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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON REGULATORY FRAMEWORKS GOVERNING CHINA–AFRICA TRADE, AND THE (MIS)ALIGNMENT INTRODUCED BY HIMALAYAN TRADE-ROUTE CHALLENGES

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ABSTRACT

The rapid evolution of artificial intelligence (AI) is reshaping the regulatory and material foundations of international trade, with significant implications for China–Africa economic relations. This article argues that the emerging AI trade nexus can only be understood through the joint analysis of fragmented multi-level governance and contested physical geography. It examines how the dual-use nature of AI—covering hardware, software, and data-driven services—challenges traditional export control regimes and intersects with data governance frameworks amid intensifying US–China technological rivalry and Africa's pursuit of digital sovereignty. Moving beyond policy-centred approaches, the paper shows how material geography mediates digital trade flows. Using the Himalayan region as an illustrative case, it demonstrates how geopolitical tensions, infrastructure constraints, and logistical bottlenecks indirectly reroute China–Africa AI supply chains, shaping enforcement capacity and vulnerabilities to regulatory circumvention. The article concludes by proposing integrated policy responses emphasizing multilateral cooperation, regulatory harmonisation, and export-control modernisation.

Keywords: *Artificial Intelligence, China, Africa, Himalayan Trade, Trade Challenge.*
Jel Codes: *F13, F52, O33, F63.*

1. INTRODUCTION

Artificial Intelligence has evolved from a specialized field of computer science into a central, transformative technology underpinning global commerce, with profound and direct implications for the structure of international trade. This influence manifests across three interconnected streams: trade in goods, such as the advanced hardware (e.g., GPU accelerators, specialized semiconductors, and

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servers) required to train and run AI systems; trade in services, including cloud computing platforms and API-access to proprietary large language models; and the cross-border data flows that fuel algorithmic learning and service delivery. The global race for AI supremacy is, therefore, not merely a competition for algorithmic innovation but a complex struggle over supply chain security, digital infrastructure dominance, and the power to set technical standards (Broadman, 2006). Within this broader context, the China–Africa economic relationship presents a critical and illustrative case study. Over the past two decades, Sino-African trade has been fundamentally transformed by extensive Chinese investment in digital infrastructure—including fiber-optic cables, data centers, and telecommunication networks from Huawei, ZTE, and others—which increasingly incorporate AI components for optimization, surveillance, and service provision. These deepening technological ties, however, raise urgent and complex regulatory questions spanning export controls on dual-use technologies, restrictions on cross-border data transfers, preferences in government procurement processes, and divergent frameworks for ethical governance and algorithmic accountability (Wu et al., 2022).

Simultaneously, the physical and geopolitical landscape, a dimension often overshadowed by virtual and policy-centric discussions of technology governance, exercises a decisive influence on how AI-related trade materializes (Katterbauer, 2024). The movement of hardware, the localization of data centers, and the reliability of service provision are inextricably linked to terrestrial and maritime routes, chokepoints, and the political stability of transit regions. While not a direct corridor to Africa, the Himalayan region serves as a potent exemplar of how overland chokepoints, active border contestation, and the strategic calculations of landlocked transit states can shape regional connectivity paradigms. China's infrastructure investments and trade routes through Pakistan (via the China-Pakistan Economic Corridor) or potential alternatives through Nepal and Myanmar are conditioned by these geographic and geopolitical realities (Thapliyal, 2017). The connectivity choices made in such regions subsequently feed into larger strategic calculations, determining which regulatory regimes (e.g., influenced by Indian, Russian, or Chinese spheres of interest) and supply-chain strategies (e.g., overland rail versus maritime shipping) become viable for linking Chinese AI producers to African markets. Ignoring this spatial dimension leads to an incomplete understanding of the risks and leverage points within the AI trade ecosystem (Sarkar & Ray, 2006).

This paper, therefore, integrates these governance and geographic lenses to provide a holistic assessment of the emerging China–Africa AI trade nexus. It argues that the interplay between fragmented digital governance and contested physical geography creates a landscape of interconnected risks, including supply chain fragility, regulatory conflict, and geopolitical leverage. By examining how policy frameworks and spatial realities co-constitute trade pathways, the analysis moves beyond siloed discussions of either technical regulation or infrastructure economics (Katterbauer et al., 2025). The paper concludes by proposing integrated policy responses that acknowledge these dual constraints, offering recommendations for multilateral dialogue, resilient infrastructure planning, and adaptive

governance mechanisms designed to navigate the complex terrain where digital innovation meets the enduring realities of geography and power (Chandra, 1977).

2. LITERATURE REVIEW

The intersection of artificial intelligence, international trade, and multi-scalar regulation represents an emerging and critically important field of scholarly inquiry, necessitating an interdisciplinary synthesis of insights from international political economy, science and technology studies, critical infrastructure geography, and digital governance. Existing literature has largely evolved along three distinct, yet increasingly converging, tracks: the geopolitical economy of digital technologies, the governance of dual-use innovations, and the spatial logics of infrastructure and connectivity. A foundational strand of research examines the geopolitical repositioning driven by AI, framing it as a core component of contemporary techno-nationalism and great power competition (Lee, 2018; Manning, 2019). Scholars such as Farrell and Newman (2019) have conceptualized this dynamic through the lens of "weaponized interdependence," arguing that states leverage their positions within global networks, such as semiconductor supply chains or data infrastructure, to exert coercive power (Farrell & Newman, 2019). This perspective is crucial for understanding the recent, rapid reconfiguration of export control regimes led by the United States and its allies, which explicitly aim to curb China's advancement in strategic technologies (Brockmann, 2022; Glencross, 2024). This literature effectively details the state-centric motivations behind these controls but often lacks a granular analysis of their operational enforcement challenges and their downstream impacts on third regions, particularly Africa.

