officer re-evaluates and weighs all evidence, including electronic documents. Subjective, emotional, and contextually sensitive experiences, such as the “fear of persecution,” which is central to asylum law, must be assessed with particular care. These individual experiences cannot be fully and reliably represented through the objectifiable datasets and statistical patterns upon which artificial intelligence systems are based. This structural limitation carries the risk of insufficient understanding of the asylum seeker's personal narrative in AI-assisted decision-making processes and undermining the obligation to provide individualized assessments. How the data collected in these processes is processed and which criteria and profiling parameters are used must be subject to oversight; records relating to AI systems should not be kept in “secure non-public” areas, thus excluding them from public scrutiny. States should not limit their evaluation of AI systems solely to technical efficiency criteria when procuring them; they should place democratic values and, in particular, a data protection approach inherent in the design phase (privacy by design) at the center of the specifications. In terms of accountability, the blurring of the lines of accountability within the “network structure” established between the administration and private actors should not be allowed; It must be clearly and unequivocally defined who is legally responsible for algorithmic errors.

3 METHODOLOGY

This section summarizes the definitions of interval-valued q-ROFSs (IV q-ROFSs), and the formulations of SWARA and RAM, respectively. Uncertainty in word-based calculations is minimized with IV q-ROFS, while criterion weighting and alternative ranking are performed using SWARA and RAM, respectively. The methodological flow is summarized in Figure 1.

Figure 1

Methodological Flow



3.1 IV q-ROFSs

Suppose that $\boldsymbol{S}$ is the finite universal set. The mathematical form of an IV q-ROFS (X) over S is described in Eq. (1) (Suri et al., 2025).

$$\boldsymbol{X} = \{\boldsymbol{x}, ([\boldsymbol{\mu}_X^-(\boldsymbol{x}), \boldsymbol{\mu}_X^+(\boldsymbol{x})], [\boldsymbol{\vartheta}_X^-(\boldsymbol{x}), \boldsymbol{\vartheta}_X^+(\boldsymbol{x})]) | \boldsymbol{x} \in \boldsymbol{S}\} \quad (1)$$

Where $\boldsymbol{\mu}_X = [\boldsymbol{\mu}_X^-(\boldsymbol{x}), \boldsymbol{\mu}_X^+(\boldsymbol{x})]$ and $\boldsymbol{\vartheta}_X = [\boldsymbol{\vartheta}_X^-(\boldsymbol{x}), \boldsymbol{\vartheta}_X^+(\boldsymbol{x})]$ are interval-valued belonging and non-belonging grades of $\boldsymbol{x} \in \boldsymbol{S}$, respectively. Moreover, it is satisfied condition in Eqs. (2) – (4) for each $\boldsymbol{q} \geq \boldsymbol{1}$.

$$\boldsymbol{0} \leq \boldsymbol{\mu}_X^-(\boldsymbol{x}) \leq \boldsymbol{\mu}_X^+(\boldsymbol{x}) \leq \boldsymbol{1} \quad (2)$$

$$\boldsymbol{0} \leq \boldsymbol{\vartheta}_X^-(\boldsymbol{x}) \leq \boldsymbol{\vartheta}_X^+(\boldsymbol{x}) \leq \boldsymbol{1} \quad (3)$$

$$\boldsymbol{0} \leq \left(\boldsymbol{\mu}_X^+(\boldsymbol{x})\right)^{\boldsymbol{q}} + \left(\boldsymbol{\vartheta}_X^+(\boldsymbol{x})\right)^{\boldsymbol{q}} \leq \boldsymbol{1} \quad (4)$$

The indeterminacy grade of $\boldsymbol{x}$ to X is identified by Equations. (5).

$$\boldsymbol{\pi}_X = [\boldsymbol{\pi}_X^-(\boldsymbol{x}), \boldsymbol{\pi}_X^+(\boldsymbol{x})] = \left[\sqrt[q]{\boldsymbol{1} - \left(\boldsymbol{\mu}_X^+(\boldsymbol{x})\right)^{\boldsymbol{q}} - \left(\boldsymbol{\vartheta}_X^+(\boldsymbol{x})\right)^{\boldsymbol{q}}}, \sqrt[q]{\boldsymbol{1} - \left(\boldsymbol{\mu}_X^-(\boldsymbol{x})\right)^{\boldsymbol{q}} - \left(\boldsymbol{\vartheta}_X^-(\boldsymbol{x})\right)^{\boldsymbol{q}}}\right] \quad (5)$$

Let $\boldsymbol{X} = ([\boldsymbol{\mu}_X^-, \boldsymbol{\mu}_X^+)], [\boldsymbol{\vartheta}_X^-, \boldsymbol{\vartheta}_X^+])$ be an IV q-ROFN. Then, score function of X is defined as Equations. (6).

$$\mathbb{S}(\boldsymbol{X}) = \frac{\boldsymbol{1}}{\boldsymbol{4}}[(\boldsymbol{1} + (\boldsymbol{\mu}_X^-)^{\boldsymbol{q}} - (\boldsymbol{\vartheta}_X^-)^{\boldsymbol{q}}) + (\boldsymbol{1} + (\boldsymbol{\mu}_X^+)^{\boldsymbol{q}} - (\boldsymbol{\vartheta}_X^+)^{\boldsymbol{q}})] \quad (6)$$

