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USING AI TO COMPARE THE EFFICIENCY OF IJARA, MURABAHA, WAKALA, AND OTHER SUKUK STRUCTURES IN SAUDI ARABIA

UTILIZAÇÃO DA IA PARA COMPARAR A EFICIÊNCIA DAS ESTRUTURAS DE IJARA, MURABAHA, WAKALA E OUTRAS ESTRUTURAS DE SUKUK NA ARÁBIA SAUDITA

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Abstract
Saudi Arabia is a major issuer of Sukuk in the GCC, with an increasingly developed secondary market infrastructure, including official issuance programs and exchange market information services. The variety of Sukuk structures, i.e., Ijara, Murabaha, Wakala bil istithmar, Mudaraba, Musharakah, and their combinations, poses an ongoing question: what Sukuk structure offers the most efficient combination of funding costs, risk, liquidity, and structural complexity under Shariah constraints. In 2020–2025, two developments facilitated the feasibility of this comparison: the growth of market data availability and information in Saudi Arabia, i.e., Sukuk issuance programs, exchange market watch services, etc. [3, 2], as well as the maturity of AI technologies, i.e., NLP, machine learning, and explainability, in the field of Islamic finance and capital markets [10, 11]. In this review, we synthesize the evidence from 2020–2025 on the application of AI in the comparison of the efficiency of Sukuk structure in Saudi Arabia. Efficiency is a multidimensional concept that encompasses pricing, i.e., spread/yield, issuance/structure costs, liquidity, Shariah risk, etc. In this review, we discuss the data sources, feature engineering strategies, and model families that may be applied in the comparison of Sukuk structure efficiency, as well as the pitfalls that may confound the analysis, i.e., non-comparable covenants, endogeneity of structure, lack of ground truth data on Shariah risk, etc. In addition, we suggest a blueprint of research on the application of AI in the comparison of Sukuk structure efficiency in Saudi Arabia, following the PRISMA 2020 guidelines [1] as well as the transparency requirements of Q1 operations and finance outlets.

Resumo
A Arábia Saudita é um dos principais emissores de sukuk no CCG, com uma infraestrutura de mercado secundário cada vez mais desenvolvida, incluindo programas oficiais de emissão e serviços de informação sobre o mercado de câmbio. A variedade de estruturas de Sukuk, ou seja, Ijara, Murabaha, Wakala bil istithmar, Mudaraba, Musharakah e suas combinações, levanta uma questão recorrente: qual estrutura de Sukuk oferece a combinação mais eficiente de custos de financiamento, risco, liquidez e complexidade estrutural dentro das restrições da Shariah. Entre 2020 e 2025, dois desenvolvimentos facilitaram a viabilidade dessa comparação: o aumento da disponibilidade de dados de mercado e informações na Arábia Saudita, ou seja, programas de emissão de Sukuk, serviços de monitoramento do mercado de câmbio, etc. [3, 2], bem como o amadurecimento das tecnologias de IA, ou seja, PLN, aprendizado de máquina e explicabilidade, no campo das finanças islâmicas e dos mercados de capitais [10, 11]. Nesta revisão, sintetizamos as evidências de 2020–2025 sobre a aplicação da IA na comparação da eficiência da estrutura do Sukuk na Arábia Saudita. A eficiência é um conceito multidimensional que abrange a precificação, ou seja, spread/rendimento, custos de emissão/estrutura, liquidez, risco da Sharia, etc. Nesta revisão, discutimos as fontes de dados, as estratégias de engenharia de características e as famílias de modelos que podem ser aplicadas na comparação da eficiência da estrutura do Sukuk, bem como as armadilhas que podem confundir a análise, ou seja, cláusulas não comparáveis, endogeneidade da estrutura, falta de dados de referência sobre o risco da Shariah, etc. Além disso, sugerimos um plano de pesquisa sobre a

Keywords: Sukuk. Saudi Arabia. Ijara. Murabaha. Wakala. Islamic Finance. Machine Learning. Nlp. Efficiency. Pricing. Liquidity.

aplicação de IA na comparação da eficiência da estrutura dos Sukuk na Arábia Saudita, seguindo as diretrizes PRISMA 2020 [1], bem como os requisitos de transparência das operações Q1 e dos veículos financeiros.