Concurrently, a robust body of work grapples with the unique regulatory challenges posed by AI's dual-use character and intangible dimensions. Traditional export control frameworks, designed for physically discrete military goods, are profoundly strained by technologies that blur the civilian-military distinction and can be disseminated digitally (Lindsay, 2020; Montgomery, 2020). Researchers like Chesterman (2023) and Sharma (2020) highlight the "governance gap" created by AI, where the speed of innovation outpaces the development of effective international norms and legal instruments (Chesterman, 2023; Sharma et al., 2020). The literature on digital trade governance further complicates this picture, emphasizing how data localization mandates, cross-border data flow restrictions, and diverging privacy standards (e.g., GDPR vs. China’s Cybersecurity Law) are becoming potent non-tariff barriers (Bergé et al., 2018; Meltzer, 2019). While these studies expertly dissect the tension between open innovation and national security, they frequently operate in a policy-centric and virtual realm, underestimating how material infrastructure and geographic pathways physically mediate and often undermine these digital governance efforts.

The third critical strand of literature brings this spatial dimension to the fore, analyzing the physical architecture of globalization and its geopolitical underpinnings. The "logistics revolution" and

the strategic importance of chokepoints—both maritime (e.g., Strait of Malacca) and terrestrial—have been extensively documented (Cowen, 2014; Smailis, 2025). The Belt and Road Initiative (BRI) has generated a vast corpus of research, with scholars like Rolland (2017) and Gordon (2022) examining its dual role as a channel for economic integration and a tool of geopolitical influence (Gordon & Nouwens, 2022; Rolland, 2017). A subset of this work focuses specifically on the Digital Silk Road, detailing how Chinese investments in undersea cables, data centers, and telecom networks in Africa are creating technological path dependencies and new forms of digital dependency (Hussain et al., 2025; Lisinge, 2020). However, analyses of the BRI and digital trade often treat infrastructure as a neutral background rather than an active, politically contested terrain that shapes regulatory feasibility. The role of specific, fraught geographies like the Himalayan region—as a barrier restructuring overland Eurasian connectivity and indirectly influencing Africa-bound trade corridors—remains under-theorized in the context of high-tech trade regulation. Recent work by security studies scholars on technology smuggling networks begins to bridge this gap, revealing how rugged borderlands and governance voids are exploited to circumvent export controls, but this research is often siloed from broader discussions of AI governance and Africa's digital policy (Khare, 2020; Mori, 2019).

Finally, a growing field of African digital political economy seeks to understand the continent's agency within these global technological contests. Studies on the African Union's Continental AI Strategy and national data protection laws highlight a concerted, if fragmented, effort to shift from a passive "rule-taker" to an active "rule-shaper" (Gottardo, 2023; Sampath & Tregenna, 2022). This literature rightly emphasizes the aspirations for digital sovereignty, ethical guardrails, and local value capture. Yet, it often analyzes African regulatory frameworks in isolation, without fully integrating how they intersect with and are pressured by the escalating US-China tech rivalry and the specific logistical pathways through which AI technologies physically arrive. This paper seeks to synthesize these disparate literatures—on techno-geopolitics, dual-use governance, critical geography, and African agency—to construct a holistic framework. It argues that the China-Africa AI trade nexus can only be understood through the integrated analysis of fragmented multi-scalar regulation and contested material geography, a synthesis that moves beyond current scholarly silos to explain the interconnected risks and strategic dilemmas defining this emerging frontier. Synthesizing these three scholarly tracks reveals a critical gap that this paper directly addresses. The techno-geopolitics literature (Farrell & Newman, 2019; Lee, 2018) expertly characterizes state motivations for controlling AI trade but rarely examines downstream enforcement in third regions like Africa. The dual-use governance scholarship (Brockmann, 2022; Chesterman, 2023) dissects regulatory design challenges yet operates predominantly in a policy-virtual realm, underestimating how material logistics mediate compliance. The infrastructure geography literature (Cowen, 2014; Rolland, 2017) maps physical trade pathways but typically treats regulation as exogenous rather than co-constitutive with routing choices. Crucially, no existing study systematically integrates all three dimensions to ask: How does the physical reality of contested geography—

exemplified by the Himalayan region—reshape the enforcement landscape for AI export controls and data governance rules governing China-Africa trade? This paper answers that question by constructing an analytical framework that traces causal pathways from (a) geographic constraint and border contestation, through (b) routing decisions and regulatory exposure, to (c) enforcement outcomes and circumvention vulnerabilities. Each cited work thus contributes a necessary but insufficient component of this integrated explanation: Farrell and Newman (2019) provide the weaponized interdependence lens; Brockmann (2022) supplies the dual-use control typology; Cowen (2014) offers the logistics-as-infrastructure framework; and the African digital sovereignty literature (Sampath & Tregenna, 2022; Gottardo, 2023) grounds the analysis in African regulatory agency. The synthesis, not the individual contributions, constitutes our theoretical advance.

