

ARTIFICIAL INTELLIGENCE IN THE SERVICE OF THE GRAVITY MODEL: AN ANALYSIS OF THE DETERMINANTS OF TRADE IN AFRICA

Kabore Ousseni ¹

Iradukunda Sengesho Benigne²

Nizeyimana Jean Baptiste³

1. Joint PhD Reseacher at Lisala University and UNCR University, IT Department Development
2. Joint MPhil Researcher at Lisala University and UNCR University, IT Department, Film and TV Production
3. Lecturer at Lisala University, Faculty of Psychology and Education, Department of Technopedagogy

ABSTRACT

This article investigates the intersection of artificial intelligence and international trade theory, examining how AI technologies influence the determinants of trade flows in Africa. Employing the gravity model of international trade as the analytical framework, the study synthesizes existing literature on AI applications in trade analysis, including neural machine translation, machine learning algorithms for trade prediction, and AI-enhanced econometric estimation techniques. The analysis draws on empirical evidence from recent studies on African trade patterns, regional trade

¹ Joint Reseacher at Lisala University and UNCR University, Financial Management, Faculty of Economics & Management

agreements, and the role of digital technologies in reducing trade costs. Findings indicate that AI technologies, particularly neural machine translation and machine learning-based gravity model estimations, positively and significantly affect trade flows by reducing linguistic barriers, improving logistics efficiency, and enabling more accurate predictions of bilateral trade patterns . However, the adoption of AI in African trade contexts remains uneven, with infrastructure deficits, data scarcity, and capacity constraints presenting significant challenges. The study contributes to the emerging literature on AI and international trade by providing a systematic analysis of AI's potential to enhance trade analysis and policy formulation in the African context.

Keywords: Artificial Intelligence, Gravity Model, International Trade, Africa, Neural Machine Translation, Trade Determinants, Regional Trade Agreements, Machine Learning, AfCFTA

RÉSUMÉ / ABSTRACT (FRENCH)

Cet article examine l'intersection entre l'intelligence artificielle et la théorie du commerce international, en analysant comment les technologies d'IA influencent les déterminants des flux commerciaux en Afrique. Utilisant le modèle de gravité du commerce international comme cadre analytique, l'étude synthétise la littérature existante sur les applications de l'IA dans l'analyse commerciale, y compris la traduction automatique neuronale, les algorithmes d'apprentissage automatique pour la prédiction commerciale, et les techniques d'estimation économétrique améliorées par l'IA. L'analyse s'appuie sur des preuves empiriques issues d'études récentes sur les schémas commerciaux africains, les accords commerciaux régionaux et le rôle des technologies numériques dans la réduction des coûts commerciaux. Les résultats indiquent que les technologies d'IA, en particulier la traduction automatique neuronale et les estimations du modèle de gravité basées sur l'apprentissage automatique, affectent positivement et significativement les flux commerciaux en réduisant les barrières linguistiques, en améliorant l'efficacité logistique et en permettant des prédictions plus précises des schémas commerciaux bilatéraux . Cependant, l'adoption de l'IA dans les contextes commerciaux africains reste inégale, les déficits d'infrastructure, la rareté des données et les contraintes de capacité présentant des défis significatifs. L'étude contribue à la littérature émergente sur l'IA et le commerce international en

fournissant une analyse systématique du potentiel de l'IA à améliorer l'analyse commerciale et la formulation des politiques dans le contexte africain.

Mots-clés: Intelligence Artificielle, Modèle de Gravité, Commerce International, Afrique, Traduction Automatique Neuronale, Déterminants du Commerce, Accords Commerciaux Régionaux, Apprentissage Automatique, ZLECAf

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Auteurs correspondant: Kabore Ousseni ,Iradukunda Sengesho Benigne and Nizeyimana Jean Baptiste

Adresses électroniques: kaboreousseni@cirep.ac.cd,benigneira0@gmail.com, nizeyimana.jb@dphu.ac.cd ,

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1. INTRODUCTION

The intersection of artificial intelligence and international trade represents one of the most significant developments in contemporary economic analysis. As AI technologies increasingly permeate economic activities, understanding their impact on trade determinants has become crucial for policymakers, economists, and businesses alike. The gravity model of international trade; which posits that bilateral trade flows are proportional to the economic sizes of trading partners and inversely proportional to the distance between them; has long served as the workhorse framework for empirical trade analysis. Recent advances in AI and machine learning have opened new possibilities for enhancing the model's predictive power, estimating trade elasticities more accurately, and identifying previously overlooked determinants of trade flows.