Assume that $\boldsymbol{X} = ([\boldsymbol{\mu}_X^-, \boldsymbol{\mu}_X^+], [\boldsymbol{\vartheta}_X^-, \boldsymbol{\vartheta}_X^+])$ and $\boldsymbol{Y} = ([\boldsymbol{\mu}_Y^-, \boldsymbol{\mu}_Y^+], [\boldsymbol{\vartheta}_Y^-, \boldsymbol{\vartheta}_Y^+])$ are two IV q-ROFNs. The basic rules of operations for IV q-RONs are estimated with Equations. (7) - (11).

$$\boldsymbol{X} \oplus \boldsymbol{Y} = \left(\left[\sqrt[q]{(\boldsymbol{\mu}_X^-)^q + (\boldsymbol{\mu}_Y^-)^q - (\boldsymbol{\mu}_X^-)^q(\boldsymbol{\mu}_Y^-)^q}, \sqrt[q]{(\boldsymbol{\mu}_X^+)^q + (\boldsymbol{\mu}_Y^+)^q - (\boldsymbol{\mu}_X^+)^q(\boldsymbol{\mu}_Y^+)^q}\right], [\boldsymbol{\vartheta}_X^-\boldsymbol{\vartheta}_Y^-, \boldsymbol{\vartheta}_X^+\boldsymbol{\vartheta}_Y^+]\right) \quad (7)$$

$$\boldsymbol{X} \otimes \boldsymbol{Y} = \left([\boldsymbol{\mu}_X^-\boldsymbol{\mu}_Y^-, \boldsymbol{\mu}_X^+\boldsymbol{\mu}_Y^+], \left[\sqrt[q]{(\boldsymbol{\vartheta}_X^-)^q + (\boldsymbol{\vartheta}_Y^-)^q - (\boldsymbol{\vartheta}_X^-)^q(\boldsymbol{\vartheta}_Y^-)^q}, \sqrt[q]{(\boldsymbol{\vartheta}_X^+)^q + (\boldsymbol{\vartheta}_Y^+)^q - (\boldsymbol{\vartheta}_X^+)^q(\boldsymbol{\vartheta}_Y^+)^q}\right]\right) \quad (8)$$

$$\boldsymbol{\lambda \odot X} = \left(\left[\sqrt[q]{\mathbf{1} - (\mathbf{1} - (\boldsymbol{\mu}_X^-)^q)^{\lambda}}, \sqrt[q]{\mathbf{1} - (\mathbf{1} - (\boldsymbol{\mu}_X^+)^q)^{\lambda}}\right], \left[(\boldsymbol{\vartheta}_X^-)^{\lambda}, (\boldsymbol{\vartheta}_X^+)^{\lambda}\right]\right); \boldsymbol{\lambda} > \mathbf{0} \quad (\mathbf{9})$$

$$\boldsymbol{X^{\lambda}} = \left(\left[(\boldsymbol{\mu}_X^-)^{\lambda}, (\boldsymbol{\mu}_X^+)^{\lambda}\right], \left[\sqrt[q]{\mathbf{1} - (\mathbf{1} - (\boldsymbol{\vartheta}_X^-)^q)^{\lambda}}, \sqrt[q]{\mathbf{1} - (\mathbf{1} - (\boldsymbol{\vartheta}_X^+)^q)^{\lambda}}\right]\right); \boldsymbol{\lambda} > \mathbf{0} \quad (\mathbf{10})$$

$$\boldsymbol{X^C} = ([\boldsymbol{\vartheta}_X^-, \boldsymbol{\vartheta}_X^+], [\boldsymbol{\mu}_X^-, \boldsymbol{\mu}_X^+]) \quad (\mathbf{11})$$

Consider that $\boldsymbol{X_i} = \left(\left[\boldsymbol{\mu}_{X_i}^-, \boldsymbol{\mu}_{X_i}^+\right], \left[\boldsymbol{\vartheta}_{X_i}^-, \boldsymbol{\vartheta}_{X_i}^+\right]\right)$ is a collection of IV q-ROFNs. Then the weighted average and geometric means are calculated using Equations. (12) and (13), respectively.

$$\mathbb{A}(\boldsymbol{X_i}) = \left(\left[\sqrt[q]{\mathbf{1} - \prod_{i=1}^{n}\left(\mathbf{1} - \left(\boldsymbol{\mu}_{X_i}^-\right)^q\right)^{w_i}}, \sqrt[q]{\mathbf{1} - \prod_{i=1}^{n}\left(\mathbf{1} - \left(\boldsymbol{\mu}_{X_i}^+\right)^q\right)^{w_i}}\right], \left[\prod_{i=1}^{n}\left(\boldsymbol{\vartheta}_{X_i}^-\right)^{w_i}, \prod_{i=1}^{n}\left(\boldsymbol{\vartheta}_{X_i}^+\right)^{w_i}\right]\right) \quad (\mathbf{12})$$

$$\mathbb{G}(\boldsymbol{X_i}) = \left(\left[\prod_{i=1}^{n}\left(\boldsymbol{\mu}_{X_i}^-\right)^{w_i}, \prod_{i=1}^{n}\left(\boldsymbol{\mu}_{X_i}^+\right)^{w_i}\right], \left[\sqrt[q]{\mathbf{1} - \prod_{i=1}^{n}\left(\mathbf{1} - \left(\boldsymbol{\vartheta}_{X_i}^-\right)^q\right)^{w_i}}, \sqrt[q]{\mathbf{1} - \prod_{i=1}^{n}\left(\mathbf{1} - \left(\boldsymbol{\vartheta}_{X_i}^+\right)^q\right)^{w_i}}\right]\right) \quad (\mathbf{13})$$

3.2 IV q-ROF-SWARA

SWARA is one of the subjective methods used to determine the weighting values of criteria. Because the method uses linguistic expressions, its integration with IV q-ROFS is proposed in this manuscript. The operation of this version is described as follows (Shahbaz et al., 2025).