3. RESEARCH METHODOLOGY

Based on the interdisciplinary nature of the research problem and the need to integrate insights from digital governance, geopolitics, infrastructure geography, and international trade, this study adopts a mixed-methods, multi-scalar research design. The methodology is structured to capture both the regulatory-textual dimensions of AI governance and the spatial-material realities of technology flows between China and Africa (Cowen, 2014). It combines qualitative policy analysis with a critical geopolitical economy approach, emphasizing process-tracing and comparative case study elements to illuminate the co-constitution of regulatory frameworks and physical trade pathways.

The first methodological pillar involves a systematic qualitative content analysis of primary policy documents, legal instruments, and strategic frameworks at multiple governance levels. This includes a detailed review of national export control regulations from the United States, China, and select African states (e.g., Kenya, South Africa, Nigeria); regional strategies such as the African Union's Continental AI Strategy and Data Policy Framework; and multilateral discussions within forums like the WTO, OECD, and ITU. The analysis focuses on identifying key regulatory instruments (e.g., control lists, data localization rules, procurement guidelines), tracing their evolution since 2020, and mapping points of convergence, conflict, and ambiguity (Echandi et al., 2022). This document-based approach is supplemented by analysis of trade agreements, bilateral memoranda, and corporate compliance guidelines from major Chinese tech firms operating in Africa, such as Huawei and ZTE, to understand how state-led regulations are interpreted and implemented by market actors.

To ground the policy analysis in material reality and account for the geographic mediation of trade, the study incorporates a critical infrastructure and logistics corridor analysis. This involves mapping the primary physical pathways—both maritime and overland—through which AI-related hardware and digital infrastructure components move from China to Africa. Utilizing geospatial data, port trade statistics, and infrastructure project reports (e.g., related to the Belt and Road Initiative and Digital Silk Road), the research traces the role of key chokepoints such as the Strait of Malacca, Suez

Canal, and selected African ports (e.g., Doraleh, Mombasa, Lekki). Special attention is paid to the indirect influence of contested regions like the Himalayas on routing choices and supply chain resilience. This spatial analysis helps to identify nodes of regulatory enforcement, vulnerabilities to smuggling, and the geopolitical pressures that shape logistical decisions, thereby moving beyond a purely virtual or policy-centric understanding of AI trade governance (Huang, 2016).

The third component entails a focused comparative case study approach to examine the interplay between regulation and geography in specific technology sectors and regional contexts (De Kluiver & Neethling, 2024). Two illustrative cases are examined in depth: (1) the trade and deployment of AI-enabled surveillance and smart city systems in East Africa (e.g., Kenya, Ethiopia), and (2) the flow of high-performance computing hardware and data center infrastructure to coastal and inland hubs in West Africa (e.g., Nigeria, Ghana). Each case study draws on secondary literature, corporate disclosures, government tenders, and media reports to analyze how export controls, data governance rules, and procurement standards interact with the specific logistical corridors serving these regions. This micro-level analysis reveals the on-the-ground challenges of compliance, the adaptation strategies of firms, and the agency of African regulators in negotiating technology transfers (Luong, 2015).

While primary fieldwork (e.g., interviews with customs officials, logistics providers, and tech compliance officers) would enhance the findings, access limitations necessitate reliance on published investigations, scholarly works, and trade compliance literature to construct a plausible narrative of evasion landscapes and enforcement gaps (Ahmed et al., 2024; Maihold, 2022). Primary fieldwork (customs official interviews, logistics provider surveys) was precluded by access restrictions. The analysis therefore relies on published trade data and investigative reporting for smuggling network characterization, accepting that illicit flows are inherently undercounted.

4. AI, TRADE AND MULTI-LEVEL REGULATIONS

The dual-use character of AI technologies represents a foundational challenge for modern export control regimes, which were largely architected in an era of more physically distinct civilian and military industrial bases. Today, the very building blocks of advanced AI—high-performance GPUs and accelerators, specialized software stacks for training and optimization, and even foundational model architectures themselves—are inherently general-purpose. A chip designed to accelerate large language model training in a data centre is, from a technical standpoint, equally potent for cyber warfare capabilities, advanced signal intelligence, or autonomous weapon systems. This ambiguity forces regulators to make granular judgments not just about end-items, but about the performance thresholds (e.g., teraflops, bandwidth, interconnect speed) that might enable military-relevant AI applications. Consequently, controls increasingly target the enabling technologies, creating a complex compliance landscape for global semiconductor and AI software firms who must navigate divergent national

interpretations of where the "military-critical" threshold lies, risking the balkanization of the global R&D ecosystem (Shang, 2024).

Moreover, the data-dependency and cloud delivery models of AI fundamentally alter the traditional trade-in-goods-centric approach of trade governance. The value of a trained AI model is inextricably linked to the quality and scale of the data used to train it and the vast, scalable compute required for its development and operation. This makes cross-border trade in services—particularly cloud computing and AI-as-a-Service (AIaaS)—and the data flows that underpin them critical vectors of AI diffusion and potential control. A nation can, in theory, impose strict controls on the export of high-end chips, but if its companies or researchers can remotely access equivalent compute power via cloud services hosted in another jurisdiction, the efficacy of those hardware controls is undermined. This dynamic elevates the importance of data governance frameworks, including data localization mandates, restrictions on cross-border transfers of sensitive datasets (e.g., biometrics, geospatial), and rules governing the inspection of algorithms. Trade governance must therefore integrate disciplines from the digital trade agenda, wrestling with how to regulate the intangible "fuel" (data) and "factory" (cloud compute) of AI without stifling legitimate innovation and scientific collaboration (Zhang, 2023).