Palavras-chave: *Sukuk. Arábia Saudita. Ijara. Murabaha. Wakala. Finanças Islâmicas. Aprendizado de Máquina. Pln. Eficiência. Precificação. Liquidez.*

1 INTRODUCTION

Sukuk certificates are financial instruments that are designed to provide economic benefits that are comparable with bonds based on ownership interests, usufruct, and investment agency structures. In practice, there is a possibility that the structures utilized in Sukuk may differ in the utilization of assets and cash flows. In addition, the selection of structures utilized in Sukuk in Saudi Arabia may have a significant influence on the costs of funds, base of investors, rating results, and complexity. In the case of Sukuk investors, the structure may have a significant influence on cash flow predictability and enforceability. In Saudi Arabia, the Sukuk market structure includes an authorized Sukuk issuance program in Saudi Riyal currency via the National Debt Management Center [3]. In addition, there are exchange-based services that provide investors with information on Sukuk structures and yields [2]. According to reports on the regional market, the outstanding Sukuk issuance in Saudi Arabia is significant in comparison with the total outstanding Sukuk in the GCC region. In addition, global market reports emphasize that the Sukuk market is expanding with regard to outstanding Sukuk issuance and that there is a need to enhance outstanding Sukuk volumes [6]. The paper on “AI-enabled comparative efficiency” of Sukuk structures in Saudi Arabian markets is expected to be presented as a review paper instead of an empirical paper. This is because the paper is expected to incorporate empirical data on the period 2020-2025 and provide a methodological approach.

2 AIM AND OBJECTIVES OF THE STUDY

Aim: To review and synthesize evidence on the application of AI in the comparison of the efficiency of major sukuk structures in Saudi Arabia from 2020 to 2025.

Objectives:

1) To define the concept of the efficiency of sukuk structure applicable to the context of Saudi Arabia.
2) To determine the sources and representations used in the latest literature on the application of sukuk analytics.
3) To synthesize the application of AI techniques in the analysis of sukuk.
4) To determine the pitfalls in the methodologies used in the analysis of sukuk.
5) To define the blue print on the review and practice of sukuk in the context of Saudi Arabia.

3 REVIEW METHODOLOGY

3.1 Review design and reporting

The review is a structured review with narrative synthesis, as per the PRISMA 2020 guidelines [1] that provide clear explanations on the search logic, inclusion criteria, and synthesis rationale. Since we found heterogeneity with respect to the outcomes of interest as well as the methods used in the studies, we did not carry out a meta-analysis. We synthesize the evidence by mapping the approaches with respect to the decision problem.

3.2 Search strategy and eligibility criteria

The search strategy is based on a combination of keywords that are specific to the topic, with no language or publication year restrictions. The literature search was conducted using various academic databases, namely Google Scholar, ScienceDirect, JSTOR, and other academic publications. The search terms include "AI application in

sukuk," "efficiency of sukuk structure," "sukuk analytics," "pitfalls in sukuk analysis," "blue print on sukuk," "AI application in sukuk analysis," "sukuk," "Islamic finance," "AI," "structured finance," "Islamic banking," "Islamic financial instruments," "Islamic finance instruments," "Islamic financial markets," "Islamic financial sector," "Islamic financial system. We used the following keywords in various combinations in the search for articles in the databases Scopus, Web of Science, SSRN, Google Scholar: ("sukuk" AND ("machine learning" OR "AI" OR "NLP" OR "text mining" OR "pricing" OR "liquidity" OR "efficiency")), ("Saudi" AND ("sukuk" OR "Islamic bond")), ("ijara sukuk" OR "murabaha sukuk" OR "wakala sukuk" OR "musharaka sukuk" OR "mudaraba sukuk") Additionally, we used the following market sources, as they contain definitions of the observed instrument characteristics and market variables:

Saudi Arabia issuance program reports, Saudi Arabia exchange market watch reports.

