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REGULATING ARTIFICIAL INTELLIGENCE AND SMART CONTRACTS IN PAKISTAN'S COMMERCIAL TRANSACTIONS: A MERCANTILE LAW FRAMEWORK FOR DIGITAL TRADE AND CONSUMER PROTECTION

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Abstract

The increasing integration of artificial intelligence (AI) and smart contracts into commercial transactions has significantly reshaped the structure and operation of digital trade systems worldwide. These technologies enhance efficiency, transparency, and automation in commercial dealings; however, they simultaneously introduce complex legal and regulatory challenges related to contractual validity, liability allocation, consumer protection, and regulatory oversight. In Pakistan, the existing mercantile legal framework remains largely grounded in traditional contract principles and electronic transaction laws, which are insufficient to address the autonomous and self-executing nature of AI-driven systems and blockchain-based smart contracts. This legal gap has created uncertainty for regulators, businesses, and consumers operating within the emerging digital economy. This study examined the regulatory challenges associated with AI and smart contracts in Pakistan's commercial transactions and proposed a comprehensive mercantile law framework for digital trade and consumer protection. A quantitative, explanatory, and cross-sectional research design was employed, using structured survey data collected from legal practitioners, fintech professionals, regulators, academicians, and technology experts. The data were analysed using descriptive statistics and Structural Equation Modelling (SEM) to test the proposed relationships among variables. The findings revealed that AI adoption and smart contract utilization significantly enhance commercial efficiency and legal certainty in digital transactions. Furthermore, the existence of an effective mercantile regulatory framework plays a critical mediating role in strengthening consumer protection and promoting a sustainable digital economy. The study concludes that Pakistan requires a technology-responsive and adaptive legal framework that integrates AI

governance, smart contract recognition, and robust consumer protection mechanisms to ensure secure and sustainable digital trade development.

INTRODUCTION

The Fourth Industrial Revolution has fundamentally transformed global commerce through the convergence of artificial intelligence (AI), blockchain technology, and digital platforms. Contemporary commercial transactions are increasingly characterized by algorithmic decision-making, automated contractual performance, and decentralized digital infrastructures that facilitate cross-border trade and commercial interactions without traditional intermediaries (Schwab, 2017). Artificial intelligence systems are now extensively deployed in financial services, e-commerce, logistics, insurance, and supply chain management to perform functions such as predictive analytics, customer profiling, risk assessment, automated negotiations, and fraud detection. Simultaneously, blockchain-based smart contracts have emerged as self-executing digital agreements that automatically implement contractual terms once predefined conditions are fulfilled (Werbach & Cornell, 2017). These technological developments are reshaping commercial relationships by introducing unprecedented levels of efficiency, transparency, and automation into modern trade systems.

Artificial intelligence refers to computational systems capable of performing tasks that ordinarily require human intelligence, including reasoning, learning, prediction, and autonomous decision-making (Russell & Norvig, 2021). In commercial settings, AI technologies facilitate automated decision-making processes that influence pricing mechanisms, consumer credit assessments, market forecasting, and contractual negotiations. Similarly, smart contracts represent computer protocols operating on blockchain networks that execute contractual obligations automatically through programmed instructions and cryptographic verification mechanisms (De Filippi & Wright, 2018). Unlike conventional contracts that depend upon human intervention and institutional enforcement mechanisms, smart contracts significantly reduce transaction costs and execution delays by eliminating intermediaries and introducing automated compliance structures.

The integration of AI and smart contracts has generated significant economic opportunities for digital trade. Businesses increasingly rely upon intelligent algorithms and blockchain technologies to enhance operational efficiency, reduce administrative burdens, and improve transactional certainty. Studies indicate that AI-driven automation substantially increases productivity, enhances market responsiveness, and strengthens supply chain resilience by enabling real-time decision-making and predictive capabilities (Brynjolfsson & McAfee, 2014). Likewise, smart contracts facilitate secure and transparent commercial transactions by ensuring automatic performance and minimizing information asymmetries among contracting parties (Mik, 2017). Consequently, digital technologies are increasingly becoming essential components of contemporary commercial ecosystems and are redefining the legal and economic foundations of trade relationships.

Despite their transformative potential, artificial intelligence and smart contracts present complex legal, regulatory, and ethical challenges that challenge traditional principles of mercantile law. Classical contract law is primarily founded upon concepts of human consent, intention, offer and acceptance, contractual capacity, and judicial enforcement mechanisms. The emergence of autonomous technologies complicates these foundational assumptions because contractual decisions may be generated by algorithms with limited human supervision or intervention (Kerikmäe & Hoffmann, 2022). Similarly, the self-executing and immutable nature of smart contracts raises significant legal questions concerning contractual interpretation, mistake, misrepresentation, unconscionability, force majeure, and remedial mechanisms (Raskin, 2017). Existing legal doctrines are therefore increasingly strained by technological innovations that transcend conventional legal categories and regulatory assumptions.

The deployment of AI systems in commercial transactions further raises concerns regarding algorithmic accountability, transparency, discrimination, data governance, and consumer rights. Artificial intelligence frequently relies upon extensive data processing and machine-learning techniques that may produce opaque decision-making outcomes and unintended biases. Algorithmic errors in credit scoring, automated consumer profiling, or digital financial services can expose individuals to discriminatory practices and undermine procedural fairness and consumer protection standards (Cath et al., 2018). Moreover, autonomous decision-making systems often create difficulties in determining liability and accountability when commercial harm results from algorithmic failures or unintended outcomes. Consequently, legal systems worldwide are increasingly confronted with the challenge of balancing technological innovation with principles of fairness, accountability, and consumer protection.