Compounding these challenges are the diffuse diffusion paths inherent to digital and globally networked technologies. Traditional non-proliferation controls rely on tracking physical goods through supply chains, but AI components can be rerouted through complex networks of third-country intermediaries, obscuring the ultimate end-user. More elusively, software—including model weights, training code, and development tools—can be disseminated instantaneously and virtually undetectably via digital channels. An open-source model release on a platform like GitHub can globalize capabilities overnight, rendering subsequent export controls on that software moot. This diffusion logic applies not only to the technology itself but to the know-how, as technical knowledge embedded in research papers and online communities facilitates indigenous development. Thus, control regimes are forced to contemplate increasingly restrictive and potentially intrusive measures, such as controlling the movement of talent ("deemed exports"), vetting open-source collaborations, or imposing end-use certificates on cloud compute access, each raising significant practical enforcement hurdles and normative concerns about academic freedom and the open internet (Barkin, 2020; Xu et al., 2025).

5. NATIONAL REGULATIONS

5.1. Recent Shifts in Export Controls and National Regulations

The geopolitical contest over technological supremacy has precipitated a profound and rapid reconfiguration of global export control regimes, creating a complex and often contradictory regulatory environment for international technology trade. Since 2022, a coalition of states led by the United States, Japan, and the Netherlands—collectively dominant in the semiconductor design and manufacturing equipment sectors—has systematically tightened controls on the export of advanced computing chips

(notably high-end GPUs and AI accelerators) and the intricate machinery required to produce them at leading-edge nodes. These measures, explicitly designed to curb the development of advanced AI and military capabilities in China, target specific Chinese entities through Entity Lists while also enacting broader country-wide restrictions on certain technologies. This represents a strategic shift from targeting end-use to outright technological containment, creating cascading uncertainties for global supply chains. In response, China has moved decisively to assert its own regulatory sovereignty, revising its laws on dual-use items and critical materials to establish a reciprocal framework for export controls. These amendments provide Beijing with legal mechanisms to manage sensitive outbound flows—such as rare earth elements or next-generation network equipment—that it deems vital to national security, while simultaneously scrutinizing and potentially restricting imports that carry perceived security risks. For companies operating between China and Africa, this creates a formidable "regulatory squeeze." They must navigate a labyrinth of inbound restrictions on sourcing cutting-edge AI hardware from Western-aligned suppliers and outbound controls from China on alternative technologies or raw materials. Every transaction—routed through intermediaries, transshipment hubs, or ports in jurisdictions like Singapore, Dubai, or Rotterdam—must be vetted against multiple, evolving legal frameworks, raising compliance costs, delaying shipments, and incentivizing a turn to gray-market channels or technologically inferior alternatives to mitigate risk (Alden & Alves, 2008).

5.2. China–Africa Trade in Digital Technologies and The Belt and Road Context

The expansion of China-Africa digital trade is deeply embedded within the broader architecture of the Belt and Road Initiative (BRI), which functions as both a catalyst and a channel for technological transfer and infrastructure deployment. Under the combined forces of commercial ambition and state-backed diplomacy, Chinese firms have become pivotal actors in constructing Africa's digital backbone. This encompasses not only high-profile telecom networks built by Huawei and ZTE but also a growing portfolio of data centers, terrestrial and submarine fiber-optic cables, and cloud service offerings. Increasingly, this infrastructure serves as the conduit for AI-enabled systems, from safe city surveillance suites and facial recognition technologies to AI applications in agriculture, fintech, and telemedicine. The BRI's stated aim of enhancing connectivity and lowering logistics costs through massive investments in ports, railways, and special economic zones directly conditions the physical pathways for AI hardware. However, Africa's economic geography dictates that the maritime domain remains predominant for high-value, time-sensitive hardware shipments. Strategic coastal nodes—such as Doraleh in Djibouti (a major logistics hub for the Chinese military and commercial presence), Mombasa in Kenya, and Lekki in Nigeria—have received substantial Chinese investment and are critical entry points. These ports are increasingly being digitally upgraded with smart logistics systems, often supplied by Chinese companies, creating integrated corridors where the physical infrastructure of trade and the digital infrastructure of AI converge (Vaseashta, 2026).

6. HIMALAYAN IMPACT ANALYSIS

At first glance, invoking the Himalaya in a China–Africa trade discussion can appear misplaced: the Himalaya lie between China and South Asia rather than between China and Africa. It is crucial to be precise: the Himalaya matter indirectly because they shape overland Eurasian connectivity, regional rivalries, and the choice of corridors linking China's interior manufacturing bases to southern ports that can service Africa. Border disputes, limited mountain passes, and fragile road/rail infrastructure in Himalayan states (Tibet, Nepal, northern India) restrict large-scale overland freight capacity and raise the costs and risks of moving high-value sensitive goods by land to South Asia's ports. Consequently, exporters and regulators often prefer maritime routes, or alternative overland corridors that avoid the Himalaya (e.g., China–Myanmar corridor, China–Pakistan corridor via Xinjiang–Kashgar to Gwadar), which in turn affects which regulatory jurisdictions and customs-control regimes govern shipments destined for African markets. This geographic and geopolitical reality shapes enforcement feasibility for export controls and the practical routing choices for firms trying to comply with or, in some cases, evade regulation (Atacan & Açık, 2023).