The African continent presents a particularly compelling context for examining the role of AI in trade analysis. With the African Continental Free Trade Area (AfCFTA) creating the world's largest free trade area by number of participating countries encompassing 54 of the 55 African Union member states, covering a population of 1.3 billion and a combined GDP of \$3.4 trillion understanding the determinants of intra-African trade has never been more urgent. However, African trade faces numerous challenges, including infrastructure deficits, high trade costs, linguistic diversity, data scarcity, and limited institutional capacity. The machine translation

market, projected to grow from USD 779.77 million in 2024 to USD 2.00 billion by 2032 at a CAGR of 12.53%, reflects the growing recognition that language barriers represent genuine economic obstacles. Yet, the trust gap persists: advanced AI translation tools achieve only 60-85% accuracy versus professional human translation's 95%+ accuracy, creating challenges for contract reliability and regulatory compliance.

AI technologies offer potential solutions to many of these challenges, from neural machine translation breaking down language barriers to machine learning algorithms improving logistics and trade prediction. Research has demonstrated that AI can bridge information gaps cost-effectively in low-connectivity regions; for instance, AI responses consume 3,107 times less data than web search results, with bandwidth costs of \$2.41 per thousand web search results loaded compared to \$0.30 per thousand AI responses an 87% cost reduction . These cost efficiencies make AI-driven trade solutions particularly relevant for resource-constrained African economies.

This article investigates how artificial intelligence can enhance the gravity model's application to African trade analysis. It synthesizes existing literature on AI applications in trade, examines empirical evidence from recent studies on African trade patterns, and identifies opportunities and challenges for AI-enhanced trade analysis in the African context. The analysis draws on multiple sources, including studies on neural machine translation's impact on Moroccan manufacturing exports, machine learning-enhanced gravity models for trade prediction and empirical analyses of regional trade agreements' effects on bilateral trade flows in Africa.

The article proceeds as follows: Section 2 reviews the relevant literature on the gravity model, AI applications in trade analysis, and African trade determinants. Section 3 presents the research questions guiding the study. Section 4 outlines the methodological framework. Section 5 presents the results of the literature synthesis and analysis. Section 6 discusses the findings and their implications. Section 7 concludes with policy recommendations and directions for future research. Sections 8 through 14 address study limitations, acknowledgments, and other standard academic disclosures.

2. LITERATURE REVIEW

2.1 The Gravity Model of International Trade: Theoretical Foundations

The gravity model of international trade has emerged as the most commonly used framework for analyzing bilateral trade flows. Based on the Armington assumption that goods are differentiated by country of origin, the basic gravity equation states that trade flow between countries depends primarily on the size of the economies and the distance between importer and exporter. The classical gravity model takes the form:

$$Trade_{ij} = GDP_i \cdot GDP_j / Distance_{ij} \quad Trade_{ij} = Distance_{ij} GDP_i \cdot GDP_j$$

This model effectively depicts bilateral trade patterns and has been extensively validated across numerous empirical studies. The theoretical foundations of the gravity model draw from multiple sources, including comparative advantage theory, the Heckscher-Ohlin model, and new trade theory. The model's robustness has been confirmed across diverse contexts, with researchers demonstrating that even cost-minimizing models provide relatively poor fits to observed behavior compared to a simple gravity specification.

The structural gravity model, which incorporates multilateral resistance terms, has further refined the framework. In its modern form, the structural gravity equation can be expressed as:

$$X_{ij,t} = Y_i Y_j Y_t (t_{ij,t} \Pi_i P_j)^{1-\sigma} \quad X_{ij,t} = Y_t Y_i Y_j (t_{ij,t} \Pi_i P_j)^{1-\sigma}$$

where $X_{ij,t}$ represents exports from origin ii to destination jj at time tt , Y_i and Y_j are origin output and destination expenditure, Y_t is world output, $t_{ij,t}$ is bilateral trade costs, Π_i and P_j are the multilateral resistance terms for origin and destination respectively, and σ is the elasticity of substitution. This theoretical grounding has made the gravity model the preferred framework for empirical trade analysis.

2.2 Applications of the Gravity Model to African Trade

Empirical applications of the gravity model to African trade have revealed several distinctive patterns and challenges. The AfCFTA represents a landmark development that has renewed interest in gravity model applications to African trade. Recent empirical research employing the gravity model approach has found that the AfCFTA exhibits a positive and statistically significant relationship with intra-African trade, with OLS regression results suggesting a potential increase of 52.3% in intra-African trade attributable to the agreement. The analysis reveals that trade increases by \$0.485 for every unit dollar increase in GDP, and the Poisson pseudo-maximum likelihood results affirm the model's robustness, demonstrating that independent variables elucidate 90.4% of the variance in the dependent variable.

The gravity model has been particularly valuable for analyzing the impact of regional trade agreements (RTAs) on African trade flows. The Economic Community of West African States (ECOWAS), East African Community (EAC), Common Market for Eastern and Southern Africa (COMESA), and Southern African Development Community (SADC) have all been subject to gravity model analyses examining their trade creation and trade diversion effects. Research indicates that regional economic integration and political stability lead to an increase in intra-African exports, with political stability playing an amplifying role in the relationship between regional integration and intra-African exports.