Firstly, *n* criteria are defined. Next, linguistic evaluations are collected and then, transformed into IV q-RONs. Thus, evaluation matrix illustrated in Equations. (14) is obtained.

$$\boldsymbol{A} = \begin{bmatrix} \boldsymbol{a_{11}} & \cdots & \boldsymbol{a_{1n}} \\ \vdots & \ddots & \vdots \\ \boldsymbol{a_{k1}} & \cdots & \boldsymbol{a_{kn}} \end{bmatrix} \quad (\mathbf{14})$$

Where $\boldsymbol{a_{ij}} = \left(\left[\boldsymbol{\mu^{-}_{a_{ij}}}, \boldsymbol{\mu^{+}_{a_{ij}}}\right], \left[\boldsymbol{\vartheta^{-}_{a_{ij}}}, \boldsymbol{\vartheta^{+}_{a_{ij}}}\right]\right)$. Later, the aggregated elements of criteria are established using Equations. (15).

$$\mathbb{G}(\boldsymbol{X_i}) = \left(\left[\prod_{i=1}^{n}\left(\boldsymbol{\mu^{-}_{X_i}}\right)^{w_i}, \prod_{i=1}^{n}\left(\boldsymbol{\mu^{+}_{X_i}}\right)^{w_i}\right], \left[\sqrt[q]{\boldsymbol{1} - \prod_{i=1}^{n}\left(\boldsymbol{1} - \left(\boldsymbol{\vartheta^{-}_{X_i}}\right)^{q}\right)^{w_i}}, \sqrt[q]{\boldsymbol{1} - \prod_{i=1}^{n}\left(\boldsymbol{1} - \left(\boldsymbol{\vartheta^{+}_{X_i}}\right)^{q}\right)^{w_i}}\right]\right) \quad (\boldsymbol{13})$$

Behind, the aggregated elements are defuzzified by Equations. (16).

$$\mathbb{S}(\boldsymbol{d_j}) = \frac{\boldsymbol{1}}{\boldsymbol{4}}\left[\left(\boldsymbol{1} + \left(\boldsymbol{\mu^{-}_{d_j}}\right)^{q} - \left(\boldsymbol{\vartheta^{-}_{d_j}}\right)^{q}\right) + \left(\boldsymbol{1} + \left(\boldsymbol{\mu^{+}_{d_j}}\right)^{q} - \left(\boldsymbol{\vartheta^{+}_{d_j}}\right)^{q}\right)\right] \quad (\boldsymbol{16})$$

Subsequationsuently, the criteria are arranged in order of magnitude of their score values. Then, the significance ratio is calculated by subtracting the previous score value from the previous one. After that, the coefficients of criteria are computed with Equations. (17).

$$\boldsymbol{cof_j} = \begin{cases} \boldsymbol{1} & \boldsymbol{j = 1} \\ \boldsymbol{1 + sr_j} & \boldsymbol{j > 1} \end{cases} \quad (\boldsymbol{17})$$

Where $\boldsymbol{sr}$ refers to significance ratio. Next, initial weights of criteria are obtained via Equations. (18).

$$\boldsymbol{iw_j} = \begin{cases} \boldsymbol{1} & \boldsymbol{j = 1} \\ \boldsymbol{iw_{j-1}/cof_j} & \boldsymbol{j > 1} \end{cases} \quad (\boldsymbol{18})$$

Finally, the final weights of criteria are determined using Equations. (19).

$$\boldsymbol{fw_j} = \frac{\boldsymbol{iw_j}}{\sum_{j=1}^{n}\boldsymbol{iw_j}} \quad (\boldsymbol{19})$$

3.3 IV q-ROF-RAM

RAM is a modern ranking method that evaluates beneficial and cost criteria separately and ranks alternatives based on the difference in compensation degrees between these criterion types. Because the method uses linguistic expressions, its integration with IV q-ROFS is proposed in this manuscript. The operation of this version is described as follows (Anushree and Sharma, 2025).