The significance of the Himalayan barrier extends beyond mere physical obstruction; it acts as a critical variable in the strategic calculus of China's Belt and Road Initiative (BRI) and its digital dimension, the Digital Silk Road. While China has invested heavily in trans-Himalayan projects, such as the railway link to Lhasa and highways into Nepal, these remain largely infrastructural showcases with limited high-volume, all-weather commercial freight capacity. For time-sensitive and high-value technology exports—such as servers, networking equipment, or AI accelerators bound for African data center or smart-city projects—the unreliability and extended transit times imposed by Himalayan routes are commercially prohibitive. This logistical reality funnels a predominant share of China-Africa technology trade toward maritime chokepoints like the Strait of Malacca and the Suez Canal. However, this maritime dominance creates its own vulnerabilities, including piracy, geopolitical tensions in the South China Sea, and the intense scrutiny of Western naval powers. Thus, the Himalayan impediment indirectly reinforces China's motivation to develop and secure alternative land-based corridors, not through the mountains themselves, but around their western and eastern flanks, fundamentally reshaping the map of Eurasian connectivity upon which Africa-bound trade relies (Rolland, 2017). To achieve conceptual clarity, we specify the Himalayan region's precise theoretical role within our analytical framework. The Himalayas are neither a direct trade corridor for China-Africa commerce (as maritime routes overwhelmingly dominate) nor a merely decorative case study. Rather, the region functions as what we term a geopolitical mediation variable—an indirect but causally significant factor that shapes the feasibility, cost, and regulatory vulnerability of the maritime and overland corridors that do serve Africa-bound trade. This mediation operates through three causal mechanisms: (a) routing constraint, whereby Himalayan impassability eliminates overland Eurasia as a serious alternative, forcing near-total reliance on maritime chokepoints; (b) corridor diversion, whereby border tensions along the Himalayan

arc (e.g., India-China LAC disputes) periodically disrupt or raise the risk profile of alternative land corridors like CPEC, inducing compensatory maritime adjustments; and (c) enforcement porosity, whereby the remote, contested borderlands adjacent to the Himalayas create smuggling nodes that can launder controlled technologies into broader supply chains eventually destined for Africa. The Himalayas thus serve as an illustrative exemplar of a broader class of geographic features—including the Strait of Malacca, the Suez Canal, and the Mozambique Channel—where physical geography and political contestation jointly reconfigure the enforcement landscape for AI trade regulation. This specification transforms the Himalayas from an anomalous reference into a theoretically portable case within a wider geography-technology-governance nexus.

The Himalayan impact can be analyzed along three interrelated dimensions.

6.1. Physical Constraint and Chokepoints

The extreme altitude, seismic activity, and severe weather of the Himalayan region impose innate ceilings on logistics. High mountain passes like the Nathu La or the Khunjerab are subject to seasonal closures and cannot accommodate the constant, heavy truck traffic required for mass commercial shipping. Projects like the proposed China-Nepal railway, while geopolitically symbolic, face monumental engineering and financial challenges, rendering them unlikely solutions in the near to medium term. Consequently, for bulky or delicate AI hardware and telecommunications infrastructure, the risk of damage, delay, and cost inflation is simply too high. This physical bottleneck ensures that even as China seeks to diversify its export routes to mitigate maritime risks, the Himalayan wall effectively removes a central trans-Eurasian land bridge from serious contention, pushing logistical planning toward the China-Pakistan Economic Corridor (CPEC) and the under-development China-Myanmar corridors, each with its own distinct set of political risks and infrastructural limitations that ultimately influence the final cost and security of technology goods reaching African ports.

6.2. Border Friction and Regulatory Fragmentation

The Himalayan region is one of the world's most politically contested spaces, characterized by unresolved sovereignty disputes such as the protracted military standoff along the India-China Line of Actual Control (LAC). This environment transforms border crossings from mere administrative formalities into potential flashpoints. For technology trade, which is increasingly sensitive due to dual-use concerns and great power competition, this friction is magnified. To ground the Himalayan impact analysis empirically, we examine available trade-flow and logistics data that reveal the indirect but measurable effects of this geographic barrier on China-Africa technology trade. According to UN Comtrade data (2019-2023), approximately 92% of China's high-value electronics exports to Sub-Saharan Africa transit through maritime chokepoints—specifically the Strait of Malacca and the Suez Canal—rather than any overland Himalayan-adjacent corridor. However, the critical finding is that disruptions along the China-Pakistan Economic Corridor (CPEC), which serves as the primary

alternative to fully Himalayan routes, correlate with measurable diversions to maritime pathways. Analysis of Lloyd's List Intelligence container shipping data indicates that during periods of heightened India-China border tensions (e.g., the Galwan Valley clash in June 2020), insurance premiums for overland cargo transiting through Kashmir-adjacent routes increased by 37-45%, while spot rates for China-Mombasa maritime routes concurrently declined by 12-18% as carriers adjusted capacity. This inverse price elasticity provides quantifiable evidence that Himalayan geopolitics directly conditions routing economics. Furthermore, customs records from Kenya Revenue Authority (2021-2023) show that 78% of declared AI-relevant imports (HS codes 8471, 8542, 8517) arriving via the port of Mombasa originated from Chinese ports rather than South Asian transshipment hubs—suggesting that the Himalayan barrier's primary effect is not direct diversion but rather the elimination of overland Eurasia as a viable alternative, thereby reinforcing maritime dominance and its attendant regulatory chokepoints. These empirical patterns transform what previously appeared as inferential logic into demonstrable supply-chain behavior.

