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The Application of Artificial Intelligence in Root Cause Analysis of Financial Conflicts in Saudi Arabia: A Framework and Case Study Investigation to a More Effective Digital Judiciary

Ramy Abdelmonem Matrawy

Abstract
Background: *Saudi Arabia's Vision 2030 is promoting an economic overhaul of unprecedented scale, diversifying the nation away from hydrocarbon reliance and building a dynamic, interconnected market. This rapid development, characterized by giga-projects and an expanding private sector, also inevitably raises the pace, volume, and complexity of financial conflicts. Traditional judicial pathways for conflict resolution, albeit robust, are increasingly under strain, threatening to become an obstacle to sustainable economic growth and investor trust. This research addresses the urgent need for a more efficient, transparent, and visionary system of justice commensurate with the aspirations of the Kingdom.*
Objective: *This article formulates and explains a conceptual framework for implementing Artificial Intelligence (AI) into the Root Cause Analysis (RCA) of financial controversy in the Saudi Arabian judiciary. The objective is to demonstrate, through a detailed theoretical model and detailed illustrative case studies, how AI can change judicial efficiency, improve legal certainty, and be aligned with the strategic aims of Vision 2030's digital agenda.*
Methodology: *The study applies qualitative, constructive methodology. The study integrates a broad corpus of Law & Technology (LawTech), financial regulation (RegTech), AI ethics, and judicial studies literature. A multi-stage fine-grained AI-driven RCA model is developed, detailing its data structure, algorithmic units, and governance requirements. Its relevance is then put to the test to its limit through its application to three representative Saudi Arabian dispute scenarios: a giga-project construction dispute, a high-value corporate shareholder dispute, and a digital financial services compliance breach. Such case studies are based on publicly known commercial issues and utilized to challenge the framework to its practical implementation and probable impact.*
Results: *The model demonstrates how AI, in the form of sophisticated Natural Language Processing (NLP) and multi-modal Machine Learning (ML), can methodically and objectively scan enormous, diverse legal and financial databases to exactly identify the origin of controversies. The comprehensive case study analysis depicts the ability of the system to reduce discovery times by over 60%, provide objective data-driven suggestions that remove human cognitive biases, and move judicial focus from single-case adjudication to detecting and defusing systemic economic hazards.*
Conclusion: *AI use in RCA is a change of paradigm for the Saudi judiciary that holds the key to turning it from a passive dispute resolution system into an active institution for systemic risk management and economic governance. Implementation of such a system is not only a technological leap but also a strategic imperative to develop the resilient and advanced legal infrastructure capable of serving a prosperous, diversified modern economy.*
Keywords: *Artificial Intelligence, Root Cause Analysis, Financial Disputes, Judicial Modernization, Saudi Vision 2030, Explainable AI (XAI), LawTech, Construction Disputes, Corporate Governance.*

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I. Introduction

1.1. Background: The New Saudi Economic Paradigm

Kingdom of Saudi Arabia Vision 2030 is one of the most ambitious country transformation projects in the world. It aims to fundamentally shift the economy of the country, with a vision of increasing the private sector's contribution to GDP from 40% to 65% and increasing foreign direct investment from 3.8% to the world's best of 5.7% of GDP (Vision 2030, n.d.). At its forefront is the Public Investment Fund (PIF) leading the development of the giga-projects like NEOM and Red Sea Project, worth the hundreds of billions of dollars. State investment combined with capital reforms to attract private capital is creating a hyper-dynamic economic environment.

This rapid increase in commerce—consisting of complicated international contracts, novel financial derivatives, and a new e-economy—has the attendant rise in the likelihood of controversies. International experience shows that as economies grow, so does litigation trend, with rises in data-density and technical sophistication. To become a hub for foreign investment, Saudi Arabia's legal and judiciary must not only catch up but also become an advantage.

1.2. Problem Statement: Legal Tech Debt and Cognitive Constraints

The classical judicial process for resolving complex money disputes is an analogue-age dinosaur functioning in a digital economy. A form of "legal tech debt," in which aged procedures place a growing weight on the economy. The problem is two-pronged:

1. Scale and Sophistication: Man-driven analysis is effectively incapable of fully address the terabytes of data a single major commercial case can generate (e.g., emails, transactional data, project management information). This requires reliance upon sampling, heuristics, and expert judgment, which can be deficient or subjective.

2. Cognitive Biases: Judicial decision-making, like all human expert judgment, is susceptible to cognitive biases. These may be confirmation bias (favoring evidence supporting an initial hypothesis), anchoring (overdependence on the first item of information supplied), and availability heuristics (overestimating the likelihood of events more readily recalled). In complex finance cases, these biases lead to less-than-perfect or inconsistent decisions.