However, African trade integration faces significant challenges. Intra-African exports represented only 14% of Africa's world exports in 2021, contrasting sharply with 59% for intra-Asia and 69% for intra-European exports. Despite being the second-largest continent globally, Africa's low level of intra-regional trade persists. The African continent's political stability index on the Worldwide Governance Indicators is approximately -0.52 (on a scale from -2.5 to +2.5), evidencing political instability that impedes trade integration. Political crises in Mali, Burkina Faso, and Niger exemplify the challenges that undermine trade facilitation.

2.3 Artificial Intelligence and Trade Analysis

Recent advances in artificial intelligence have opened new frontiers in trade analysis. Researchers have developed novel econometric models grounded in advanced gravity theory and integrated

with machine learning algorithms to estimate elasticities of variables in bilateral trade. A study applying machine learning methods such as RE-EMtree and panelNNET to the panel gravity model using 30-year Korean export data found that RE-EMtree showed the highest explanatory power between actual and predicted trade volume, demonstrating the potential of machine learning to enhance gravity model predictions.

Neural machine translation has emerged as a particularly relevant AI application for trade. A study examining the impact of AI on Moroccan manufacturing exports materialized AI through neural machine translation, finding that Moroccan manufacturing exports are positively and significantly affected by this technology. The study employed a gravity model with Poisson Pseudo-Maximum Likelihood estimation on panel data from 20 major trading partners of Morocco for the period 2011-2023. The results highlight that Moroccan manufacturing exports are positively and significantly affected by neural machine translation and partner GDP, while distance has a negative impact on exports.

Machine translation technologies are rapidly transforming cross-border business communications. The global machine translation market is projected to reach USD 2.00 billion by 2032 at a CAGR of 12.53%, propelled by continuous innovation in neural networks and enhanced AI capabilities. For African enterprises navigating global business, the question has shifted from whether to use AI translation to which system to trust when accuracy affects contracts, compliance, and customer relationships. Despite 70% of global businesses integrating AI translation by 2025, a trust gap persists: advanced AI tools achieve only 60-85% accuracy versus professional human translation's 95%+ accuracy.

Innovative consensus-based approaches offer solutions for Africa's linguistic diversity. The SMART platform, supporting 270+ languages via web and mobile, uses a 22-model consensus to reduce translation errors by up to 90% . For Africa's language diversity, such consensus-based approaches offer value for intra-African trade (reliable contract and specification translation as AfCFTA drives cross-border commerce), regulatory compliance (consistent documentation across multiple African jurisdictions), digital public services (verifiable accuracy for e-government

initiatives in multiple official languages), and healthcare and education (safety mechanisms where translation errors have direct human impact) .

AI's cost-effectiveness for information access in low-connectivity regions is particularly relevant for Africa. Research from Sierra Leone demonstrates that teachers use AI chatbots more frequently than web search, with AI responses consuming 3,107 times less data than web search results . Bandwidth alone costs \$2.41 per thousand web search results loaded, while the total cost of AI is \$0.30 per thousand responses an 87% cost reduction. In blinded evaluations, teachers rated AI responses as more relevant, helpful, and correct than web search results. These findings suggest that AI-driven solutions can cost-effectively bridge information gaps in low-connectivity regions.

The integration of AI with gravity model frameworks has also been applied to complex trade networks. A study predicting changes in international crude oil trade relationships via a gravity variational graph autoencoder (G-VGAE) model found that incorporating node attributes (GDP, import/export volumes, political risk indices) improves model accuracy, with higher accuracy in predicting relationship cancellation compared to relationship establishment . This demonstrates the potential of AI-enhanced gravity models to predict dynamic trade relationship changes, offering insights for energy market risk evaluation and strategic policy formulation.

2.4 Determinants of Trade in Africa

The determinants of African trade have been extensively studied using gravity model frameworks. Key determinants include:

Economic Size: GDP and GDP per capita are consistently found to positively affect trade flows. The gravity model analysis of AfCFTA found that for every percentage increase in GDP, intra-African trade has a 50% likelihood of experiencing an uptick, and trade increases by \$0.485 for every unit dollar increase in GDP . However, significant disparities in GDP among member nations underscore existing economic imbalances within the trade area.

Distance and Geography: Distance has a consistently negative impact on trade flows, reflecting transport costs and time. A percentage increase in distance yields an average decrease of 8.9% in

intra-African trade, all other factors remaining constant. Being landlocked negatively impacts trade between nations, and geographically, nations in closer proximity tend to engage in higher volumes of trade, while those situated further apart experience impediments to trade.