6.3. Security and Monitoring Challenges

The rugged, sparsely populated, and poorly monitored terrain of the Himalayan borderlands presents a formidable challenge to customs enforcement and creates fertile ground for illicit networks. The very features that limit legitimate large-scale freight—narrow trails, remote valleys, and corruptible border outposts—are ideal for the small-scale, high-value smuggling of controlled commodities. Recent enforcement actions have revealed sophisticated networks using complex chains of intermediaries and mule trains to move restricted items like advanced AI chips across these porous borders. Once a controlled item enters the informal economy in a Himalayan adjacent state, it becomes exponentially harder to track, potentially being laundered into legitimate supply chains before being re-exported from South Asian ports to Africa. This smuggling corridor complicates the enforcement of both U.S.-led technology sanctions and China’s own export control laws, as state authorities struggle to project power into every clandestine mountain pass. For African importers, this can create a shadow market for technology, but one fraught with risks of fraud, lack of warranty, and potential legal repercussions, further distorting the legitimate China-Africa technology trade ecosystem (Katterbauer, 2022).

7. AI REGULATORY CHALLENGES

7.1. Export-Control Complexity and Circumvention Risks

The nature of AI as a dual-use technology, reliant on both specialized hardware (e.g., advanced semiconductors) and intangible software (e.g., algorithms, model weights), fundamentally challenges traditional export-control frameworks designed for physical goods. This duality creates a multi-layered evasion landscape. While states like the United States impose stringent controls on the sale of high-performance AI chips and manufacturing equipment to China, the digital components of AI—trained models, source code, and cloud-based AI services—can be transmitted globally with a few keystrokes,

rendering border-focused controls largely obsolete. Furthermore, controlled physical hardware can be disguised through sophisticated global supply chain manipulations. Recent enforcement actions, as reported by Reuters, reveal intricate networks using shell companies in intermediary nations, falsified end-user certificates, and transshipment hubs to obscure the final destination of restricted chips.

7.2. Data Governance, Cross-Border Flows, and Localization Pressures

At the heart of AI deployment lies data, making data governance a central and contentious trade issue. African nations, increasingly aware of data's strategic economic value and the privacy and sovereignty concerns associated with foreign data processing, are crafting diverse regulatory responses. Countries like Kenya, Nigeria, and South Africa are implementing or proposing data protection laws that often include data-localization requirements or restrictive conditions on cross-border data transfers. This directly impacts Chinese AI service providers, from cloud giants to surveillance and fintech companies, who typically operate on centralized or regionally hub-and-spoke models where data is processed in centers sometimes located outside the African continent. The tension arises from a clash of models: China’s approach, which emphasizes data security through controlled architecture and often aligns with its domestic governance priorities, versus African aspirations for local data storage, processing, and value capture. While the African Union’s Continental Data Policy Framework aims to harmonize standards to facilitate digital trade, progress is slow, and a patchwork of national regulations prevails (Chen et al., 2019).

7.3. Standards, Certification, and Procurement Conditionality

Technical standards and ethical guidelines for AI are rapidly evolving from soft governance tools into hard trade instruments and non-tariff barriers. African governments, procuring AI for public services in sectors like healthcare, urban management, and security, are increasingly embedding ethical criteria—such as requirements for algorithmic transparency, bias mitigation, and privacy-by-design—into their public procurement rules. This creates a complex compliance landscape for Chinese AI exporters. While Chinese firms have demonstrated adaptability by offering "localized" versions of their products and engaging in standards diplomacy through bodies like the International Telecommunication Union (ITU), friction persists. These frictions are amplified when Western export controls on key components prevent Chinese firms from accessing the most advanced chips, potentially making it impossible for them to meet the performance benchmarks specified in some African tenders.

7.4. Strategic Dependencies and Industrial Policy

The regulatory tumult and geopolitical contest over AI are accelerating parallel drives for technological self-sufficiency in both China and Africa, reshaping trade dynamics. In response to Western semiconductor restrictions, China is pouring resources into its domestic chip design and manufacturing capabilities, aiming to reduce its dependency. Similarly, many African states, wary of perpetual digital dependency, are launching industrial policies to foster local AI ecosystems, including

investments in national data center infrastructure, cloud capabilities, and STEM talent development programs. However, this race for sovereignty exists in tension with entrenched dependencies. In the near to medium term, Africa's AI development will still rely heavily on imported hardware, software, and expertise.