The regulatory challenges associated with smart contracts are equally significant. While smart contracts enhance efficiency and transactional certainty, they also create uncertainties regarding their legal recognition, enforceability, jurisdictional applicability, and compatibility with existing contractual doctrines. Questions remain concerning the legal status of blockchain-generated agreements, the allocation of responsibilities among developers and users, and the mechanisms available for dispute resolution in decentralized commercial environments (Werbach & Cornell, 2017). Since smart contracts execute automatically and may be irreversible once deployed, traditional legal remedies such as rescission, injunctions, and equitable interventions may become difficult to implement. These challenges necessitate the development of modern legal frameworks capable of regulating technologically mediated commercial relationships.

Globally, policymakers and regulatory institutions have increasingly recognized the necessity of establishing comprehensive governance mechanisms for artificial intelligence and digital commerce technologies. International initiatives have emphasized principles of transparency, accountability, human oversight, risk management, and consumer protection in the regulation of AI systems and digital transactions (OECD, 2024). Similarly, numerous jurisdictions have initiated legislative reforms concerning electronic commerce, digital assets, and blockchain technologies to provide legal certainty and facilitate innovation while safeguarding public interests. These developments demonstrate an emerging global consensus that technological progress must be accompanied by adaptive legal frameworks capable of responding to evolving commercial realities.

In Pakistan, digital transformation has accelerated considerably during the past decade due to increasing internet penetration, rapid expansion of e-commerce platforms, fintech innovation, and the proliferation of digital payment systems. Businesses and consumers increasingly rely upon online marketplaces, electronic payment infrastructures, and technology-driven commercial services for conducting transactions and accessing financial products. The growing digital economy presents substantial opportunities for economic development, financial inclusion, and international trade integration. Nevertheless, Pakistan's existing mercantile legal framework remains primarily grounded in traditional legal principles that were developed before the emergence of artificial intelligence, blockchain technologies, and automated contractual systems.

Pakistan's commercial regulatory framework, including contract law, electronic transaction regulations, and consumer protection statutes, does not comprehensively address the legal implications arising from AI-enabled decision-making and smart contracts. Existing legislation provides limited guidance regarding the legal validity of self-executing agreements, algorithmic accountability, automated contractual consent, digital liabilities, cybersecurity obligations, and consumer rights within technologically mediated commercial transactions. Furthermore, the absence of dedicated regulatory standards creates uncertainty for businesses, investors, regulators, and consumers seeking to engage in emerging digital markets. Such regulatory ambiguities may

impede technological innovation, discourage investment, and undermine public confidence in digital commerce ecosystems.

The absence of a coherent mercantile law framework governing artificial intelligence and smart contracts represents a significant regulatory and scholarly challenge in Pakistan. Existing legal scholarship predominantly addresses electronic commerce and cybercrime regulation while offering limited examination of the intersection between mercantile law and emerging digital technologies. Moreover, insufficient attention has been devoted to developing an integrated regulatory framework capable of reconciling principles of commercial certainty, technological innovation, and consumer protection within Pakistan's evolving digital economy. Therefore, a comprehensive examination of the legal and regulatory dimensions of AI and smart contracts is both timely and necessary.

Accordingly, this study critically evaluates the adequacy of Pakistan's existing mercantile legal framework in regulating artificial intelligence and smart contracts within commercial transactions. Through doctrinal and comparative legal analysis, the study seeks to identify existing regulatory deficiencies and propose a comprehensive mercantile law framework that promotes legal certainty, supports digital trade, strengthens consumer protection, and facilitates responsible technological innovation. The study ultimately contributes to the emerging discourse on technology governance by advancing a context-specific legal framework capable of supporting Pakistan's transition toward a secure, inclusive, and sustainable digital economy.

Problem Statement

Artificial intelligence and smart contracts are rapidly transforming commercial transactions by introducing automated decision-making processes, decentralized contractual mechanisms, and digitally integrated trading systems. These technological innovations offer significant benefits in terms of efficiency, transparency, cost reduction, and transactional certainty. However, their increasing adoption simultaneously generates complex legal and regulatory challenges that traditional mercantile law frameworks are inadequately equipped to address. The fundamental principles of contract law, commercial liability, and consumer protection have historically been constructed around assumptions of human agency, manual contractual performance, and judicially enforceable obligations. The emergence of autonomous technologies and self-executing agreements fundamentally disrupts these assumptions and exposes significant deficiencies within existing legal systems.

In Pakistan, the expansion of digital trade, fintech services, electronic commerce platforms, and blockchain-based commercial activities has accelerated considerably. Despite these developments, the country's mercantile legal framework remains fragmented and technologically underdeveloped. Existing laws governing contracts, electronic transactions, and consumer rights provide limited regulatory guidance concerning algorithmic accountability, legal recognition of smart contracts, allocation of liability arising from autonomous systems, digital consent, cybersecurity obligations, and dispute resolution mechanisms for technology-driven commercial relationships. Consequently, businesses, regulators, investors, and consumers operate within an environment characterized by legal uncertainty and regulatory ambiguity.

The absence of comprehensive legal standards governing artificial intelligence and smart contracts poses significant practical and policy concerns. Businesses may encounter difficulties in determining the enforceability of automated agreements and the allocation of responsibilities when algorithmic errors or system failures result in commercial losses. Consumers remain vulnerable to opaque algorithmic decision-making processes, discriminatory outcomes, information asymmetries, and inadequate remedies arising from automated transactions. Similarly, regulators face considerable challenges in balancing technological innovation with public interest considerations, market integrity, and consumer protection objectives.

From a scholarly perspective, substantial research has examined electronic commerce regulation and

cybersecurity issues in Pakistan; however, limited attention has been devoted to the intersection of mercantile law, artificial intelligence governance, and blockchain-enabled smart contracts. Existing literature lacks an integrated legal analysis examining how traditional commercial law doctrines should adapt to emerging technologies and fails to provide a comprehensive regulatory model specifically tailored to Pakistan's digital economic context. The absence of such scholarship constitutes a significant research gap because legal uncertainty may impede digital innovation, discourage domestic and foreign investment, and hinder the sustainable development of Pakistan's digital economy.