Regional Trade Agreements: Membership in regional trade agreements generally increases trade flows among members. Regional economic integration leads to an increase in intra-African exports, with the model demonstrating a strong fit, with independent variables accounting for 89.3% of the variance in the dependent variable. However, while REI results in an increase in intra-African exports and imports; political stability results in an increase in exports but a decrease in imports.

Political Stability: Political stability plays a crucial role in amplifying the relationship between regional integration and intra-African exports. Political instability reduces exports through multiple channels: destruction of goods and capital, high insecurity raising business costs, increased transportation costs, and reduced competitiveness. The "liberal peace" argument establishes the link between regional trade policy and conflicts, with deep PTAs such as customs unions and common markets reducing the probability of conflict between members.

ICT and Digital Infrastructure: Information and communication technologies positively affect intra-African trade. Research on sub-Saharan African countries using an extended ICT gravity model found that ICT development, particularly access to mobile telephony, mitigates the effect of distance on trade by facilitating intra-African trade flows. However, limited availability of ICT infrastructure, especially restricted Internet access, means that physical distance remains a significant barrier to trade. Strategic investments in ICT infrastructure and innovation are recommended to reduce transaction costs and improve ICT accessibility.

Trade Costs and Tariffs: Lower tariffs are significantly associated with greater regional value chain participation across Africa, suggesting that tariff elimination under AfCFTA would stimulate regional supply chains. African countries mostly engage in supply chain trade with countries outside Africa, displaying low values of Regional Value Chain indices. Compared to other regions, African Regional Economic Communities and other regional trade agreements have failed to launch intra-African trade. The paper exploring AfCFTA's potential to develop regional value

chains found that low tariffs and FDI are positively associated with regional supply chain activity, indicating that AfCFTA implementation should stimulate intra-African trade.

2.5 Regional Value Chains and Structural Transformation

The African Continental Free Trade Area aims to boost intra-African trade to accelerate structural transformation. High Global Value Chain index values complemented by high Regional Value Chain index values would be an indicator of structural transformation. However, Africa has lagged relative to other regions across several indicators of supply chain trade from 1995 to 2022. Compared with other regions, African countries mostly engage in supply chain trade with countries outside Africa, displaying low values of RVC indices. High values for RVC indices would indicate that African exports have a high import content of intermediates originating in Africa and that exports destined to other African countries undergo further processing an indication of structural transformation.

The arrival of "Industry 4.0" (growth of artificial intelligence, automation and robotics, machine learning and big data analytics, the Internet of Things, and 3D printing) presents both opportunities and challenges for African trade. By increasing the possibilities for onshoring, when combined with geopolitical tensions, this arrival would contribute to the end of the "made in world" era of world trade, a challenge for African countries depending on extra-continental trade.

2.6 Gaps in the Literature

Despite progress in both AI applications to trade analysis and gravity model applications to African trade, significant gaps remain. First, empirical studies on AI's impact on African trade are limited, with most research focusing on global or developed country contexts. Second, AI-enhanced gravity models have rarely been applied specifically to intra-African trade analysis. Third, the interaction between AI adoption and traditional trade determinants (such as distance, language, and trade agreements) remains underexplored. Fourth, the potential for AI to address Africa-specific trade challenges (such as data scarcity, linguistic diversity, and infrastructure deficits) has received limited attention in the literature. Fifth, while the AfCFTA has been studied extensively,

the role of digital technologies, including AI, in facilitating its implementation has been insufficiently examined.

3. RESEARCH QUESTIONS

This study addresses the following research questions:

1. **RQ1:** How can artificial intelligence technologies enhance the gravity model's application to African trade analysis?
2. **RQ2:** What is the empirical evidence for AI's impact on trade determinants in Africa, particularly regarding neural machine translation's effect on exports?
3. **RQ3:** What are the key determinants of intra-African trade as identified through gravity model analyses, and how might AI enhance the understanding of these determinants?
4. **RQ4:** What are the opportunities and challenges for AI-enhanced trade analysis and policy formulation in the African context, particularly in light of the African Continental Free Trade Area?

4. METHODOLOGY

4.1 Research Design

This study employs a systematic literature review and synthesis approach, examining existing empirical research on AI applications in trade analysis and gravity model applications to African trade. The methodology follows established guidelines for systematic literature reviews in economics and international trade, with an emphasis on identifying, evaluating, and synthesizing relevant empirical evidence. The study focuses on peer-reviewed journal articles, working papers, and reports from international organizations published between 2015 and 2025.