After defining m alternatives, the linguistic evaluations are collected. These linguistic evaluations are converted to IV q-RONs. Next, the decision elements are established using Equations. (20).

$$\boldsymbol{h_{ij}} = \left(\left[\sqrt[q]{1-\prod_{t=1}^{k}\left(1-\left(\mu_{h_{ij}^{t}}^{-}\right)^{q}\right)^{\frac{1}{k}}}, \sqrt[q]{1-\prod_{t=1}^{k}\left(1-\left(\mu_{h_{ij}^{t}}^{+}\right)^{q}\right)^{\frac{1}{k}}}\right], \left[\prod_{t=1}^{k}\left(\vartheta_{h_{ij}^{t}}^{-}\right)^{\frac{1}{k}}, \prod_{t=1}^{k}\left(\vartheta_{h_{ij}^{t}}^{+}\right)^{\frac{1}{k}}\right]\right) \quad (20)$$

Where $\boldsymbol{h_{ij}^{t}}$ is an IV q-ROFN of alternative-j regarding criterion-i for resource-t. Then, the decision matrix is normalized with Equations. (21) and (22).

$$\mathfrak{n}_{ij} = \left(\left[\mu_{h_{ij}}^{-}, \mu_{h_{ij}}^{+}\right], \left[\vartheta_{h_{ij}}^{-}, \vartheta_{h_{ij}}^{+}\right]\right); j \in B \quad (21)$$

$$\mathfrak{n}_{ij} = \left(\left[\vartheta_{h_{ij}}^{-}, \vartheta_{h_{ij}}^{+}\right], \left[\mu_{h_{ij}}^{-}, \mu_{h_{ij}}^{+}\right]\right); j \in C \quad (22)$$

Behind, the normalized elements are multiplied by final weights of criteria. For this, Equations. (23) is used.

$$b_{ij} = fw_j \odot \mathfrak{n}_{ij} \quad (23)$$

Afterwards, the weighted elements are summed according to types of criteria with the help of Equations. (24) and (25).

$$S_i^{+} = \sum_{j \in B} b_{ij} \quad (24)$$

$$\boldsymbol{S_i^-} = \sum_{j \in C} \boldsymbol{b_{ij}} \qquad (25)$$

Where the addition operator is defined in Equations. (7). Finally, the ranking scores of alternatives are obtained by Equations. (26).

$$\boldsymbol{R_i} = \sqrt[2+\mathbb{S}(S_i^-)]{\boldsymbol{2} + \mathbb{S}(\boldsymbol{S_i^+})} \qquad (26)$$

4 ANALYSIS

This section summarizes the results of an analysis evaluating the use of artificial intelligence in immigration processes by states, in terms of a governance approach consistent with the rule of law. AI governance models are shown in Table 1.

Table 1

AI Governance Models

AI Governance Model	Abb
Actual Automation and Decision Transfer Model	AADTM
Weak Human-Controlled AI Model	WHCAI
Strong Human-Controlled AI Model	SHCAI
Administrative Support Model	ADSUP
Rights Empowering Administrative Support Model	REASM

These governance models represent different ways of integrating artificial intelligence into immigration procedures, each with distinct implications for decision making and legal responsibility. The Actual Automation and Decision Transfer Model relies on artificial intelligence as the primary determinant of decisions, while human involvement is largely limited to formal validation. The Weak Human Controlled AI Model includes human approval mechanisms, yet the algorithmic structure remains the dominant factor shaping outcomes. In contrast, the Strong Human Controlled AI Model uses artificial intelligence as a supportive analytical tool, while legal assessment and final decisions are clearly retained by human authorities. The Administrative Support Model limits the role of artificial intelligence to operational tasks such as document management and process acceleration without influencing substantive decisions. Finally, the Rights

Empowering Administrative Support Model focuses on strengthening applicants' procedural rights by using artificial intelligence to improve access to information, transparency, and reasoning, while preserving full human control over decision making. The criteria used in evaluating these models are determined. The evaluation criteria, along with their abbreviations, are given in Table 2.

Table 2

Evaluation Criteria

Criterion	Abb
The positioning of decision-making authority	DMA
Accountability and legal responsibility	ALR
Obligation to make individualized assessments	OIA
Obligation to provide reasoned decisions	ORD
Guarantee of effective legal remedies	ELR
Protection of personal data and obligation to limit actions to the purpose	PDP
Protection of the principle of the inalienability of public power	IPP
Continuity of procedural safeguards in crisis conditions	CPS

These criteria play a central role in selecting governance models for the use of artificial intelligence in immigration procedures. The positioning of decision-making authority determines whether final power remains with accountable public officials or shifts toward automated systems. Accountability and legal responsibility ensure that unlawful or erroneous decisions can be clearly attributed and effectively reviewed. The obligation to make individualized assessments requationsuires that each case is examined on its own merits rather than through generalized algorithmic patterns. The obligation to provide reasoned decisions supports transparency and allows affected individuals to understand the basis of administrative outcomes. The guarantee of effective legal remedies ensures that applicants can challenge decisions and obtain meaningful judicial review. The protection of personal data and the obligation to limit actions to the stated purpose safeguard individuals against misuse of sensitive information. The protection of the principle of the inalienability of public power prevents the full delegation of sovereign authority to automated systems. Finally, the continuity of procedural safeguards in crisis conditions ensures that fundamental legal protections are maintained even under exceptional administrative pressure. All evaluation criteria are of a benefit type, and evaluations are collected accordingly.

4.1 Weighting of criteria

Firstly, linguistic evaluations about evaluation criteria in Table 2 are collected and then, transformed into IV q-RONs. Thus, evaluation matrix is obtained. This matrix is illustrated in Table 3.