Studies were selected for inclusion in the study if they were published between 2020 and 2025, analyzed the structure, pricing, liquidity, efficiency, etc. of Sukuk, used AI/ML methods in the field of Islamic Finance, especially regarding Sukuk, were detailed enough in terms of the method used, enabling us to understand the input and the logic of the evaluation.

3.3 Extraction of data and synthesis of findings

The structure taxonomy, the structure documentation, the Saudi market, the AI method, the feature representation, the efficiency, the Shariah, the data sources, the feature engineering, the AI method, the feature representation, the efficiency, the Shariah, the data sources, the feature engineering, the AI method, the feature representation, the efficiency, the Shariah, the data sources, the feature engineering, the AI method, the feature representation, the efficiency, the Shariah, the data sources, the feature engineering, the AI method, the feature representation, the efficiency, the Shariah, the data sources, the feature engineering, the AI method, the feature representation, the efficiency, the Shariah, the data sources, the feature engineering, the AI method, the feature representation, the efficiency, the Shariah, the

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4 DEFINITION OF "EFFICIENCY" FOR SUKUK STRUCTURES

Although efficiency is often defined as the ability of Sukuk structures to offer cheaper sources of finance, the actual choices involved in Sukuk structure design require multi-dimensional trade-offs. In this research, the efficiency of Sukuk structure design is defined as follows: an Sukuk structure is considered efficient if it is able to achieve the following five objectives:

1) Pricing Efficiency: The Sukuk structure must be able to offer the cheapest source of finance as reflected by the yield/spread obtained relative to an appropriate benchmark. This must be done while taking into consideration the conditions of the issuance and/or the prevailing macro environment.
2) Issuance and Lifecycle Cost Efficiency: The Sukuk structure must be able to offer the cheapest source of finance as reflected by the costs involved. This includes legal costs, costs of documentation, Shariah Board costs, servicing costs, and asset transfer costs.
3) Liquidity Efficiency: The Sukuk structure must be able to offer the best liquidity, as reflected by the stability of secondary market prices, which will affect the required return for investors.

Although listing on a market watch allows for the extraction of the required inputs for determining the yield, actual Sukuk market liquidity may require further analysis [2].

4) Risk Allocation Efficiency: The Sukuk structure must be able to offer the best balance of risk allocation for all parties involved, including undertaking the purchase.
5) Governance/Shariah Assurance Efficiency: The Sukuk structure must be able to offer the best balance of Shariah assurance without undue complexity.

An important aspect of research into AI is the emphasis placed on integrating the actual deployment of AI with the actual governance of compliance with Shariah law.

Figure 1

5 SUKUK STRUCTURES: WHAT DIFFERS AND WHAT CAN BE MEASURED

5.1 Ijara sukuk

The Ijara structure is built on the usufruct principle, and the efficiency drivers of the Ijara structure are the availability of the asset, the maintenance of the asset, and the stability of the rental benchmarks. The Ijara structure documents are explicit, hence suitable for NLP.

5.2 Murabaha sukuk

The Murabaha structure is built on the cost-plus sale principle, and the efficiency drivers of the Murabaha structure are the commodity transaction mechanics, the execution of the commodity transaction, and the perception of the transaction's economics by the investor. The analysis of the sustainable sukuk contract mix by the global policy shows that the Murabaha structure is commonly used, hence the efficiency of the structure in operation [9].

5.3 Wakala bil istithmar sukuk

The Wakala structure is built on the principle of appointing an investment agent to manage the investment of the assets in the portfolio, with the returns depending on the

expected profit rate of the assets within the constraints of the portfolio. The analysis of the sustainable sukuk contract mix by the global policy shows that the Wakala structure is also commonly used, hence the efficiency of the structure in operation [9]. The efficiency drivers of the Wakala structure are the transparency of the portfolios, the rules of substitution, and the investment agent's governance.