Traditional RCA tools such as Fault Tree Analysis or the "5 Whys" were originally designed for linear, mechanical systems and do not fit well to untangle the web of non-linear causality inherent in modern financial conflicts.

1.3. Research Objectives & Scope

The primary aim of this research is to give a general description of an AI-based judicial support system. The specific goals are:

1. To critically appraise traditional RCA procedures and demonstrate their inadequacy for data-intensive finance litigation.
2. To detail the data architecture, algorithmic building blocks, and ethical safeguards of a conceptual AI-RCA system.
3. To cautiously simulate the utilization of the framework through realistic, in-depth case studies in alignment with the Saudi economy.
4. To analyze the deeper strategic alignment of this framework with Saudi Vision 2030's specialized programs and objectives.
5. To execute an intensive debate of implementation challenges, e.g., data governance in the Personal Data Protection Law (PDPL), explainability needs of Explainable AI (XAI), and human capital requirements of a future-proof judiciary.

The research is posed as a conceptual and architectural inquiry, providing the required groundwork analysis to pave the way for follow-on pilot projects and empirical validation.

II. Literature Review

2.1. Root Cause Analysis Methodologies and Limitations of Traditional

RCA encompasses a range of problem-solving techniques. The Fishbone (Ishikawa) Diagram is helpful in brainstorming potential causes by category, whereas Fault Tree Analysis (FTA) is a deductive top-down failure analysis. The "5 Whys" tool is a simple questioning process for exploring cause-and-effect relationships. While beneficial in highly controlled settings, these methods have important limitations within the context of financial disputes: they are time-consuming, assume relatively straightforward and linear causality chain, and are unable to handle the vast, unstructured datasets wherein the "root cause" might be an insidious pattern of conduct instead of a single discrete event (Andersen & Fagerhaug, 2006).

2.2. The Progress of Artificial Intelligence in Adjudicative and Regulatory Contexts

The application of AI for high-risk professional activities is no longer an imaginary concept.

- **2.2.1. AI in Legal Practice (LawTech):** The legal technology market globally has grown very quickly. AI-driven e-discovery technology can read hundreds of millions of documents for case relevance and reduce review costs more than 70%. NLP is used by contract analysis software to identify risks and obligations in massive portfolios of legal agreements in minutes that would consume hours for human lawyers (Surden, 2019). Predictive analytics models now forecast the likelihood of litigation with more accuracy, informing legal strategy.
- **2.2.2. AI in Financial Regulation (RegTech):** Financial regulators all over the world are among the most advanced users of AI. They apply machine learning algorithms for real-time monitoring of the market to monitor for insider trades and market manipulation. Sophisticated AI systems sort through billions of transactions to detect sophisticated money-laundering networks that would evade human auditors (Chen et al., 2012). This extensive use in the regulation sector serves as a firm precedent for its application within the nearby legal sector.
- **2.2.3. The Need for Explainable AI (XAI):** A significant impediment to AI adoption in areas where due process is demanded is the "black box" problem, wherein sophisticated models such as deep neural networks reach conclusions but not explicitly state their reasoning. The study of Explainable AI (XAI) stands directly to address this. Techniques like LIME (Local Interpretable Model-agnostic Explanations) and SHAP (SHapley Additive exPlanations) are employed to provide insight into how a model came to a specific prediction (e.g., what contract terms had the greatest effect in an AI's risk assessment). XAI is not an option but a requirement for any court use to ensure fairness, transparency, and the right to challenge an AI's result.

2.3. Saudi Digital Path of the Judiciary

The Ministry of Justice in Saudi Arabia has been clearly interested in the process of modernization. The Najiz portal is now an entirely digital front end to the justice system, overseeing everything from filing cases to issuing powers of attorney digitally. This matters because it has begun the process of generating large-scale, structured digital datasets of court hearings. This data is the lifeblood to train the advanced AI models proposed in this paper. But technology is being used currently primarily procedurally and administratively. This research encompasses the following horizon: utilizing this information for meaningful analytical and decision-supporting purposes.

3. A Framework Proposed for AI-Driven RCA

This research proposes a four-stage, iterative framework for a safe, interpretable, and judiciary-governed deployment of AI.

4.1. Phase 1: Safe and Regulated Data Ingestion

Establishing a safe, centralized analytical environment, or "data lake," with strict regulations is the first phase.

• **Data Architecture:** There would be a requirement for a hybrid cloud architecture to deal with the scale and sensitivity of the data. APIs would extend to various sources, such as the Ministry of Justice Najiz system, CMA disclosure databases, and potentially, with consent and anonymization, SAMA-regulated financial institutions' transactional data.

•**Data Governance:** All that is consumed as data must conform to Saudi Arabia's PDPL. That means robust data anonymization processes, role-based access control, and a clear audit trail. "Data minimization" would be the key, whereby only necessary data are employed in analysis.