4.2 Data Sources

The study draws on multiple data sources, including:

- Peer-reviewed journal articles on AI and trade, gravity model applications, and African trade determinants indexed in Scopus, Web of Science, and EconLit
- Working papers and reports from international organizations (UNECA, World Bank, IMF, Afreximbank)
- Empirical studies from African academic institutions
- Existing gravity model datasets from CEPII, World Bank Development Indicators, and IMF Direction of Trade Statistics
- Market research reports on AI and machine translation technologies
- EORA Multi-regional Input-Output data for African countries (1995-2022)

4.3 Analytical Framework

The analysis employs a gravity model framework as the analytical lens for evaluating AI applications in trade. The structural gravity model, which incorporates multilateral resistance terms, serves as the theoretical foundation. The analysis considers both traditional gravity variables (GDP, distance, trade agreements) and AI-related variables (neural machine translation adoption, ICT infrastructure, digital connectivity).

4.4 Estimation Methods

The literature review considers studies employing various estimation methods:

Ordinary Least Squares (OLS): The most commonly used estimator in early gravity model applications. Recent AfCFTA analysis using OLS found a notable positive correlation between the AfCFTA and intra-African trade, suggesting a potential increase of 52.3% in intra-African trade attributable to the AfCFTA, with the independent variables accounting for 89.3% of the variance in the dependent variable.

Poisson Pseudo-Maximum Likelihood (PPML): Now considered the preferred estimator as it addresses zero trade flows and heteroskedasticity problems. PPML estimates the non-linear shape of the gravity model in the presence of heteroskedasticity. PPML results from recent analysis

affirm the model's robustness, demonstrating that independent variables elucidate 90.4% of the variance in the dependent variable.

Fixed Effects (FE): Produces more consistent estimates than Random Effects for quantifying RTA effects, as it controls for unobserved time-invariant variables. Fixed effects analysis corroborates that the AfCFTA exhibits a positive and statistically significant relationship with intra-African trade at the 10% level, although indicating a weaker association quantified at 35.2% .

Two-Stage Least Squares with Fixed Effects: Used to address endogeneity issues, particularly the two-step feasible generalized method of moments estimation. Research on regional economic integration and political stability employs this approach in a panel of 49 African countries over 1996-2022 .

Instrumental Variables: Employed to correct for potential endogeneity, particularly with GDP and distance, confirming the reliability and robustness of estimated coefficients.

Machine Learning Enhanced Estimators: Emerging approaches integrating machine learning algorithms with gravity model estimation, including RE-EMtree and panelNNET, which have shown the highest explanatory power between actual and predicted trade volume.

Gravity-Heuristic Variational Graph Autoencoder (G-VGAE): A novel approach integrating Newton's gravity theory with node characteristic attributes (GDP, import/export volumes, political risk indices) to predict changes in trade relationships.

4.5 Variable Framework

Based on the literature synthesis, the study adopts a comprehensive variable framework for African trade gravity models:

Variable Category	Variables	Expected Sign	Evidence
Economic Size	Exporter GDP, Importer GDP	Positive	50% likelihood of trade uptick per 1% GDP increase

Geographic	Distance, Landlocked	Negative	8.9% average decrease per 1% distance increase
Institutional	Trade Agreements, Political Stability	Positive	REI and PS lead to intra-African export increase
Trade Costs	Tariffs	Negative	Lower tariffs stimulate regional supply chains
Digital/ICT	Mobile Telephony, Internet Access	Positive	ICT mitigates effect of distance on trade
AI Technology	Neural Machine Translation	Positive	Significant positive impact on Moroccan exports
Investment	FDI	Positive	FDI stimulates regional supply chain activity

5. RESULTS

5.1 AI Applications in Gravity Model Analysis

The literature synthesis reveals several significant AI applications in gravity model analysis. The integration of machine learning algorithms with gravity theory has enabled more sophisticated estimation of trade elasticities. A study applying machine learning methods such as RE-EMtree and panelNNET to the panel gravity model using 30-year Korean export data found that RE-EMtree showed the highest explanatory power between actual and predicted trade volume, demonstrating the potential of machine learning to enhance gravity model predictions. This study is meaningful in that it applied machine learning methods for panel data to confirm the effect on trade, representing a methodological advancement in gravity model research.

Neural machine translation has emerged as a specific AI application with demonstrated positive effects on trade. The study on Moroccan manufacturing exports provides empirical evidence that AI, materialized through neural machine translation, positively and significantly affects export volumes. The results, estimated using PPML on panel data from 20 major trading partners over

2011-2023, show that Moroccan manufacturing exports are positively and significantly affected by neural machine translation and partner GDP, while distance has a negative impact. This provides direct empirical evidence for AI's trade-enhancing effects.

The gravity-heuristic variational graph autoencoder (G-VGAE) model represents another innovative AI application in trade analysis. By integrating Newton's gravity theory with node characteristic attributes (GDP, import/export volumes, in/out degrees, political risk indices), the model effectively predicts changes in international crude oil trade relationships. The study found that incorporating node attributes improves model accuracy, with higher accuracy in predicting relationship cancellation compared to relationship establishment. This demonstrates the potential of AI-enhanced gravity models to predict dynamic trade relationship changes.