Accordingly, there is a compelling need to critically examine the adequacy of Pakistan's existing mercantile laws and formulate a comprehensive, technology-responsive legal framework capable of regulating artificial intelligence and smart contracts while simultaneously promoting digital trade, ensuring commercial certainty, and strengthening consumer protection.

Research Questions

1. To what extent do Pakistan's existing mercantile laws adequately regulate artificial intelligence and smart contracts in commercial transactions?
2. What legal, regulatory, and consumer protection challenges arise from the use of artificial intelligence and smart contracts in Pakistan's digital trade ecosystem?
3. How have selected international jurisdictions regulated artificial intelligence and smart contracts in commercial transactions?
4. What legal reforms are necessary to establish a comprehensive mercantile law framework for digital trade and consumer protection in Pakistan?

Research Objectives

1. To critically evaluate the adequacy of Pakistan's existing mercantile laws governing artificial intelligence and smart contracts in commercial transactions.
2. To identify and analyse the legal, regulatory, and consumer protection challenges associated with AI-driven commercial activities and smart contracts.
3. To comparatively examine international regulatory approaches concerning artificial intelligence and smart contract governance.
4. To develop a comprehensive mercantile law framework for regulating artificial intelligence and smart contracts in Pakistan while promoting digital trade and safeguarding consumer rights.

Significance of the Study

Theoretical Significance

This study contributes to the emerging body of literature on digital commerce regulation by integrating principles of mercantile law, artificial intelligence governance, blockchain regulation, and consumer protection within a unified analytical framework. The research advances scholarly understanding of how traditional contract doctrines and commercial law principles should evolve to accommodate autonomous technologies and self-executing agreements.

Practical Significance

The study provides businesses, legal practitioners, financial institutions, technology developers, and digital platform operators with a comprehensive understanding of the legal implications of artificial intelligence and smart contracts in commercial transactions. The proposed framework offers practical guidance regarding contractual enforceability, liability allocation, risk management, and consumer protection obligations within digitally mediated commercial environments.

Policy Significance

The study offers evidence-based recommendations for legislators, policymakers, and regulatory institutions seeking to modernize Pakistan's commercial legal infrastructure. The proposed mercantile law framework may facilitate the development of technology-responsive legislation that promotes legal certainty, encourages digital innovation, strengthens investor confidence,

protects consumer rights, and supports the sustainable growth of Pakistan's digital economy.

Literature Review

Artificial Intelligence and the Transformation of Commercial Transactions

Artificial intelligence (AI) has emerged as one of the most transformative technologies of the digital economy, fundamentally reshaping commercial transactions, market interactions, and business decision-making processes. AI systems increasingly perform functions that were traditionally dependent upon human judgment, including credit assessments, customer profiling, predictive analytics, fraud detection, risk management, and automated negotiations (Russell & Norvig, 2021). The integration of machine learning algorithms and data-driven systems into commercial environments has significantly enhanced operational efficiency, reduced transaction costs, and accelerated decision-making processes.

The literature indicates that AI-driven commercial systems generate substantial economic benefits by enabling firms to optimize resource allocation, improve market responsiveness, and increase productivity (Brynjolfsson & McAfee, 2014). In financial services, AI technologies facilitate automated lending decisions, algorithmic trading, and digital payment infrastructures that promote financial inclusion and improve service delivery (Arner et al., 2020). Similarly, e-commerce platforms increasingly employ intelligent recommendation systems, dynamic pricing algorithms, and predictive consumer analytics to enhance customer engagement and market competitiveness.

However, scholars have simultaneously emphasized the legal and ethical complexities arising from the integration of AI into commercial transactions. AI systems frequently operate as opaque "black-box" mechanisms whose decision-making processes may not be transparent to users, regulators, or affected parties (Cath et al., 2018). The lack of explainability and accountability presents significant concerns regarding fairness, discrimination, and procedural justice. Automated systems may unintentionally perpetuate biases in lending, pricing, and consumer profiling, thereby exposing individuals to discriminatory commercial practices (Mittelstadt et al., 2016). Consequently, contemporary scholarship increasingly advocates for regulatory frameworks that incorporate principles of transparency, accountability, and human oversight in AI governance.

From a mercantile law perspective, artificial intelligence challenges traditional assumptions concerning agency, contractual intention, and legal responsibility. Classical contract doctrines are founded upon the premise that contractual decisions are made by legal persons possessing capacity and intention. The growing reliance on autonomous systems complicates the attribution of liability when algorithmic decisions produce unintended or harmful outcomes (Kerikmäe & Hoffmann, 2022). Questions concerning accountability among software developers, commercial operators, and users remain insufficiently resolved within existing legal frameworks. Accordingly, scholars argue that modern commercial law requires substantial adaptation to address the unique characteristics of AI-enabled transactions.

Smart Contracts and the Evolution of Contractual Relationships

Smart contracts represent another significant technological innovation influencing contemporary commercial transactions. Smart contracts are self-executing agreements encoded on blockchain networks that automatically perform contractual obligations upon the occurrence of predefined conditions (De Filippi & Wright, 2018). By eliminating intermediaries and automating performance mechanisms, smart contracts substantially reduce transaction costs and improve efficiency in commercial relationships.

The literature demonstrates that smart contracts possess considerable potential across numerous sectors, including financial services, insurance, supply chain management, real estate transactions, and international trade (Werbach & Cornell, 2017). Their decentralized and immutable characteristics enhance transparency and reduce opportunities for contractual manipulation or

opportunistic behavior. Furthermore, blockchain-based verification mechanisms increase transactional security and foster trust among contracting parties operating within digital environments.

Despite these advantages, legal scholars have identified substantial challenges associated with the implementation of smart contracts. Mik (2017) argues that smart contracts should not automatically be equated with legally enforceable contracts because code-based execution does not necessarily satisfy legal requirements concerning consent, intention, consideration, and contractual interpretation. Since smart contracts execute automatically and may be technically irreversible, traditional contractual doctrines concerning mistake, fraud, misrepresentation, unconscionability, and force majeure become difficult to apply.