Table 3

Evaluation Matrix

	DMA	ALR	OIA	ORD	ELR	PDP	IPP	CPS
EV1	([.65,.8],[.4,.5])	([.4,.5],[.6,.7])	([.3,.4],[.7,.8])	([.8,.9],[.2,.35])	([.4,.5],[.6,.7])	([.65,.8],[.4,.5])	([.3,.4],[.7,.8])	([.2,.3],[.8,.85])
EV2	([.8,.9],[.2,.35])	([.4,.5],[.6,.7])	([.3,.4],[.7,.8])	([.65,.8],[.4,.5])	([.4,.5],[.6,.7])	([.5,.65],[.5,.6])	([.1,.2],[.85,.9])	([.05,.1],[.9,.95])
EV3	([.8,.9],[.2,.35])	([.5,.65],[.5,.6])	([.3,.4],[.7,.8])	([.65,.8],[.4,.5])	([.4,.5],[.6,.7])	([.65,.8],[.4,.5])	([.2,.3],[.8,.85])	([.1,.2],[.85,.9])
EV4	([.65,.8],[.4,.5])	([.4,.5],[.6,.7])	([.3,.4],[.7,.8])	([.65,.8],[.4,.5])	([.4,.5],[.6,.7])	([.65,.8],[.4,.5])	([.3,.4],[.7,.8])	([.2,.3],[.8,.85])
EV5	([.8,.9],[.2,.35])	([.4,.5],[.6,.7])	([.2,.3],[.8,.85])	([.65,.8],[.4,.5])	([.3,.4],[.7,.8])	([.5,.65],[.5,.6])	([.1,.2],[.85,.9])	([.1,.2],[.85,.9])
EV6	([.9,.95],[.05,.1])	([.4,.5],[.6,.7])	([.3,.4],[.7,.8])	([.8,.9],[.2,.35])	([.4,.5],[.6,.7])	([.65,.8],[.4,.5])	([.1,.2],[.85,.9])	([.2,.3],[.8,.85])
EV7	([.65,.8],[.4,.5])	([.5,.65],[.5,.6])	([.2,.3],[.8,.85])	([.65,.8],[.4,.5])	([.3,.4],[.7,.8])	([.5,.65],[.5,.6])	([.3,.4],[.7,.8])	([.1,.2],[.85,.9])
EV8	([.9,.95],[.05,.1])	([.4,.5],[.6,.7])	([.3,.4],[.7,.8])	([.8,.9],[.2,.35])	([.4,.5],[.6,.7])	([.65,.8],[.4,.5])	([.3,.4],[.7,.8])	([.2,.3],[.8,.85])
EV9	([.8,.9],[.2,.35])	([.5,.65],[.5,.6])	([.2,.3],[.8,.85])	([.65,.8],[.4,.5])	([.4,.5],[.6,.7])	([.65,.8],[.4,.5])	([.1,.2],[.85,.9])	([.1,.2],[.85,.9])
EV10	([.65,.8],[.4,.5])	([.4,.5],[.6,.7])	([.2,.3],[.8,.85])	([.8,.9],[.2,.35])	([.4,.5],[.6,.7])	([.65,.8],[.4,.5])	([.3,.4],[.7,.8])	([.2,.3],[.8,.85])

Later, the IV q-ROFNs for each criterion are summed using Equations. (15). The aggregated elements are displayed in Table 4 for q=1.

Table 4

Aggregated Elements for q=1

	DMA	**ALR**	**OIA**	**ORD**	**ELR**	**PDP**	**IPP**	**CPS**
Agg	([.78,.89], [.2,.314])	([.43,.55], [.57,.668])	([.26,.36], [.74,.82])	([.72,.85], [.3,.434])	([.38,.48], [.62,.719])	([.61,.76], [.43,.528])	([.22,.32], [.77,.844])	([.15,.24], [.83,.879])

Subsequationsuently, the defuzzified aggregated elements are computed by Equations. (16). Next, the evaluation criteria are sorted. Then, the significance ratio is calculated, and the coefficients of evaluation criteria are computed with Equations. (17). Later, initial weight for each criterion is obtained via Equations. (18). The results are summarized in Table 5.

Table 5

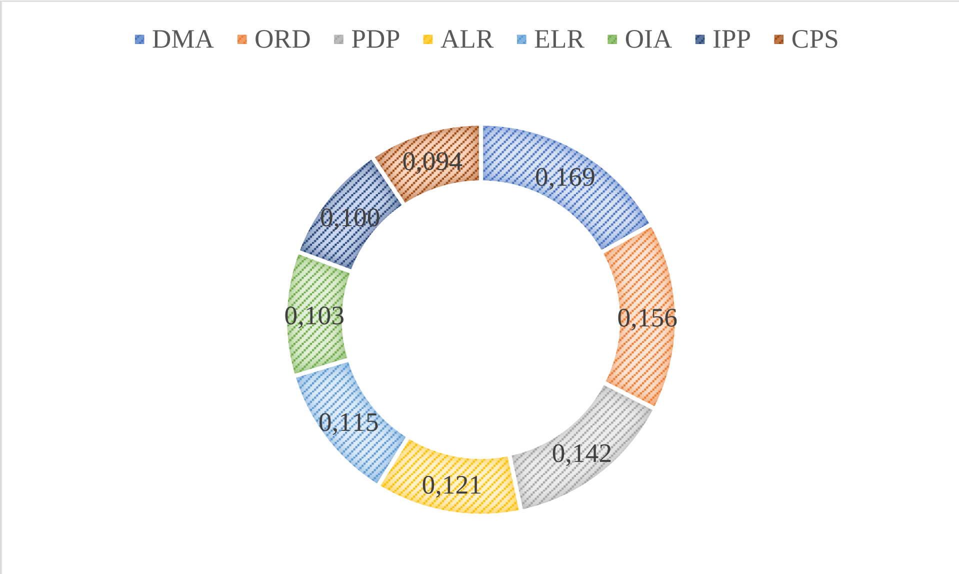
Significance Ratio, Coefficient, and Initial Weight for q=1