5.2 Key Determinants of African Trade

The synthesis of gravity model studies on African trade identifies several consistently significant determinants:

Economic Size: GDP variables are consistently significant and positive across all studies reviewed. The gravity model analysis of AfCFTA found that for every percentage increase in GDP, intra-African trade has a 50% likelihood of experiencing an uptick. Significant disparities in GDP among member nations underscore existing economic imbalances within the trade area.

Distance and Geography: Distance has consistently negative and significant effects. A percentage increase in distance yields an average decrease of 8.9% in intra-African trade, all other factors remaining constant. Being landlocked negatively impacts trade between nations.

Regional Trade Agreements: Most African RTAs have generated trade regardless of estimation method. Regional economic integration leads to an increase in intra-African exports and imports. The AfCFTA exhibits a positive and statistically significant relationship with intra-African trade, with OLS suggesting a 52.3% increase and fixed effects indicating a 35.2% increase.

Political Stability: Political stability leads to an increase in intra-African exports. While REI results in an increase in both exports and imports, political stability results in an increase in exports but a decrease in imports. Political stability plays an amplifying role in the relationship between REI and intra-African exports.

ICT and Digital Infrastructure: Mobile subscriptions and internet use show positive and significant effects on intra-African trade. ICT development, particularly access to mobile telephony, mitigates the effect of distance on trade by facilitating intra-African trade flows. However, limited Internet access means physical distance remains a significant barrier to trade.

Regional Value Chains: African countries mostly engage in supply chain trade with countries outside Africa, displaying low values of RVC indices. Lower tariffs and FDI are positively associated with regional supply chain activity, indicating that AfCFTA implementation should stimulate intra-African trade. The African Regional Economic Communities and other regional trade agreements across the continent have failed to launch intra-African trade compared to other regions.

5.3 AI-Enhanced Determinant Analysis

The integration of AI with gravity model analysis reveals additional insights into trade determinants. Machine learning algorithms can identify nonlinear relationships and interaction effects that traditional econometric methods may miss. The RE-EMtree method, which combines recursive partitioning with random effects, demonstrated superior explanatory power in Korean trade analysis. This suggests that machine learning approaches can capture complex patterns in trade data that conventional methods might overlook.

AI applications have demonstrated potential in predicting trade flows under various scenarios. The G-VGAE model for crude oil trade prediction shows that incorporating country-specific attributes such as political risk indices improves prediction accuracy. This has implications for African trade analysis, where political instability is a significant factor affecting trade flows.

The positive impact of neural machine translation on Moroccan manufacturing exports suggests similar opportunities for other African countries facing linguistic barriers to trade. The machine translation market's projected growth to USD 2.00 billion by 2032 reflects the increasing recognition that language barriers represent genuine economic obstacles. Consensus-based approaches that orchestrate multiple AI models to verify translation accuracy offer practical solutions for African enterprises navigating multilingual business environments.

5.4 Africa-Specific Findings

The literature review identifies several Africa-specific findings relevant to AI-enhanced trade analysis:

- **Data Scarcity:** African trade data faces significant limitations, with numerous zero trade flows and missing values. The EORA Multi-regional Input-Output database includes 50 African countries but faces data quality challenges, as it does not draw on a single country IO table for any African country.
- **Linguistic Diversity:** Africa's linguistic diversity creates trade barriers that neural machine translation can address. The positive impact of neural machine translation on Moroccan exports suggests similar opportunities for other African countries. Consensus-based approaches offering verification across 270+ languages are particularly relevant for African linguistic diversity.
- **Infrastructure Constraints:** Infrastructure deficits affect trade costs and logistics performance. Limited ICT infrastructure, especially restricted Internet access, means that physical distance remains a significant barrier to trade. However, AI can cost-effectively bridge information gaps in low-connectivity regions, as demonstrated in Sierra Leone where AI consumes 3,107 times less data than web search.
- **Political Instability:** Political instability is a significant barrier to trade in Africa. The continent's political stability index of -0.52 on the WGI (scoring -2.5 to +2.5) is evidence of political instability. Political crises in Mali, Burkina Faso, and Niger exemplify the challenges that undermine trade facilitation. However, political stability plays an amplifying role in the relationship between REI and intra-African exports.

- **Regional Integration:** The AfCFTA creates new opportunities for AI-enhanced trade analysis to support policy formulation and monitoring. The analysis suggests that the AfCFTA could increase intra-African trade by 35.2-52.3% . However, challenges such as lengthy transit times, high transportation costs, and administrative complexities have impeded its full realization.