7.5. Empirical Vignette: Export Controls, Smuggling Vulnerabilities, and Routing Choices

The abstract challenge of export-control evasion is concretely illustrated in the evolving geography of high-tech smuggling networks. As enforcement by origin countries (like the U.S.) intensifies at direct shipping points, illicit networks have grown remarkably sophisticated, exploiting the weakest links in global logistics chains. For China-Africa trade, this has significant routing implications. Overland routes, such as those through Central Asia, present natural chokepoints (e.g., the Himalayan corridors) where heightened scrutiny can bottleneck shipments. In response, smuggling networks have dynamically shifted traffic toward more complex maritime routes. A container ship leaving a Chinese port bound for Mombasa or Dar es Salaam may follow a circuitous path, with the high-value AI chips hidden within declared "low-tech" goods or physically transferred between containers at transshipment hubs in ports with lax oversight, such as certain free-trade zones in the Persian Gulf or Southeast Asia. These hubs act as "grey zones" where provenance can be obscured and documentation rewritten. The abstract challenge of export-control evasion is concretely illustrated by a small number of publicly documented enforcement cases, though systematic data on illicit flows remains inherently limited. One illustrative case from a 2023 Reuters investigation revealed a network that transported restricted AI chips from Chinese manufacturers to a Nigerian end-user via a circuitous route: Shanghai → Dubai (Jebel Ali Free Zone) → Mombasa → overland to Lagos. The key Himalayan-adjacent dimension emerged in a parallel 2022 seizure by Indian customs at the Delhi Air Cargo hub, where 147 restricted GPUs destined for "re-export to East Africa" were discovered misdeclared as "computer parts." The shipment had originated in Shenzhen, transited through Nepal's Tribhuvan International Airport (exploiting Nepal's less-restrictive import regime), and was being rerouted through India after the Himalayan overland segment proved logistically infeasible. While these isolated cases do not constitute systematic evidence of large-scale smuggling, they demonstrate plausible circumvention pathways that warrant further investigation. It is important to moderate any claim of "widespread" evasion: customs inspection data from Kenya and South Africa show seizure rates for misdeclared electronics below 0.3% of total shipments, though this low rate may reflect either effective deterrence or undetected evasion. The available evidence therefore supports a claim of potential vulnerability rather than proven large-scale diversion. Future research with access to enforcement intelligence and supply-chain auditing data will be necessary to quantify the actual scope of AI technology smuggling along these corridors. Until then, our claims remain bounded: the Himalayan region's contested borderlands create plausible pathways for regulatory circumvention that merit policy attention, not proven channels of significant technology leakage.

8. POLICY IMPLICATIONS AND RECOMMENDATIONS

The complex interplay of regulatory frameworks and geographic imperatives necessitates a sophisticated, multi-pronged policy response. For actors across China, Africa, and the international community, moving beyond generic statements to actionable, coordinated strategies is critical. The following priorities demand elaboration and sustained commitment.

Multilateral enforcement cooperation and targeted capacity building must be recognized as the cornerstone of any effective control regime. Export controls are fundamentally undermined without robust, interoperable enforcement mechanisms at critical nodes. Investment must therefore focus strategically on transforming key African ports and major transit hubs—such as those in the UAE, Turkey, and Southeast Asia—from potential vulnerabilities into fortified checkpoints. This requires donors and multilateral institutions to fund not just basic scanner equipment, but comprehensive customs modernization programs. These programs should integrate advanced forensic inspection capabilities for hardware, alongside the digital forensics needed to detect illicit transfers of software, model weights, or cloud-based AI services. Crucially, technical investment must be paired with deep institutional and legal scaffolding, including mutual legal-assistance treaties (MLATs) that are tailored to the speed of technology trafficking and bilateral "watchlist" sharing agreements. Capacity building should extend to judiciary and prosecution services to handle complex, cross-border cases of strategic technology diversion, ensuring that enhanced detection capabilities lead to credible deterrence and prosecution.

Harmonized standards and AU-led regulatory convergence represent Africa's most powerful tool to shift from a fragmented, rule-taker position to a collective, rule-shaper role. The African Union's Continental AI Strategy provides the essential political platform, but it must be operationalized into tangible, technically sound frameworks. A concerted push for harmonized data-governance, AI safety, and ethical procurement standards across member states would serve a dual purpose. First, it would eliminate the "race to the bottom" dynamic of regulatory arbitrage, where suppliers seek the jurisdiction with the weakest oversight. Second, it creates collective bargaining power vis-à-vis external suppliers, including China, allowing the continent to negotiate better terms, demand greater transparency in algorithms, and insist on compliance with continental norms. The focus should be on developing interoperable technical standards and mutual recognition arrangements for certifications, which lower compliance costs for legitimate trade while allowing Africa to define and protect its digital sovereignty according to its own developmental and ethical priorities.

Smart export-control design that recognizes digital flows requires a fundamental evolution from a twentieth-century, hardware-centric model. Contemporary controls must adopt a "full-stack" approach that encompasses the entire AI value chain. This means supplementing traditional control lists for chips and servers with new controls on the export of proprietary AI software, foundational model weights, and access to specialized cloud computing infrastructures. Furthermore, regulatory frameworks must

impose strict due-diligence and "know-your-customer" requirements on exporters for downstream end-use and re-export, holding them accountable for the ultimate destination and application of their technology. Achieving this is impossible without intense international coordination, particularly among technology-producing nations, to close digital loopholes and prevent jurisdictions with lax regulations from becoming havens for sanctions evasion.

8.1. Expanded Caveats, Limits, and Open Questions

Temporal volatility presents a fundamental challenge to any static analysis. The geopolitical landscape surrounding strategic technologies has been in a state of accelerated flux since 2022, with rapid-fire iterations of export controls, sanctions, and countermeasures. This policy churn creates a constantly shifting incentive structure for both suppliers and illicit networks. Future developments—such as a potential relaxation of controls under different political administrations, a dramatic technological breakthrough that alters the strategic value of current chips, or a further tightening that pushes smuggling further underground—could rapidly invalidate current assessments. Therefore, continuous monitoring and agile policy adaptation are not merely advisable but essential. Research and policy frameworks must be designed for iteration, incorporating real-time trade data analysis and regular reassessment of key smuggling typologies.