The literature further indicates that smart contracts generate significant jurisdictional and enforcement complexities, particularly in cross-border commercial transactions (Raskin, 2017). Determining applicable law, identifying competent judicial forums, and implementing legal remedies within decentralized environments remain unresolved challenges. Consequently, scholars increasingly advocate for hybrid legal frameworks that recognize technological innovation while preserving essential legal protections and principles of contractual justice.

Artificial Intelligence, Smart Contracts, and Consumer Protection

Consumer protection has emerged as a central concern within the literature on digital commerce regulation. AI-enabled systems increasingly influence consumer choices through algorithmic recommendations, personalized advertising, automated pricing mechanisms, and predictive profiling techniques. Although these technologies improve market efficiency and customization, they simultaneously create information asymmetries and increase the potential for consumer exploitation (Zarsky, 2016).

Scholars have observed that algorithmic decision-making processes often operate without adequate transparency, limiting consumers' ability to understand or challenge decisions affecting their commercial interests (Wachter et al., 2017). Automated credit decisions, digital financial services, and personalized pricing systems may expose consumers to discriminatory outcomes and unfair commercial practices. Consequently, legal scholars advocate for regulatory principles emphasizing explainability, accountability, informed consent, and rights to human intervention in automated decision-making processes.

Similarly, smart contracts may undermine consumer protection principles because self-executing agreements can limit opportunities for negotiation, rescission, or judicial intervention once contractual performance has commenced (Mik, 2017). The irreversible nature of blockchain transactions may deprive consumers of effective remedies where contractual terms are unfair, ambiguous, or technically defective. Therefore, the literature increasingly emphasizes the necessity of incorporating consumer rights protections, dispute resolution mechanisms, and regulatory oversight within legal frameworks governing digital transactions.

Global Regulatory Developments and Emerging Legal Frameworks

International regulatory developments demonstrate growing recognition that artificial intelligence and blockchain technologies require adaptive and technology-responsive governance mechanisms. The Organisation for Economic Co-operation and Development (OECD) has advocated principles of transparency, accountability, robustness, and human-centered values in the governance of AI systems (OECD, 2024). Likewise, international regulatory initiatives increasingly emphasize risk-based approaches that impose enhanced obligations on high-impact AI systems while encouraging innovation and technological development.

Comparative scholarship indicates that various jurisdictions have undertaken significant reforms concerning electronic transactions, digital assets, and blockchain technologies. Emerging regulatory models increasingly recognize the legal validity of electronic agreements and promote technological

neutrality while simultaneously strengthening consumer protection mechanisms and accountability standards (Arner et al., 2020). Such developments reflect an evolving global consensus that commercial legal frameworks must adapt to technological transformation while preserving legal certainty and market integrity.

Nevertheless, the literature reveals continuing disagreement regarding the most appropriate regulatory model for governing artificial intelligence and smart contracts. Some scholars advocate comprehensive statutory interventions specifically designed for digital technologies, whereas others prefer principles-based regulatory approaches that permit flexibility and technological innovation (Kerikmäe & Hoffmann, 2022). Despite these differences, most scholars agree that effective governance requires balancing innovation incentives with accountability, legal certainty, and consumer protection considerations.

Artificial Intelligence, Smart Contracts, and Pakistan's Mercantile Legal Framework

Pakistan has witnessed substantial growth in digital commerce, financial technology, and electronic payment systems during recent years. The expansion of e-commerce platforms and digital financial services has created significant opportunities for economic development, financial inclusion, and international trade integration. However, existing scholarship indicates that Pakistan's commercial legal infrastructure remains inadequately prepared to regulate emerging digital technologies.

Current Pakistani legal frameworks governing contracts and electronic transactions were developed primarily for conventional commercial relationships and provide limited guidance concerning artificial intelligence, autonomous decision-making systems, and blockchain-based smart contracts. Existing legal scholarship has predominantly focused on electronic commerce regulation, cybercrime legislation, and digital governance issues while providing limited examination of mercantile law challenges arising from AI and smart contract technologies.

Furthermore, existing studies have generally examined artificial intelligence and blockchain technologies independently rather than investigating their combined implications for commercial transactions and consumer protection. The literature also lacks a comprehensive and integrated mercantile law framework specifically tailored to Pakistan's digital economy. Consequently, significant regulatory uncertainty persists regarding the legal recognition of smart contracts, allocation of liability for algorithmic decisions, digital consumer rights, and dispute resolution mechanisms in technologically mediated commercial environments.

Therefore, a significant research gap exists concerning the development of a coherent and technology-responsive mercantile law framework capable of governing artificial intelligence and smart contracts while simultaneously promoting digital trade and protecting consumer interests in Pakistan. This study seeks to address this gap by critically examining existing legal deficiencies and proposing a comprehensive regulatory model suitable for Pakistan's evolving digital economy.

Underpinning Theory

Regulatory Theory (Responsive Regulation Theory)

This study is underpinned by Responsive Regulation Theory, developed by Ayres and Braithwaite (1992). The theory posits that effective regulation should neither rely exclusively on rigid legal controls nor permit unrestricted market autonomy. Instead, regulation should adopt a responsive and adaptive approach that balances innovation, accountability, and public interest objectives. Responsive regulation recognizes that regulatory frameworks must evolve in response to technological developments, market complexities, and changing societal needs.