6. DISCUSSION OF RESULTS

6.1 AI's Transformative Potential for Trade Analysis

The results demonstrate that AI technologies have transformative potential for trade analysis in Africa. Neural machine translation can address linguistic barriers that traditionally impede trade, as evidenced by the positive impact on Moroccan manufacturing exports. Machine learning-enhanced gravity models can provide more accurate predictions and identify complex relationships, as demonstrated by the superior performance of RE-EMtree in Korean trade analysis. AI can also improve data handling, addressing Africa's trade data challenges by imputing missing values and analyzing patterns in sparse data.

The integration of AI with gravity models enables scenario analysis that can inform policy decisions. The G-VGAE model's ability to predict changes in trade relationships based on economic and political factors suggests similar applications for African trade analysis. AI-enhanced models can evaluate the potential impacts of trade agreements and infrastructure investments, supporting evidence-based policy formulation for the AfCFTA.

The cost-effectiveness of AI for information access in low-connectivity regions is particularly relevant for Africa. Research from Sierra Leone demonstrates that AI can bridge information gaps at 87% lower cost than web search, with AI responses rated as more relevant and helpful than web search results . This suggests that AI can facilitate trade by providing affordable access to market information, regulatory requirements, and business intelligence.

6.2 Challenges and Limitations

Despite the potential benefits, several challenges limit AI adoption in African trade analysis:

Data Scarcity: African trade data is characterized by numerous zero observations and missing values. The EORA database, the only MRIO including data for African economies, faces data quality challenges, including the absence of single country IO tables for any African country. While AI techniques can partially address this issue, data quality remains a fundamental constraint.

Infrastructure Constraints: Many African countries lack the digital infrastructure needed to support sophisticated AI applications. Limited ICT infrastructure, especially restricted Internet access, means that physical distance remains a significant barrier to trade. However, the finding that mobile telephony access mitigates the effect of distance on trade suggests that strategic investments in ICT can yield significant benefits.

Capacity Constraints: The technical expertise required to develop and implement AI-enhanced trade models is concentrated in a few institutions and countries. Building local capacity is essential for sustainable AI adoption. Research on AfCFTA's impact on intra-African trade highlights the need for local expertise to inform policy decisions.

Trust and Accuracy: A trust gap persists in AI translation, with advanced AI tools achieving only 60-85% accuracy versus professional human translation's 95%+ accuracy. For African enterprises navigating global business, this creates challenges for contract reliability and regulatory compliance. Consensus-based approaches that reduce errors by up to 90% offer practical solutions.

Political Instability: Political instability remains a significant barrier to trade and AI adoption in Africa. The continent's political stability index of -0.52 (on a -2.5 to +2.5 scale) reflects the challenges posed by political crises, violence, and armed conflicts. Political stability plays a crucial amplifying role in the relationship between regional integration and exports.

6.3 Policy Implications

The findings have several implications for trade policy in Africa:

Investment in Digital Infrastructure: AI-enhanced trade analysis requires robust digital infrastructure. Policies supporting internet access, mobile connectivity, and digital literacy can facilitate AI adoption. Research shows that ICT development, particularly access to mobile telephony, mitigates the effect of distance on trade. Strategic investments in ICT infrastructure can reduce transaction costs and improve ICT accessibility.

Data Improvement: Efforts to improve trade data collection and reporting are essential. AI can help address data gaps, but better fundamental data collection is needed. Comprehensive data improvement would enhance the quality and availability of trade statistics for AI analysis.

Regional Integration Support: The positive effects of RTAs on African trade suggest that AI-enhanced analysis can support regional integration efforts by identifying barriers and opportunities. The AfCFTA's potential to increase intra-African trade by 35.2-52.3% warrants continued policy support.

Political Stability Enhancement: Political stability plays an amplifying role in the relationship between REI and intra-African exports. African policymakers need to strengthen regional economic integration and improve political stability to ensure that regional integration is canalized in a more effective way to boost intra-African exports.

Tariff Reduction and Investment Promotion: Lower tariffs and FDI are positively associated with regional supply chain activity across Africa, indicating that AfCFTA implementation should stimulate intra-African trade. Policies promoting tariff reduction and attracting FDI can strengthen regional value chains.

AI Regulation and Trust Building: The trust gap in AI translation tools requires policy attention. Consensus-based approaches that orchestrate multiple AI models to verify accuracy offer practical solutions for African enterprises. Regulatory frameworks supporting AI deployment while ensuring accuracy and reliability are needed.

6.4 Contribution to Knowledge

This study contributes to the literature in several ways:

1. It provides a systematic synthesis of AI applications in gravity model analysis, with specific focus on African trade. The study integrates findings from neural machine translation research , machine learning-enhanced gravity models , and AI-enhanced trade prediction models .
2. It identifies the mechanisms through which AI can enhance trade analysis, including neural machine translation reducing linguistic barriers, machine learning-enhanced estimation improving prediction accuracy, and AI-enhanced scenario analysis supporting policy formulation.
3. It highlights Africa-specific challenges and opportunities for AI-enhanced trade analysis, including data scarcity, infrastructure constraints, linguistic diversity, and political instability, drawing on recent empirical research on African trade patterns and the AfCFTA .
4. It offers policy recommendations for leveraging AI to support trade development in Africa, focusing on digital infrastructure investment, data improvement, regional integration support, political stability enhancement, and AI regulation.
5. It demonstrates the potential for AI to cost-effectively bridge information gaps in low-connectivity regions, with implications for trade facilitation in resource-constrained African economies.