	DMA	ORD	PDP	ALR	ELR	OIA	IPP	CPS
Score	.788	.708	.605	.437	.381	.266	.230	.170
sr		.080	.103	.168	.055	.115	.036	.060
cof	1.000	1.080	1.103	1.168	1.055	1.115	1.036	1.060
iw	1.000	.926	.839	.718	.681	.610	.589	.556

Finally, the final weight value for each evaluation criterion is determined using Equations. (19). These values are presented in Figure 2.

Figure 2

Final Weights for q=1



According to the final weights presented in Figure 2, the positioning of decision-making authority emerges as the most important evaluation criterion, with a weight value of .169, indicating its central role in assessing governance models for the use of artificial intelligence in immigration procedures. This result highlights the significance of ensuring that final decision-making power remains clearly assigned to accountable public authorities rather than being implicitly transferred to automated systems. Closely following this criterion, the obligation to provide reasoned decisions holds a weight of .156, demonstrating its critical importance in supporting transparency, legal certainty, and effective judicial review. The relatively high weight assigned to this criterion reflects the need for administrative decisions to be clearly explained and justified, particularly in contexts where algorithmic tools influence procedural outcomes. Together, these findings suggest that governance models are primarily evaluated based on their ability to preserve human authority and maintain strong reasoning requationsuirements within decision making processes.

4.2 Ranking of AI governance models

Firstly, the linguistic evaluations about AI governance models are collected. After these linguistic evaluations are converted to IV q-RONs, the decision elements are established using Equations. (20). This matrix for q=1 is expressed in Table 6.

Table 6

Decision Matrix for q=1

	DMA	ALR	OIA	ORD	ELR	PDP	IPP	CPS
AADTM	([.14,.22], [.84,.889])	([.11,.19], [.85,.904])	([.15,.24], [.83,.879])	([.1,.18], [.86,.909])	([.14,.23], [.83,.884])	([.1,.17], [.86,.914])	([.1,.18], [.86,.909])	([.12,.2], [.85,.899])
WHCAI	([.21,.31], [.77,.844])	([.26,.36], [.73,.819])	([.21,.31], [.78,.849])	([.15,.25], [.82,.874])	([.23,.33], [.76,.839])	([.25,.35], [.74,.824])	([.21,.31], [.78,.849])	([.22,.32], [.77,.844])
SHCAI	([.28,.38], [.72,.797])	([.27,.37], [.73,.809])	([.27,.38], [.73,.803])	([.31,.41], [.69,.777])	([.27,.37], [.73,.809])	([.29,.39], [.71,.793])	([.33,.44], [.67,.757])	([.31,.42], [.69,.772])
ADSUP	([.45,.58], [.55,.648])	([.46,.6], [.54,.638])	([.47,.61], [.53,.628])	([.43,.55], [.57,.668])	([.43,.55], [.57,.668])	([.43,.55], [.57,.668])	([.44,.57], [.56,.658])	([.42,.53], [.58,.679])
REASM	([.38,.5], [.62,.716])	([.4,.52], [.6,.705])	([.43,.56], [.57,.667])	([.41,.53], [.59,.696])	([.44,.57], [.56,.657])	([.44,.57], [.56,.657])	([.37,.48], [.63,.735])	([.38,.5], [.62,.716])

Behind, the normalized matrix is computed with Equations. (21) and (22). However, all criteria are useful. Therefore, the decision matrix and the normalized matrix are equationsuivalent. Next, weighted matrix is created using Equations. (23). This matrix for q=1 is exhibited in Table 7.

Table 7

Weighted Matrix for q=1

	DMA	ALR	OIA	ORD	ELR	PDP	IPP	CPS
AADTM	([.02,.04], [.97,.98])	([.01,.03], [.98,.988])	([.02,.03], [.98,.987])	([.02,.03], [.98,.985])	([.02,.03], [.98,.986])	([.01,.03], [.98,.987])	([.01,.02], [.99,.991])	([.01,.02], [.98,.99])
WHCAI	([.04,.06], [.96,.972])	([.04,.05], [.96,.976])	([.02,.04], [.97,.983])	([.03,.04], [.97,.979])	([.03,.04], [.97,.98])	([.04,.06], [.96,.973])	([.02,.04], [.98,.984])	([.02,.04], [.98,.984])
SHCAI	([.05,.08], [.95,.962])	([.04,.06], [.96,.975])	([.03,.05], [.97,.978])	([.06,.08], [.94,.961])	([.04,.05], [.96,.976])	([.05,.07], [.95,.968])	([.04,.06], [.96,.973])	([.03,.05], [.97,.976])
ADSUP	([.1,.14],[.9,.929])	([.07,.1],[.93,.947])	([.06,.09], [.94,.953])	([.08,.12], [.92,.939])	([.06,.09], [.94,.955])	([.08,.11], [.92,.944])	([.06,.08], [.94,.959])	([.05,.07], [.95,.964])
REASM	([.08,.11], [.92,.945])	([.06,.08], [.94,.958])	([.06,.08], [.94,.959])	([.08,.11], [.92,.945])	([.07,.09], [.93,.953])	([.08,.11], [.92,.942])	([.04,.06], [.96,.97])	([.04,.06], [.96,.969])

Subsequationsuently, the weighted elements are summed according to types of criteria with the help of Equations. (24) and (25). The total weighted elements of beneficial criteria are displayed in Table 8 for q=1.