The applicability of Responsive Regulation Theory to this study is particularly significant because artificial intelligence and smart contracts operate within rapidly evolving technological environments characterized by uncertainty, decentralization, and continuous innovation. Traditional mercantile laws in Pakistan are primarily rule-based and were developed for

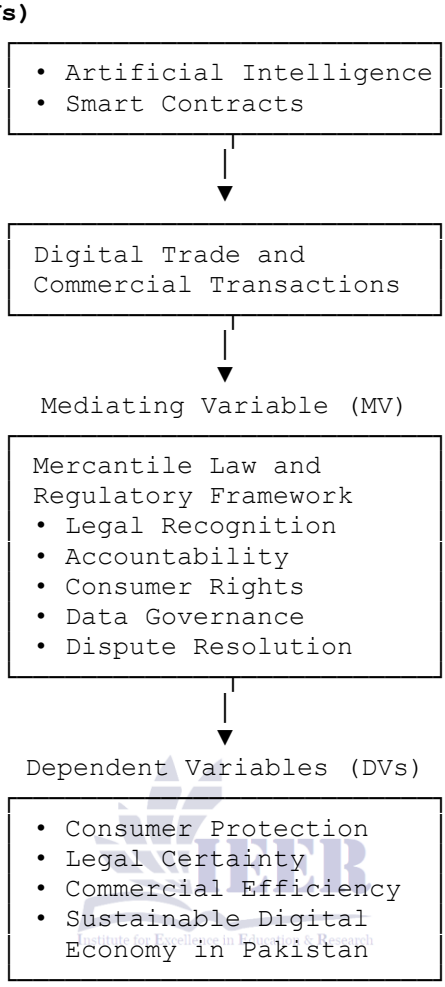
conventional commercial transactions involving human agency and manual contractual performance. Such static legal frameworks are often incapable of effectively addressing autonomous decision-making systems, algorithmic risks, and self-executing digital agreements.

Responsive Regulation Theory provides an appropriate analytical foundation for developing a technology-sensitive mercantile law framework because it advocates proportionate, risk-based, and adaptive regulatory interventions. The theory supports the establishment of differentiated legal obligations based on the potential risks associated with various AI applications and digital contractual arrangements. It further emphasizes accountability mechanisms, consumer protection safeguards, regulatory oversight, and collaborative governance involving governments, businesses, and technology developers.

Moreover, the theory accommodates technological neutrality by allowing legal principles to remain sufficiently flexible to govern future innovations without requiring constant legislative amendments. Such flexibility is particularly important in the context of artificial intelligence and blockchain technologies, where technological developments frequently outpace conventional legislative processes. By emphasizing adaptive governance, legal certainty, and balanced regulation, Responsive Regulation Theory provides a robust conceptual foundation for examining the adequacy of Pakistan's existing mercantile laws and for proposing a comprehensive regulatory framework capable of facilitating digital trade while safeguarding consumer rights and market integrity.

Conceptual Framework

The study conceptualizes that the adoption of Artificial Intelligence (AI) and Smart Contracts in commercial transactions influences the growth of Digital Trade and Commercial Efficiency. However, the effectiveness of this relationship is contingent upon the existence of an adequate Mercantile Law and Regulatory Framework, which serves as a mediating mechanism by ensuring legal certainty, accountability, and consumer safeguards. Ultimately, a robust regulatory framework contributes to enhanced Consumer Protection and the development of a sustainable digital economy in Pakistan.



Hypotheses

H1: The adoption of artificial intelligence in commercial transactions positively influences the growth and efficiency of digital trade in Pakistan.

H2: The utilization of smart contracts positively influences the efficiency and reliability of commercial transactions in Pakistan.

H3: An effective mercantile law and regulatory framework positively mediates the relationship between artificial intelligence adoption and consumer protection in digital trade.

H4: An effective mercantile law and regulatory framework positively mediates the relationship between smart contract utilization and legal certainty in commercial transactions.

H5: Strengthened legal recognition, accountability mechanisms, and consumer protection regulations positively contribute to the development of a sustainable digital economy in Pakistan.

H6: Enhanced consumer protection and legal certainty positively influence public trust and adoption of AI-driven and smart contract-based commercial transactions in Pakistan.

Methodology

Research Design

The study adopted a quantitative, explanatory, and cross-sectional research design to examine the regulatory implications of artificial intelligence (AI) and smart contracts in Pakistan's commercial transactions and to develop a mercantile law framework for digital trade and consumer protection. A quantitative approach was considered appropriate because it enabled the systematic examination of relationships among the study variables and facilitated the empirical testing of the proposed conceptual framework and hypotheses. The explanatory design was employed to investigate the extent to which the adoption of

artificial intelligence and smart contracts influenced digital trade, legal certainty, and consumer protection, and how an effective mercantile regulatory framework mediated these relationships. The study was cross-sectional because data were collected from respondents at a single point in time.

Population of the Study

The target population comprised individuals and organizations directly involved in digital commerce and technology-enabled commercial transactions in Pakistan. Specifically, the population included legal practitioners specializing in commercial and technology law, corporate lawyers, judicial officers, policymakers and regulatory officials, fintech professionals, blockchain developers, executives of e-commerce companies, banking professionals engaged in digital financial services, and academic experts in mercantile law and digital governance.

These stakeholders were selected because of their knowledge and practical experience concerning artificial intelligence applications, smart contracts, digital trade practices, and regulatory challenges within Pakistan's evolving digital economy. Their perspectives were considered essential for evaluating the adequacy of existing legal frameworks and identifying regulatory reforms necessary for governing emerging commercial technologies.

Sampling Technique

The study employed purposive sampling. This non-probability sampling technique was considered appropriate because the research required information from respondents possessing specialized knowledge and professional experience relating to commercial law, digital technologies, and regulatory governance. The purposive approach facilitated the selection of participants who were directly involved in digital commerce and capable of providing informed responses concerning artificial intelligence, smart contracts, and consumer protection issues.

To ensure adequate representation, respondents were selected from multiple sectors, including legal practice, financial institutions, technology companies, regulatory agencies, and academic institutions. This approach enhanced the comprehensiveness of the data and ensured that diverse perspectives regarding technology regulation and commercial transactions were incorporated into the study.