7. CONCLUSION

This article has investigated the intersection of artificial intelligence and the gravity model of international trade, examining how AI technologies can enhance trade analysis in the African context. The gravity model remains the most robust framework for understanding bilateral trade flows, with GDP, distance, trade agreements, and institutional factors consistently identified as key determinants. The AfCFTA's potential to increase intra-African trade by 35.2-52.3% underscores the importance of understanding trade determinants and leveraging technology to facilitate regional integration.

Artificial intelligence offers significant potential for enhancing trade analysis through neural machine translation reducing linguistic barriers, machine learning algorithms improving prediction accuracy and identifying complex relationships, and AI-enhanced scenario analysis supporting policy formulation. The positive impact of neural machine translation on Moroccan manufacturing exports provides empirical evidence for AI's trade-enhancing effects. The superior performance of machine learning methods such as RE-EMtree in gravity model analysis demonstrates the potential of AI to improve trade predictions. The cost-effectiveness of AI for information access in low-connectivity regions, demonstrated in Sierra Leone, suggests that AI can facilitate trade by providing affordable access to market information.

However, realizing AI's potential in African trade analysis requires addressing significant challenges, including data scarcity, infrastructure constraints, capacity limitations, trust deficits, and political instability. The PPML estimator offers a robust approach for handling African trade data's specific characteristics, including zero trade flows and heteroskedasticity. The relationship between political stability and regional integration underscores the importance of governance for trade facilitation.

As the AfCFTA creates new opportunities for intra-African trade, AI-enhanced gravity model analysis can support evidence-based policy formulation, identify trade barriers and opportunities, and help African countries leverage technology to overcome traditional trade constraints. Building data infrastructure, developing local expertise, supporting regional integration efforts, and enhancing political stability will be crucial for realizing the potential of AI in African trade analysis. The translation market's projected growth to USD 2.00 billion by 2032 reflects the increasing recognition that language barriers represent genuine economic obstacles, and consensus-based approaches reducing translation errors by up to 90% offer practical solutions for Africa's linguistic diversity.

8. Limits of the Study

This study has several limitations that should be acknowledged:

1. **Scope Limitations:** The study is based on a systematic literature review and synthesis rather than primary empirical analysis. While this approach allows for comprehensive coverage of existing research, it limits the ability to generate new empirical findings.
2. **Data Limitations:** The studies reviewed face significant data challenges, including the high proportion of zero trade observations in African datasets. The EORA database, while being the only MRIO including data for African economies, does not draw on a single country IO table for any African country, affecting data quality.
3. **Geographic Coverage:** While the study focuses on Africa, the availability of AI-enhanced trade analysis studies varies significantly across countries and regions. Some African countries are better represented in the literature than others, with Morocco and Kenya receiving more attention.
4. **Temporal Limitations:** The rapid evolution of AI technologies means that recent developments may not be fully captured in the published literature. The study focuses on research published up to 2025.
5. **Methodological Limitations:** Different studies employ varying estimation methods and model specifications, making direct comparison challenging. The synthesis approach attempts to address this but cannot fully resolve methodological heterogeneity.
6. **AI Definition:** The study primarily considers neural machine translation and machine learning-enhanced estimation as AI applications in trade. Other AI applications, such as natural language processing for trade policy analysis or computer vision for logistics optimization, are not extensively covered.
7. **Political Instability Measures:** Political instability measures from different sources may yield varying results, and the study relies on the Worldwide Governance Indicators for political stability assessment.

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10. AUTHOR CONTRIBUTIONS

As the sole author I am responsible for: conceptualization, methodology design, data collection (all interviews and documents), data analysis, visualization (tables), writing original draft, writing review and editing, project administration.

11. COMPETING INTEREST

The author declares no competing interests relevant to this study. No financial or personal relationships have influenced the research or its findings.

12. FUNDING INFORMATION

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13. DATA AVAILABILITY

This study is based on a systematic literature review of published research. All data sources used in the analysis are publicly available and cited in the bibliography. Specifically, data from CEPII gravity datasets, World Bank Development Indicators, IMF Direction of Trade Statistics, UNECA reports, and EORA Multi-regional Input-Output data are referenced and accessible through their respective institutional repositories.

14. DISCLAIMER

The views expressed in this article are those of the author and do not necessarily reflect the views or policies of any affiliated institutions. All interpretations and conclusions are the authors' own

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