Table 8

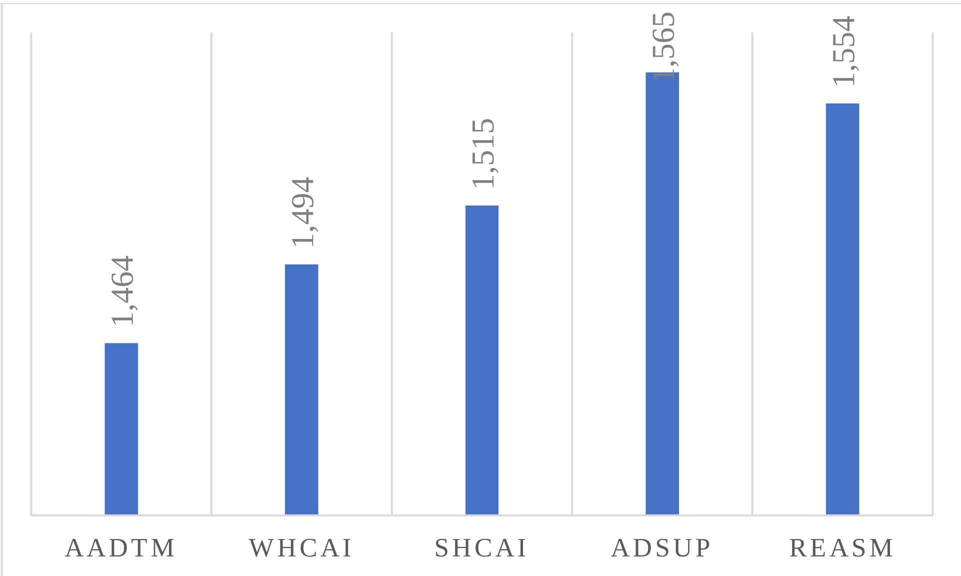
Total Weighted Elements of Beneficial Criteria for q=1

	S^+
AADTM	([.12,.2],[.85,.899])
WHCAI	([.22,.32],[.77,.843])
SHCAI	([.29,.39],[.71,.79])
ADSUP	([.44,.57],[.56,.657])
REASM	([.41,.53],[.59,.693])

Finally, the ranking scores of AI governance models are obtained by Equations. (26). The result is visualized in Figure 3 for q=1.

Figure 3

Ranking Scores for q=1



As can be seen from the ranking scores presented in Figure 3, the administrative support model is identified as the most appropriate artificial intelligence governance model, achieving the highest overall score of 1.565. This result indicates that, among the evaluated alternatives, this model provides the most balanced alignment with the selected legal and institutional criteria. The high ranking suggests that limiting the role of artificial intelligence to supportive administrative functions, such as process management and efficiency enhancement, effectively preserves core principles of the rule of law. This model appears to maintain clear human control over decision making authority while reducing legal and ethical risks associated with automated decision making. The findings imply that administrative support-oriented uses of artificial intelligence can offer practical benefits without undermining accountability, transparency, or procedural safeguards.

4.3 Sensitivity analysis

Within the scope of the sensitivity analysis, the robustness of the proposed model is examined by systematically varying the q parameter values. In this context, the analyses are repeated for q values of 1, 2, and 3 to observe whether changes in this parameter lead to significant differences in the final evaluation outcomes. The criterion final weight values obtained under each of these parameter settings are calculated separately and then compared. The results of this comparative assessment are summarized in Table 9, which presents how the relative importance of the criteria responds to variations in the q parameter. This analysis provides additional insight into the stability and reliability of the proposed decision-making framework.

Table 9

Final Weights by q Values

q	DMA	ALR	OIA	ORD	ELR	PDP	IPP	CPS
1	.169	.121	.103	.156	.115	.142	.100	.094
2	.172	.120	.101	.160	.113	.143	.098	.092
3	.167	.121	.103	.157	.115	.142	.100	.095

As can be seen in Table 9, the final weighting values of the criteria remain unchanged despite variations in the q parameter. In addition, the priority ranking of the criteria is preserved across all tested q values, indicating a high level of consistency in the results. This stability suggests that the relative importance assigned to each criterion is not sensitive to changes in the model parameter. Therefore, it can be stated that the findings of the proposed approach are robust and reliable. A similar pattern is observed in the evaluation of artificial intelligence governance models, where changes in the q value do not affect the overall ranking of the alternatives. The detailed results of this analysis for the governance models are presented in Table 10, further supporting the robustness of the proposed decision-making framework.