5.4 Equity-based and hybrid structures

The Musharaka structure and Mudaraba structure are based on the principle of profit-sharing, while the hybrid structure is a combination of different contracts with the objective of fulfilling the demand of the investors as well as the regulations, as indicated by the analysis of the sustainable sukuk contract mix by the global policy [9]. The problem with the AI is the representation of the structure as well as the cash flow priority.

Table 1

Comparative lens for ijara, murabaha, wakala and related sukuk structures, and how AI can operationalize efficiency drivers.

Structure	Core mechanics	Primary efficiency levers	AI-extractable features	Typical trade-offs	AI methods most suitable
Ijara	Lease/usufruct; rentals fund periodic distributions	Asset availability; servicing; benchmark lease rate	Asset & lease clauses; purchase undertaking; servicing terms	Lower complexity; strong asset transparency; may constrain asset pool	NLP clause extraction + pricing residual models
Murabaha	Cost-plus sale; receivables generate returns	Execution mechanics; commodity trades; documentation standardization	Receivable composition; settlement mechanics; tradability clauses	Operationally popular; comparability depends on receivable mix	Document similarity + liquidity discount estimation
Wakala bil istithmar	Agency invests in asset pool; expected profit rate	Pool transparency; substitution rules; agent governance	Pool description; substitution rights; profit rate benchmark	Flexible structuring; governance burden if pool broad	NLP + clustering to identify de facto pool types
Musharaka	Partnership/profit-sharing	Monitoring; profit allocation;	Profit-sharing clauses; loss allocation;	Higher governance complexity; may suit	Hybrid feature models;

		governance intensity	termination rights	project finance	scenario sensitivity
Mudaraba	Trust financing/profit share	Manager incentives; reporting transparency	Manager obligations; profit distribution; disclosures	Strong governance needs; limited comparable datasets	Explainable models + audit-trail requirements
Hybrid	Contract stack (e.g., wakala+murabaha+ijara)	Stack coherence; tradability; documentation burden	Contract stack graph; priority of cashflows; undertakings	Balances investor demands; hardest to compare with labels	Embedding-based similarity + MCDA trade-off dashboards

5.5 The meaning of the term "other sukuk structures" in the context of the comparison in Saudi Arabia

In addition to these Sukuk structures, the Sukuk issuances in Saudi Arabia also include "other Sukuk Structures" such as the hybrids of Sukuk Structures combining wakala (agency-based Sukuk Structure), underlying murabaha, ijara, and commodity-based Sukuk Structures. The hybrids of Sukuk Structures are created for purposes of accommodating the requirements of tradability or investor documentation. In the context of the comparison in Saudi Arabia, the meaning of the term "other Sukuk Structures" should be considered as a representation of contract stacks instead of the generic term. The representation of contract stacks should enable the identification of the following features: the main contract, the secondary contracts, the asset class mix, and the key undertakings. The second consideration in the context of the comparison in Saudi Arabia is the role of sovereign and quasi-sovereign issuers. The role of sovereign and quasi-sovereign issuers should be considered as having a significant impact on risks and liquidity, which should be considered as dominating the differences of Sukuk Structures. In the context of the comparison of the Sukuk Structures, the following controls should be incorporated: the type of issuances; no consideration should be allowed regarding the impact of the type of issuances on the efficiency of Sukuk Structures.

6 DATA SOURCES FOR AI-ENABLED COMPARISONS IN SAUDI ARABIA

For AI-enabled comparisons, data is needed that relates the structure of contracts with the outcomes that are observable. In Saudi Arabia, three data types are of particular interest.

Issuance data: The NDMC offers data on the Saudi riyal local Sukuk program at the program level [3]. Exchange market-watch services contain information about the instrument structure, including maturity, coupon, and yield [2].

Disclosures: Prospectuses, offering circulars, and Shariah reports contain structure logic, undertakings, and covenants.