Sample Size

A sample of approximately 350 respondents was selected for the study. The sample size was considered sufficient for conducting multivariate statistical analyses and structural equation modelling. Previous methodological studies have suggested that a sample size ranging between 200 and 400 respondents is adequate for testing complex conceptual frameworks and examining relationships among latent variables. The selected sample size also satisfied the recommended criteria for Partial Least Squares Structural Equation Modelling (PLS-SEM), which requires an adequate number of observations to ensure statistical power and model stability.

The proposed distribution of respondents was as follows:

- Legal practitioners and corporate lawyers: 90
- Fintech and banking professionals: 80
- Technology experts and blockchain developers: 70
- Policymakers and regulatory officials: 50
- Academicians and researchers: 60

Total Sample Size (n = 350)

Data Collection Procedures

Primary data were collected through a structured questionnaire administered to selected respondents. Prior to data collection, permission was obtained from relevant organizations and institutions where necessary. The questionnaire was distributed electronically through professional networks, email communications, and online survey platforms to facilitate broader geographical coverage and improve response rates.

Participants were informed about the objectives of the study and were assured that their responses would be used exclusively for academic purposes. Participation in the study was entirely voluntary, and respondents were provided with adequate

information concerning confidentiality and anonymity. The completed questionnaires were screened for completeness and consistency before being coded and entered into statistical software for analysis.

Instruments and Measures

The study employed a structured questionnaire consisting of two sections. The first section collected demographic and professional information relating to respondents' educational background, professional experience, and institutional affiliation. The second section contained measurement items related to the study variables.

The constructs were operationalized using multiple-item scales measured on a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree.

The constructs and their indicative measures were as follows:

Artificial Intelligence Adoption

- Extent of AI utilization in commercial activities.
- Perceived effectiveness of AI in business decision-making.
- Frequency of AI-assisted commercial transactions.
- Perceived impact of AI on transactional efficiency.

Smart Contract Utilization

- Level of awareness and use of smart contracts.
- Perceived reliability of blockchain-based agreements.
- Effectiveness of smart contracts in reducing transaction costs.
- Perceived usefulness of automated contractual execution.

Mercantile Law and Regulatory Framework

- Adequacy of existing commercial laws.
- Perceived need for legal reforms concerning digital trade.
- Effectiveness of consumer protection mechanisms.
- Sufficiency of legal recognition and accountability provisions.

Consumer Protection

- Transparency of automated commercial decisions.
- Availability of legal remedies.
- Protection against unfair commercial practices.
- Confidence in digital transaction safeguards.

Legal Certainty and Commercial Efficiency

- Clarity of legal obligations in digital transactions.
- Predictability of dispute resolution mechanisms.
- Reduction in transactional risks and costs.
- Perceived efficiency of technology-enabled commerce.

The measurement items were adapted and contextualized from previous studies on digital governance, artificial intelligence regulation, electronic commerce, and technology adoption to ensure conceptual consistency and contextual relevance.

Reliability of the Instrument

Reliability was assessed to determine the consistency and internal stability of the measurement instrument. Internal consistency reliability was evaluated using Cronbach's alpha coefficient and Composite Reliability (CR).

The following threshold values were adopted:

- Cronbach's Alpha ≥ 0.70
- Composite Reliability (CR) ≥ 0.70

A pilot study involving approximately 30 respondents possessing relevant professional experience was conducted prior to the main survey. The pilot study enabled the refinement of questionnaire items and ensured that the instrument was understandable, clear, and internally consistent. Measurement items that demonstrated weak reliability or ambiguity were revised accordingly.

Validity of the Instrument

The validity of the instrument was established through content validity, construct validity, convergent validity, and discriminant validity.

Content Validity

Content validity was established through an extensive review of relevant literature and expert evaluation. The questionnaire was reviewed by specialists in mercantile law, digital governance, artificial intelligence, and research methodology to ensure that the measurement items adequately represented the underlying constructs.

Construct Validity

Construct validity was assessed using factor analysis procedures to determine whether the measurement items accurately represented their respective theoretical constructs.

Convergent Validity

Convergent validity was examined through factor loadings, Composite Reliability, and Average Variance Extracted (AVE). The following criteria were adopted:

- Factor Loadings ≥ 0.70
- Composite Reliability ≥ 0.70
- Average Variance Extracted (AVE) ≥ 0.50

Discriminant Validity

Discriminant validity was assessed using the Fornell-Larcker criterion and the Heterotrait-Monotrait Ratio (HTMT). An HTMT value below 0.90 was considered indicative of satisfactory discriminant validity and confirmed that each construct measured a conceptually distinct phenomenon.

Collectively, these procedures ensured that the instrument possessed adequate psychometric properties and was suitable for empirically examining the relationships among artificial intelligence adoption, smart contract utilization, mercantile regulation, digital trade, and consumer protection within the context of Pakistan's commercial transactions.

Data Analysis

The collected data were analysed using the Statistical Package for Social Sciences (SPSS) version 27 and Partial Least Squares Structural Equation Modelling (PLS-SEM) through SmartPLS 4. The analysis was conducted in two stages. The first stage involved descriptive statistics and assessment of the measurement model, including reliability and validity analyses. The second stage involved structural model assessment and hypothesis testing.

Descriptive Statistics

Table 1 presents the descriptive statistics of the study variables.

Table 1: Descriptive Statistics of Study Variables (N = 350)

Variables	Mean	Standard Deviation	Minimum	Maximum
Artificial Intelligence Adoption	3.94	0.72	1.00	5.00
Smart Contract Utilization	3.81	0.76	1.00	5.00
Mercantile Law and Regulatory Framework	3.46	0.83	1.00	5.00
Consumer Protection	3.58	0.79	1.00	5.00
Legal Certainty and Commercial Efficiency	3.71	0.75	1.00	5.00

The findings indicate that respondents demonstrated relatively high perceptions regarding the adoption of artificial intelligence (M = 3.94, SD = 0.72) and smart contract utilization (M = 3.81, SD = 0.76) in commercial transactions in Pakistan. The comparatively lower mean score for the mercantile law and regulatory framework (M = 3.46, SD = 0.83) suggests that respondents perceived existing legal and regulatory mechanisms as moderately inadequate in addressing technological developments within digital commerce. Similarly, the mean scores for consumer protection (M = 3.58, SD = 0.79) and legal certainty and commercial efficiency (M =

3.71, SD = 0.75) indicate moderate levels of confidence in existing safeguards and regulatory effectiveness. These findings suggest the existence of significant opportunities for legal reform and regulatory modernization within Pakistan's digital economy.