Table 10

Ranking Scores by q Values

q	**1**	**2**	**3**
AADTM	1.464	1.461	1.473
WHCAI	1.494	1.488	1.500
SHCAI	1.515	1.510	1.521
ADSUP	1.565	1.564	1.567
REASM	1.554	1.551	1.557

Table 10 demonstrates that the ranking of the artificial intelligence governance models remains stable under different q values. In other words, variations in the q parameter do not lead to any changes in the relative importance or ordering of the evaluated governance models. This finding further confirms that the proposed model produces consistent and dependable results regardless of parameter adjustments. In the final stage of the analysis, a comparative evaluation is conducted to further validate the findings. For this purpose, the Simple Additive Weighting method is selected as a benchmark technique. The results obtained from the SAW method under different q values are presented in Table 11, allowing a direct comparison with the outcomes of the proposed approach.

Table 11

SAW by q Values

q	1	2	3
AADTM	.094	.090	.105
WHCAI	.150	.145	.155
SHCAI	.193	.189	.194
ADSUP	.293	.301	.283
REASM	.269	.275	.263

According to the results obtained from the Simple Additive Weighting method, the ranking of the artificial intelligence governance models remains the same as that produced by the proposed approach. This consistency indicates a high level of reliability in the overall findings. In other words, the correlation coefficient between the two methods is equationsual to 1, which reflects a perfect agreement in the ordering of the alternatives. Such a result suggests that the relative performance of the governance models is not influenced by the choice of decision-making technique. Therefore, it can be concluded that the ranking of the artificial intelligence governance models is method independent and reflects a stable evaluation structure rather than a technique specific outcome.

5 DISCUSSION

The findings show that the positioning of decision-making authority and the obligation to provide reasoned decisions are the most influential criteria in determining the governance approach that is most compatible with rule of law principles in immigration procedures. This result means that the preservation of clear human authority and the requationsuirement to justify administrative outcomes are seen as the core safeguards in the use of artificial intelligence (Bélanger and Bergevin-Estable, 2025). The relationship is established through the need to ensure that public power remains accountable and that individuals can understand and challenge decisions that affect their legal status. These conclusions are highly consistent with existing literature, which emphasizes transparency, accountability, and human oversight as central conditions for lawful digital governance (Tian et al., 2025). This outcome suggests that policymakers should design artificial intelligence systems that explicitly support human decision makers rather than replace them. Clear legal frameworks must define responsibility and requationsuire detailed reasoning in all automated assisted decisions. Institutional strategies should include training programs for officials, documentation standards for algorithmic use, and independent oversight mechanisms (Ozkul, 2025). Such policy measures can strengthen public trust while ensuring compliance with fundamental legal principles.

The identification of the administrative support model as the most appropriate governance approach indicates that artificial intelligence should primarily function as a supportive administrative tool rather than as a decision-making authority in immigration procedures. This finding implies that efficiency gains and procedural improvements can be achieved without compromising core rule of law guarantees (Zhang et al., 2025). The relationship is maintained because the model limits artificial intelligence to tasks such as document management, data organization, and process acceleration, while final legal assessments remain in the hands of public officials. This conclusion is strongly aligned with the broader literature, which often recommends a cautious and incremental integration of artificial intelligence into sensitive public functions (Fouskas, 2025). The result suggests that states should prioritize policies that enhance administrative capacity without transferring sovereign authority to automated systems. Strategic actions may include developing clear operational guidelines, conduct regular legal impact assessments, and ensure transparency about the scope of algorithmic tools. By adopting such measures, governments can balance innovation with legal certainty and protect both institutional integrity and individual rights (Zhong et al., 2025).

6 CONCLUSION

This study sought to identify the artificial intelligence governance approach that aligns most closely with rule of law principles in state immigration procedures. In line with this objective, a systematic decision-making framework was constructed based on criteria and governance alternatives derived from an extensive review of the relevant literature. The evaluations of ten field experts were incorporated into the analysis. The importance levels of the criteria were determined through the SWARA method, and the governance alternatives were ordered using the RAM technique. Interval valued q rung orthopair fuzzy sets were embedded into the model to capture uncertainty and hesitation in expert assessments more effectively. The findings indicate that the positioning of decision-making authority and the obligation to provide reasoned decisions are the most influential criteria in the evaluation process. The results further demonstrate that the administrative support model represents the most appropriate governance approach. Sensitivity and comparative analyses confirm the consistency and stability of these outcomes. The study enriches the existing body of knowledge by presenting an integrated and legally oriented decision framework that connects artificial intelligence governance, migration administration, and advanced multi criteria analysis.

Certain limitations should also be acknowledged. The analysis does not concentrate on a particular country or regional group, and therefore differences in domestic legal structures and administrative traditions are not directly examined. For this reason, the conclusions offer a general governance perspective rather than context specific regulatory guidance. The proposed model is also based on expert judgments, which may introduce a degree of subjectivity even though sophisticated fuzzy tools were employed to reduce uncertainty. Moreover, the set of criteria and alternatives reflects the scope of the current literature and the selected expert group. Future research could implement the model within specific national systems to evaluate its applicability under concrete legal conditions. Comparative international studies may further strengthen empirical relevance. Expanding the number of experts and combining alternative decision-making approaches may also improve the comprehensiveness and transferability of subsequationsuent analyses.

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Authors' Contribution

All authors contributed equationsually to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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