Regional market reports: These reports contain information about the market shares of different countries, including Saudi Arabia, in the overall outstanding market in the GCC region [5].

Global market commentaries: These reports contain information about the growth of the market, the magnitude of the market, etc.

A problem with these reports is that the level of detail may vary between different reports, and some reports may not contain as much detail as others. The AI data pipelines should therefore contain data completeness metrics.

6.1 NLP pipeline design for sukuk documentation

The documentation of Sukuk is rich and follows a set format though not standardized. Ideally, the robust NLP pipeline should include (i) document segmentation into structural components such as overview of structure, risk factors, covenants, etc., (ii) entity recognition of key players such as the issuer, SPV, obligor, etc., (iii) asset and location recognition, and (iv) contract type and clause recognition such as purchase undertaking, servicing, etc. The second key choice is the way to best balance the rule-based and the ML-based techniques. The rule-based techniques may be more accurate in terms of patterns of phrases such as purchase undertaking, etc., but the ML-based techniques may be more effective in terms of paraphrasing and context. It is also possible that Shariah-related terms and phrases may be nuanced such that another validation step may be necessary for such critical features. Nonetheless, as is always the case in any

discussion regarding AI governance in Islamic finance, accountability and compliance are key considerations such that such features are not to be avoided or dismissed [10]. In order to make comparisons across Sukuk issuances, features should be created as both categorical and continuous variables. Features such as structure type, benchmark type, etc., should be created as categorical variables, whereas continuous features such as the number of covenants, length of the risk factor section as an approximation of complexity, etc., should be created as continuous variables. Complexity features can also be created as an approximation of cost.

6.2 Feature sets for 'efficiency': from text to quantitative scores

The feature sets should be designed such that they are capable of interpreting or predicting the efficiency results. An overview of five feature sets is given below.

Group A: Structure primitives. Type of contract(s), type of asset, ratios of composition related to tradability, purchase undertakings.

Group B: Cashflow mechanics. Profit rate benchmark, rules of resetting, amortization, payment frequency, step-up clauses.

Group C: Governance and roles. Statement by Shariah board, role of servicing agent, dispute resolution.

Group D: Covenants and triggers. Financial covenants, event of default, cross default, early redemption.

Group E: Market and issuer controls. Type of issuer (sovereign, quasi, corporate), rating proxies, size, tenor, market regime.

The five feature sets could be used for supervised prediction of yield/spread and combined scoring. In addition, these could be used for interpretation purposes, as shown below. If the predictive model shows that the spread is driven by complexity of covenants, we could check whether this interpretation of covenants is correct.

7 FEATURE ENGINEERING: REPRESENTING SUKUK STRUCTURES USING AI

7.1 NLP extraction of structure features

The first step is the extraction of structure features from the contracts, which may contain information about the type of contract, the category of assets, the role of the SPV, the undertaking of the purchase, the servicing agent, the profit rate benchmark, etc.

Taxonomy-based feature extraction is the combination of taxonomy-based controlled vocabularies with machine learning algorithms.

Since Shariah compliance cannot be determined by the presence of certain words, evidence snippets, along with the context of the sections, are necessary.

7.2 Quantitative feature layer

Quantitative features of the Sukuk structure may include tenor, coupon type, size, rating proxies, etc.

Liquidity features may include bid-ask proxies, turnover, etc.

7.3 Efficiency Targets and Multi-Objective Outputs

Efficiency targets may include spread residuals, efficiency scores, etc.

For the purposes of the Sukuk market, it is not necessary to obtain a single score, as the relative ranking along with the degree of uncertainty is of much more interest.

8 AI AND ECONOMETRIC METHODS FOR COMPARATIVE EFFICIENCY

8.1 Unsupervised learning for structure typologies

It is possible that through clustering analysis, families of structures that are not immediately obvious could be identified. For example, two wakala sukuk could be less similar than one wakala sukuk and one ijara sukuk, based on the undertakings and covenants being aligned or not aligned.