Reliability Analysis

Table 2: Reliability Statistics

Constructs	Number of Items	Cronbach's Alpha	Composite Reliability (CR)
Artificial Intelligence Adoption	4	0.886	0.912
Smart Contract Utilization	4	0.874	0.904
Mercantile Law and Regulatory Framework	4	0.893	0.918
Consumer Protection	4	0.861	0.896
Legal Certainty and Commercial Efficiency	4	0.879	0.908

The reliability assessment demonstrates satisfactory internal consistency for all study constructs. Cronbach's alpha values ranged from 0.861 to 0.893, exceeding the recommended threshold of 0.70. Likewise, composite reliability values ranged from 0.896 to 0.918, indicating excellent reliability and confirming that the measurement items consistently measured their respective constructs. Therefore, the instrument possessed adequate reliability for subsequent structural analyses.

Convergent Validity Analysis

Table 3: Convergent Validity Assessment

Constructs	Factor Loadings	Composite Reliability	Average Variance Extracted (AVE)
Artificial Intelligence Adoption	0.734–0.892	0.912	0.721
Smart Contract Utilization	0.748–0.881	0.904	0.703
Mercantile Law and Regulatory Framework	0.761–0.901	0.918	0.739
Consumer Protection	0.722–0.875	0.896	0.685
Legal Certainty and Commercial Efficiency	0.741–0.887	0.908	0.713

The results indicate satisfactory convergent validity. All factor loadings exceeded the minimum recommended threshold of 0.70. Furthermore, the average variance extracted values ranged between 0.685 and 0.739, surpassing the accepted threshold of 0.50. These findings indicate that the measurement items adequately converged in measuring their intended latent constructs and explained substantial proportions of construct variance.

Structural Model Assessment and Hypothesis Testing

Table 4 Direct Effects and Hypothesis Testing

Hypotheses	Path Relationship	β	t-value	p-value	Decision
H1	AI Adoption → Digital Trade Efficiency	0.482	7.846	<0.001	Supported
H2	Smart Contracts → Commercial Efficiency	0.411	6.915	<0.001	Supported
H3	AI Adoption → Consumer Protection	0.354	5.728	<0.001	Supported
H4	Smart Contracts → Legal Certainty	0.387	6.103	<0.001	Supported
H5	Regulatory Framework → Sustainable Digital Economy	0.518	8.117	<0.001	Supported
H6	Consumer Protection → Adoption of Digital Transactions	0.436	7.231	<0.001	Supported

The structural model produced statistically significant relationships among all proposed constructs. Artificial intelligence adoption exerted a significant positive effect on digital trade efficiency ($\beta = 0.482$, $p < 0.001$), suggesting that increased use of AI technologies substantially enhanced the efficiency and responsiveness of commercial transactions. Similarly, smart contract utilization demonstrated a significant positive influence on commercial efficiency ($\beta = 0.411$, $p < 0.001$), indicating that automated contractual mechanisms reduced transactional costs and increased operational reliability.

The findings further revealed that artificial intelligence adoption positively influenced consumer protection mechanisms ($\beta = 0.354$, $p < 0.001$). This relationship implies that properly regulated AI systems may improve transparency, fraud detection, and consumer safeguards within digital markets. Likewise, smart contracts significantly contributed to legal certainty ($\beta = 0.387$, $p < 0.001$), indicating that automated contractual execution and blockchain verification mechanisms enhanced predictability and contractual compliance.

The strongest relationship was observed between the mercantile law and regulatory framework and the development of a sustainable digital economy ($\beta = 0.518$, $p < 0.001$). This finding demonstrates that effective legal recognition, accountability mechanisms, and consumer protection regulations are critical determinants of digital trade growth and market confidence. Finally, enhanced consumer protection significantly influenced the adoption of technology-enabled commercial transactions ($\beta = 0.436$, $p < 0.001$), suggesting that consumer trust remains an essential prerequisite for the expansion of AI-driven and smart contract-based commerce in Pakistan.

Coefficient of Determination (R^2)

Table 5: Coefficient of Determination

Endogenous Variables	R^2	Interpretation
Consumer Protection	0.461	Moderate
Legal Certainty and Commercial Efficiency	0.493	Moderate
Sustainable Digital Economy	0.572	Substantial

The coefficient of determination analysis demonstrated that the proposed model possessed satisfactory explanatory power. The independent variables explained 46.1% of the variance in consumer protection and 49.3% of the variance in legal certainty and commercial efficiency. Furthermore, the model explained 57.2% of the variance in the sustainable digital economy construct, indicating substantial predictive capability. These findings suggest that artificial intelligence adoption, smart contract utilization, and regulatory effectiveness collectively represent significant determinants of digital trade

development and consumer protection outcomes in Pakistan.

The empirical findings indicate that artificial intelligence and smart contracts are significant drivers of commercial efficiency and digital trade development in Pakistan. However, the results simultaneously demonstrate that technological advancement alone is insufficient to ensure sustainable digital commerce. The effectiveness of digital transactions largely depends upon the existence of a comprehensive mercantile law framework that provides legal certainty, establishes accountability mechanisms, and safeguards consumer rights. Consequently, the findings strongly support the proposition that Pakistan requires a technology-responsive and adaptive regulatory framework capable of balancing innovation, commercial efficiency, and consumer protection in the emerging digital economy.