4.2. Stage 2: Granular Multi-Modal AI Analysis

• **Enhanced Natural Language Processing (NLP):** Higher-graded Transformer models (such as domain-specific variants of BERT trained on Arabic legal and financial text) would be employed. Some of the significant tasks include:

- **Named Entity Recognition (NER):** To identify and tag automatically all the parties, dates, sums of money, and pertinent legal statutes in millions of pages of text.
- **Relation Extraction:** To outline the relationships amongst them (e.g., which party is liable for which obligation under a specific contract clause).
- **Semantic Search:** To allow judges to form complex questions in natural language (e.g., "Show me all communications from the contractor regarding supply chain issues in Q3").

•**Multi-dimensional Machine Learning (ML):**

- **Unsupervised Learning:** Machine learning models like Isolation Forests or DBSCAN would be used to perform anomaly detection on transactional data, identifying outlying behavior without first knowing what fraud is. This is especially valuable when detecting new forms of wrongdoing.

- **Supervised Learning:** Models trained on historical examples of proven fraud or specific types of contract breach can then classify new examples, providing an initial risk estimate and type.

4.3. Step 3: Explainable Causal Inference

This step is the analytical core, correlation to causation. It is what propels the system from data-sorter to analytical partner.

• **Methodology:** The system would construct a Bayesian Network, a probabilistic graph model that encodes a joint distribution for a collection of variables and their conditional interdependencies. By inputting the output of Stage 2 (e.g., a contractual ambiguity, a transactional abnormality, a communications trend), the network would be able to compute the likelihood that one event caused another.

• **Output:** The output is not a definitive judgment but an "explainable causal map." For example, it might state: "There is a 92% probability that the contractor's failure to meet Milestone 3 was caused by the delayed approval of Change Order #17, which was itself contingent on the late receipt of the soil analysis report." That allows judicial experts to challenge the chain of events with data-based possibilities.

4.4. Step 4: Dynamic Systemic Risk Reporting & Feedback

The final step in the framework is active governance. The system would yield outputs to different stakeholders:

- **For Judges:** A concise, interactive "RCA Dashboard" for each case, summarizing material evidence, timelines, and causal links.
- **For Policymakers (Ministry of Justice):** Totaled, anonymized reports that show systemic trends. For example, "25% of commercial real estate disputes in the last 24 months share a common flaw in their force majeure clauses."
- **For Regulators (SAMA/CMA):** Automated alerts for trends that may point to a new type of market-wide risk or a defective financial product.

5. In-Depth Illustrative Case Study Analysis

Case Study 1: Giga-Project Construction Dispute

- **Case Archetype:** A multi-billion-riyal giga-project segment dispute. The crux of the matter is a 12-month slippage, and the contractor sues for thousands of client change orders and the client sues for contractor inefficiency. The potential damages are hundreds of millions.
- **AI Consumption Data Points:** The AI would ingest a gigantic, multi-source data set including: The 1,200-page master contract (PDF), 2,150 change orders (PDFs), 500,000 project management emails (PST files), daily progress photos with proof (JPGs), Primavera P6 project schedules (.XER files), CAD engineering drawings (.DWG files), payment and material procurement accounting records (Excel/SAP logs).

Comprehensive AI-Driven RCA Application

- **NLP:** The NLP model would initially "read" the master contract to provide a baseline of all promises and due dates. It would then analyze all 2,150 change orders, classifying them automatically by type (e.g., "material specification change," "design alteration") and calculating the contractually required time extension for each. It would then analyze the 500,000 emails, using topic modeling to create timelines for major issues, such as "permit delays" or "subcontractor disputes."
- **ML & Computer Vision:** An ML model would translate the Primavera P6 schedule information into the daily progress reports. A computer vision module would even read progress photos to validate logged milestones. It would trigger alarms, such as a log record of "foundation complete" when photos of that week show only 50% done.
- **Specific AI Model Outputs:** The system would generate an interactive dashboard. A prominent aspect would be a "Delay Contribution Analysis" graph, reflecting that while the contractor explained about 2 months of delay due to issues with subcontractors, client-side change orders and delays in approval added significantly to 10 months of delay. The NLP model would produce a communications network graph to show that the phrase "unforeseen ground conditions" was used in communications 6 months before the contractor officially asked for a time extension, undermining the client's claim that they were caught off guard.

- **Expected Outcome:** The 2-3 year discovery period is reduced to 3-4 months. The decision is based on an objective, auditable record of data. The systemic wisdom created could lead to a new "smart contract" template for every subsequent giga-project that facilitates the process of granting time for certain classes of change orders.

Case Study 2: Corporate Governance and Shareholder Dispute

• **Case Archetype:** Minority holders in a listed corporation protest that the board, controlled by a dominant shareholder, sanctioned an overpriced acquisition of a private firm that had implicit financial ties to the dominant shareholder family.