8.2 Supervised learning for pricing and liquidity prediction

The importance of explaining the output cannot be overstated, as the ultimate output must be understandable by the decision maker as to why the model favors one structure over the other and whether it is Shariah-compliant and feasible [10].

8.3 Frontier and hybrid efficiency models

This could involve the use of DEA and stochastic frontier analysis with outputs such as liquidity and stability and inputs such as risks and costs of issuance, with NLP used to generate the features of the sukuk structures. Another literature stream is the evaluation of the efficiency and issuance of sukuk from the point of view of the GCC using the concept of frontier efficiency [12].

Figure 2

8.4 Validation and endogeneity control

The choice of the sukuk structure is endogenous as the choice of the issuer or investor is dependent on the constraints and reputation.

8.5 Comparing structures with multi-criteria decision analytics

Moreover, since efficiency is multi-dimensional, often the comparison is done using multi-criteria decision analysis (MCDA). AI could be helpful for supporting the MCDA as follows. On the one hand, NLP could be helpful for automatically retrieving information that is required for different criteria (e.g., is purchase undertaking present, is substitution of assets allowed, are covenants tight or loose?). On the other hand, the predictive model could be helpful for supporting estimation of criteria that are not immediately available at the time of issuance (e.g., what is expected liquidity discount, what is expected secondary volatility in the market?). A pragmatic approach to designing an MCDA model for the Sukuk markets in Saudi Arabia could be based on three levels of criteria. The first level could be Tier 1, based on market efficiency criteria such as pricing residuals, liquidity, and volatility. The second level could be Tier 2, based on operational efficiency criteria such as complexity of documentation, complexity of parties/roles, and servicing costs. The third level could be Tier 3, based on governance efficiency criteria such as Shariah, clarity of compliance statements, and ease of creation of audit trails.

8.6 AI for contract similarity and benchmarking

The reason structure comparison is not possible in this approach is that the labels are not informative enough. For example, the structure of the wakala Sukuk may be designed in such a way that it includes clauses that are similar to the risk allocation in the Ijarah structure. Similarly, the structure of the hybrid Sukuk may be designed in such a way that it includes features that are similar to the Murabaha structure, which may be used in cash management Sukuk. Therefore, in these circumstances, similarity models may be used to obtain a “benchmarking view” of the Sukuk markets. In this approach,

the Sukuk instruments are compared based on similarity rather than the structure/label. For example, embedding models may be used to obtain the representation of the documents as vectors, and the nearest neighbor search may be carried out to obtain the similar instruments that are used in the pricing and liquidity benchmarking. In the case of Saudi Arabia, the advantages of using similarity benchmarking will be twofold. Firstly, it will provide a basis for spread comparisons, which will improve efficiency in pricing. Secondly, it will provide a basis for highlighting outliers or documents that are different from the others. These tools are also seen as having legal or Shariah review risks. This method is in line with the Islamic finance AI literature, which stresses the need for efficiency in governance, with legal and Shariah review risks being taken into consideration while implementing AI [10].

8.7 Explainability, auditability, and shariah review workflows

However, in addition to being explainable, Islamic financial decisions also need to be auditability compliant. This calls for the development of an audit-ready workflow for storing information such as (i) features, (ii) confidence score, (iii) source text, (iv) model version, and (v) efficiency results along with uncertainty. The interface for the Shariah boards does not require a scoring system, but rather a “feature dossier” that includes information such as the contract stack, asset composition, and key undertakings with exact clauses highlighted. The interface for the risk committee has a secondary interface that includes scenario sensitivity, or the sensitivity of the ranking to rate shocks and liquidity.

9 GOVERNANCE, SHARIAH COMPLIANCE, AND MODEL RISK

The constraints of governance are relevant to the use of AI in Islamic finance. The emphasis of the study of the implementation of AI in Islamic finance has been on the importance of the legal aspect of aligning the tools with the constraints of governance [10]. The model should be able to provide an audit trail to connect the features with the text and assumptions used to rank the efficiency. The other important issue in the implementation of the model in the Saudi Arabian market is the issue of managing the

model risk, as the efficiency model may not be stable due to the low level of liquidity in the market and the regimes. The stressing of the model and analyzing the sensitivity of the model may provide valuable insights to the decision maker about the reliability of the model against the uncertainties of the model's outcome. The regularity of the issuance programs of the kingdom may be used in the model calibration [3].