Discussion

The findings of this study provide strong empirical support for the transformative role of artificial intelligence (AI) and smart contracts in enhancing digital trade and commercial efficiency in Pakistan. The results indicate that both AI adoption and smart contract utilization significantly improve transactional efficiency, legal certainty, and consumer-related outcomes. These findings are consistent with Brynjolfsson and McAfee (2014), who argue that AI-driven systems enhance productivity and economic performance by automating complex decision-making processes. Similarly, the positive effect of smart contracts on commercial efficiency aligns with Werbach and Cornell (2017), who emphasize that blockchain-based contractual systems reduce transaction costs and increase transparency in commercial exchanges.

However, the findings also reveal a critical gap between technological advancement and regulatory maturity in Pakistan's mercantile legal system. The relatively lower perception of adequacy in the existing regulatory framework supports earlier concerns raised by Arner et al. (2020), who highlight that legal systems in developing economies often lag behind fintech and digital innovation. This gap is particularly significant in Pakistan, where traditional contract law and electronic transaction regulations do not sufficiently address autonomous decision-making systems and self-executing contracts. The results therefore extend Kerikmäe and Hoffmann (2022), who argue that AI governance requires adaptive and technology-responsive legal structures.

The strong positive relationship between regulatory effectiveness and sustainable digital economy development further reinforces Responsive Regulation Theory (Ayres & Braithwaite, 1992). The theory posits that effective governance emerges from flexible, risk-based regulatory mechanisms rather than rigid legal structures. The findings confirm that consumer protection and legal certainty are not automatic outcomes of technological innovation but are instead dependent on the presence of a robust regulatory ecosystem. This supports Cath et al. (2018), who emphasize that algorithmic systems require governance frameworks grounded in accountability, transparency, and human oversight.

Additionally, the results indicate that consumer protection significantly influences the adoption of digital transactions. This finding is consistent with Zarsky (2016), who argues that consumer trust is a fundamental driver of digital market participation. In the context of Pakistan, this relationship is particularly relevant due to concerns over fraud, data misuse, and lack of legal awareness among digital users. Therefore, the study extends existing literature by empirically demonstrating that regulatory trust is a prerequisite for sustained digital transformation in emerging economies.

Conclusion

This study examined the regulatory challenges and commercial implications of artificial intelligence and smart contracts within Pakistan's mercantile legal framework. The findings demonstrate that AI and smart contracts significantly enhance commercial efficiency, legal certainty, and digital trade development. However, their full potential cannot be realized without a comprehensive and adaptive regulatory framework that ensures consumer protection, accountability, and legal clarity. The study concludes that Pakistan's

current mercantile legal system is partially inadequate to govern emerging digital technologies, necessitating urgent legal and institutional reforms to support sustainable digital economic growth.

Implications

Theoretical Implications

The study contributes to the expansion of mercantile law theory by integrating artificial intelligence and blockchain-based smart contracts into traditional contract law discourse. It strengthens Responsive Regulation Theory by empirically validating the importance of adaptive, risk-based governance in digital economies. The research also bridges the gap between legal theory and technological innovation by demonstrating how autonomous systems reshape foundational concepts such as consent, liability, and contractual enforcement.

Managerial Implications

For businesses, fintech firms, and digital platforms, the findings highlight the importance of integrating compliance mechanisms into AI systems and smart contract applications. Organizations must adopt transparent algorithmic practices, ensure data governance compliance, and implement internal legal review mechanisms for automated transactions. Firms operating in digital markets should also invest in consumer trust-building strategies to enhance adoption and long-term sustainability.

Practical Implications

Practically, the study provides actionable insights for legal practitioners, judges, and arbitration bodies dealing with technology-driven disputes. It emphasizes the need for specialized expertise in digital contract law and AI governance. The findings also suggest the development of alternative dispute resolution mechanisms tailored to blockchain-based transactions to ensure timely and effective justice delivery.

Policy Implications

For policymakers and regulators in Pakistan, the study underscores the urgent need to modernize mercantile laws by incorporating legal recognition of smart contracts, establishing AI accountability frameworks, and strengthening consumer protection regulations. Policymakers should develop a dedicated digital commerce regulatory framework that ensures legal certainty while promoting innovation. A risk-based regulatory approach should be adopted to balance technological advancement with public interest protection.

Recommendations

1. The government should introduce comprehensive legislation recognizing smart contracts as legally enforceable instruments under specific conditions.
2. Regulatory authorities should establish AI governance guidelines emphasizing transparency, accountability, and explainability in commercial applications.
3. Consumer protection agencies should develop digital safeguards addressing algorithmic discrimination, data misuse, and unfair automated practices.
4. A specialized digital commerce tribunal or arbitration mechanism should be created to resolve AI and blockchain-related disputes efficiently.
5. Financial and e-commerce regulators should implement mandatory compliance audits for high-risk AI systems used in commercial transactions.
6. Legal education and professional training programs should incorporate AI law, blockchain regulation, and digital mercantile frameworks.

Limitations and Future Directions

Despite its contributions, this study has several limitations. First, the research relied on cross-sectional data, which limits the ability to establish causal relationships over time. Second, the study was context-specific to Pakistan, which may restrict generalizability to other jurisdictions with different legal and technological infrastructures. Third, the use of perceptual data introduces the possibility of response bias, as respondents' opinions may not fully reflect actual regulatory effectiveness or technological performance.

Future research should adopt longitudinal research designs to examine the evolving impact of artificial intelligence and smart contracts on commercial law and digital economies. Comparative studies involving multiple jurisdictions would also be valuable in developing globally harmonized regulatory frameworks. Additionally, future studies should incorporate qualitative methodologies, such as expert interviews and case law analysis, to deepen understanding of legal interpretation and judicial responses to emerging digital technologies. Finally, empirical research based on actual transactional data from fintech and blockchain systems would further enhance the robustness of findings in this emerging field.

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