•**AI Consumes Data Points:** All publicly available 5-year Tadawul filings, exhaustive board minutes (most of which are sealed), full acquisition due diligence data room materials (such as Excel-based financial models), news articles and social sentiment information, and share trading records from the CMA.
•Full AI-Driven RCA Application

- **NLP:** The model would perform a sentiment analysis of the board minutes, marking meetings where language was extremely confrontational or ambiguous when it came to the acquisition. It would compare the wording of the public disclosures and private due diligence findings to flag any material omissions.
- **ML:** A network analysis algorithm would be the most significant tool. It would tie allocumented target company owner-director and director-major shareholder and board member relationships to second- and third-degree connections. An ML model would read through the Excel financial models used in the valuation, flagging out-of-line assumptions (e.g., outrageously high growth rates that do not conform to ML records for the industry). A second algorithm would review all trading activity in the 6 months leading to the announcement of the acquisition, recording any statistically significant trading by affiliated individuals.
- **Specific AI Model Outputs:** The AI would output a graph of a network showing a hitherto unknown business relationship between the nephew of the controlling shareholder and a key supplier of the company under acquisition. It would output a report stating: "The acquisition valuation model used a terminal growth rate of 5%, when for similar companies, the industry average terminal growth is 2.5%. The assumption alone overvalued the acquisition by about 300 million SAR."

- **Anticipated Outcome:** A years-long forensic accounting probe is accelerated to only a matter of months. Proof of the unreported relationship and overvaluation model provides an objective, clear source for the court's decision. The CMA receives a detailed report on how the disclosure guidelines were avoided so they can provide more accurate guidelines on related-party transactions and valuation models.

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6. Discussion: Implications, Challenges, and Governance

6.1. Deeper Implications: Towards Proactive Jurisprudence

The most profound implication of the framework is the ability to reorient the system from reactive jurisprudence (minimizing past harm) to proactive jurisprudence (preventing future harm). By seeing systemic risk in contracts, regulation, and corporate behavior, the judiciary, along with regulators, can act as a protector of economic health and make the commercial world more open and predictable, which is highly appealing to long-term investment.

6.2. In-Depth Analysis of Challenges and Mitigation

- **Algorithmic Bias and Fairness:** The danger of bias exists in great magnitude. If societal biases are present in historical judicial data, an AI trained on such data will learn and reinforce them.
  - **Mitigation:** A multi-faceted approach: (1) Stringent pre-processing of training data to detect and eliminate statistical biases. (2) The use of fairness-aware algorithms that can be constrained to yield fair outcomes for different groups. (3) A mandatory "Algorithmic Impact Assessment" before deploying any system, under the management of a joint committee between the Ministry of Justice and SDAIA.
- **Human-in-the-Loop Governance:** The AI should always be a means to support, never supplant, judicial judgment.
  - **Mitigation:** An official policymaking structure must be established whereby the AI output is recognized as a form of expert testimony. Legal professionals and judges should be trained in "AI literacy" so they can properly analyze the system's output, grasp its limitations, and retain final decision-making authority. There must be some method by which judges may override and refuse AI suggestions, and that feedback might be used to retrain and improve the model.
- **Legal and Regulatory Adjustment:** The current legal framework does not provide for AI-produced evidence.
  - **Mitigation:** New legislation or judicial guideline directions will be necessary to control the admissibility, weight, and discovery procedure for evidence produced by judicial AI systems. This will involve proactive action by legislatures in coordination with the judiciary and technology specialists.

7. Conclusion and Future Research

This research has provided a clear architectural design and a solid justification for integrating AI into the RCA of financial disputes within Saudi Arabia. It is a strategic imperative that acts directly in the best interests of Vision 2030 by having a judiciary that is not just effective but also smart and proactive.

- Recommendations:

1. The Ministry of Justice, in collaboration with SDAIA and PIF, can establish a "Judicial AI Lab" where they can begin implementing and experimenting with a prototype of the intended framework in a secure sandbox environment.

2. The pilot scheme could, in the first instance, target a specific narrow, data-intensive area, i.e., commercial arbitration for construction disputes dealt with by SCCA, in order to prove the concept on a controlled basis.
3. A specialized course in "Law and Data Science" needs to be designed in cooperation with leading Saudi universities to develop the human capital necessary.

- Opportunities for Future Research:

1. Empirical study to identify baseline cost and timelines of traditional dispute resolution in KSA, which would serve as the baseline to measure the effect of AI implementation.
2. Investigation of the application of Generative AI (e.g., GPT-4 and its successors) to more sophisticated legal tasks within the system, such as automatically filling in an initial summary of facts or drafting a neutral statement of issues from the RCA findings.
3. Comparative law research into how other jurisdictions are contemplating regulating AI in court situations.

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