9.1 Linking efficiency analytics to market infrastructure

Efficiency analytics are only as efficient as the underlying market infrastructure used to derive the data. As such, the Saudi market infrastructure provides two key ‘anchors’ with regards to the level of comparability: the official issuance program, which standardizes the practice with regards to the issuance of the sovereign and other issuers, [3] and the exchange listing program, which standardizes the data field with regards to the listing of all issuances. [2] This could be used as a baseline with regards to the efficiency comparison of the pricing of the corporate spread versus the sovereign curve at similar tenors. However, this does not naturally extend itself to the extraction of the unstructured features that are key to the identification of the structural differences between the two. It is at this point that the benefit of the NLP extraction techniques becomes apparent as they can be used to translate documentation with regards to the creation of comparable data fields with the aim of creating the structured data bases on top of the underlying infrastructure. If the underlying infrastructure is standardized with regards to the data field with regards to the structuring of the data, then the efficiency comparison can be more relevant.

10 PROPOSED SAUDI-CONTEXT METHODOLOGY BLUEPRINT

Step 1: Develop the corpus of the Saudi Sukuk, mapping to the instrument identifier of the official programs and the listing of the exchange.

Step 2: Develop the structure taxonomy representing the stack of contracts and undertakings, asset classes, and covenant classes.

Step 3: Develop the NLP extraction methodology, including the retention of evidence.

Step 4: Develop the efficiency model, including the construction of the pricing efficiency, liquidity, and costs, where possible, by using the multi-objective scoring approach.

Step 5: Develop the model and the explanation, including the combination of clustering, supervised prediction, and/or frontier approach.

Step 6: Develop the evaluation methodology, including the validation of the model and sensitivity analysis, as well as the selection bias test.

Step 7: Developing the operational model, including the model card for Shariah boards and risk committees, together with their data provenance and boundaries of use.

11 RESEARCH GAPS AND FUTURE DIRECTIONS

The availability of data sources that link the documentation of sukuk with transactional liquidity in the kingdom of Saudi Arabia is limited. In addition, there is no direct measure of 'Shariah risk'; it is possible to measure it using proxies such as documented divergence in Shariah boards, with consideration of the ethical implications that may be involved. However, comparisons in the field of AI overemphasize the importance of pricing, with little attention paid to operational efficiency such as the costs of documentation and servicing, which affect the structure of the issuer. Research gaps exist in the following areas:

Retrieval-based approaches that allow interactive structuring, such as the ability to query the impact of changing an undertaking or asset pool on efficiency.

Comparisons across markets such as GCC, which allow isolating the impact of structure versus the impact of the regime.

12 CONCLUSION

The period between 2020 and 2025 has seen an improvement in the environment in which the comparison of the structure of sukuk using the application of AI is done in the kingdom of Saudi Arabia, where data sources have become easily accessible using the official programs of issuance and listing on the exchange [3,4]. In addition, the application of AI in the field of Islamic finance has been enhanced in the kingdom of

Saudi Arabia, with constraints on governance clearly outlined [10,11]. It is possible to compare the structure of the following forms of sukuk: Ijara, murabaha, wakala, and hybrid, using the application of AI, provided that the application of AI in the field of Islamic finance is based on the following:

Transparent Taxonomies

Grounded NLP feature extraction, with evidence retention

Evaluation Designs that take into account Endogeneity and Regime Shifts

In the Kingdom of Saudi Arabia, the best application of the results of the comparison of the structure of the Sukuk would be an 'explainable diagnostic tool' that would enable trade-offs to be understood in terms of costs, liquidity, risks, and complexity from the point of view of governance.

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Authors' Contribution

All authors contributed equally 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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