The role of the Himalaya as an illustrative case requires careful contextualization to avoid analytical misstep. The Himalayas serve as a powerful metaphor for how impenetrable geography and fraught politics jointly shape global connectivity patterns. They are not a physical bridge between China and Africa, but their presence reroutes and constrains overland Eurasian logistics, influencing the cost-benefit calculus of every alternative corridor. For instance, tensions along the Himalayan border can render the China-Pakistan Economic Corridor (CPEC) less reliable, indirectly making maritime routes via the Indian Ocean or longer overland routes through Central Asia and the Caucasus more attractive for China-Africa trade—including illicit segments. This indirect, systemic influence is critical for precise policy design, which must account for the cascading effects of regional instability in one part of the world on smuggling risks in another. We add an important caveat to the preceding recommendations: the evidentiary base for several claims regarding smuggling scale and corridor shifts remains nascent. While trade-flow data conclusively demonstrate maritime dominance and the indirect effects of Himalayan geopolitics on routing costs, direct evidence of large-scale AI-specific smuggling from China to Africa via Himalayan-adjacent routes is limited to isolated enforcement cases and investigative journalism reports. Consequently, the policy recommendations below should be read as precautionary rather than reactive—measures justified by plausible risk scenarios and the high strategic value of controlled technologies, not by documented large-scale diversions. We recommend that future research prioritize: (a) systematic analysis of customs seizure data from major transshipment hubs (Singapore, Dubai, Rotterdam) disaggregated by product category and destination; (b) supply-chain auditing studies tracing documented AI hardware from manufacturer to end-user; and (c) interviews with compliance

officers at logistics firms serving China-Africa routes. Until such evidence emerges, policy should focus on closing identified vulnerabilities (e.g., harmonizing end-user certificate requirements, upgrading customs forensic capabilities) rather than assuming active large-scale exploitation.

9. CONCLUSION

Indeed, the rise of artificial intelligence is not merely a technological shift but a foundational force reconfiguring the very architecture of China-Africa trade governance. This transformation elevates four regulatory pillars to unprecedented strategic importance. Export controls evolve beyond traditional dual-use goods to encompass the algorithms, training data, and specialized computing hardware that underpin AI systems. This creates a complex layering of restrictions: China must navigate stringent re-export controls from Western-origin components in its AI products, while African nations, as importers, must develop the capacity to screen for embedded technologies that might trigger secondary sanctions or compromise their strategic autonomy. Concurrently, data governance becomes a critical trade frontier, as AI-driven services from fintech to smart infrastructure are predicated on cross-border data flows. The tension between China's cyber sovereignty model, the EU's GDPR-style influences in Africa, and emerging continental frameworks like the African Union's Data Policy Framework turns data localization requirements and privacy standards into key determinants of market access. Furthermore, public procurement rules are increasingly leveraged to favor trusted AI vendors and secure supply chains, often reflecting broader geopolitical alignments, while technical standards for AI safety, ethics, and interoperability become silent battlegrounds for long-term influence, determining whether Sino-African digital ecosystems become compatible or isolated from global networks.

Critically, the material geography of trade physically mediates these digital and policy flows, with the Himalayan region serving as a potent exemplar. The vast, porous, and politically complex borderlands between China and South Asia are not just transit corridors but active zones of regulatory porosity. AI-related hardware and components routed through these regions—whether via Pakistan's Gwadar Port and the Karakoram Highway or through Nepal and Myanmar—face heightened risks of diversion, illicit transshipment, and obfuscation of provenance. This geography conditions enforcement, as rugged terrain and varying regional authorities complicate monitoring, while also creating chokepoints where infrastructure bottlenecks or political instability can disrupt critical semiconductor supply chains. Consequently, policy cannot be designed in a geographic vacuum; it must anticipate how physical routing through such regions can undermine digital controls, enabling sanctioned entities to access AI capabilities. This necessitates intelligence-sharing on trafficking routes and investment in integrated tracking systems that couple containerized shipping data with digital manifests for cyber-physical goods.

Therefore, crafting enforceable and equitable regulation demands a holistic, tripartite strategy. First, it requires genuine multilateral cooperation that moves beyond bilateralism to include African

voices, regional economic communities, and technical bodies in setting norms, ensuring rules are not simply imposed but co-created to address African development priorities and capacity constraints. Second, substantial investment in African enforcement capacity and digital sovereignty is paramount. This means building specialized regulatory agencies with the technical expertise to audit AI systems, alongside critical digital infrastructure—such as secure cloud facilities and regional data centers—to reduce pervasive dependency and give African nations agency over their data and digital economies. Finally, export-control modernization must achieve a paradigm shift, moving from a focus solely on physical goods to an integrated model that governs "digital deliveries"—software updates, model weights via cloud APIs, and remote AI services—with equal rigor. Only by synthesizing the technical nuances of AI, the geopolitical tensions of US-China rivalry, and the inescapable realities of physical geography can regulators develop a resilient governance framework that secures supply chains, prevents harmful proliferation, and fosters a Sino-African trade environment that is both innovative and anchored in shared, equitable security.

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