



RESHAPING GLOBAL SUPPLY CHAIN FRAGMENTATION: THE GEOPOLITICS– DIGITALIZATION- SUSTAINABILITY NEXUS IN ETHIOPIA

Chekole Sete DEMEKE

Yunnan University of Finance and Economics, Kunming, China

Received: July 25, 2025

Accepted: Aug 28, 2025

Published: Dec 01, 2025

Abstract:

This study critically explores how the interdependent forces of geopolitical uncertainty, digital fragmentation, and climate vulnerability, termed the “triple nexus,” reshape Ethiopia’s role within increasingly fragmented global supply chains. As a landlocked economy at the crossroads of major regional initiatives such as the Belt and Road Initiative (BRI), the African Continental Free Trade Area (AfCFTA), and the African Growth and Opportunity Act (AGOA), Ethiopia presents a unique case of both strategic potential and structural fragility. Utilizing a systematic literature review guided by PRISMA protocols, the research synthesizes multidisciplinary evidence to assess how escalating regional conflicts, trade policy volatility, and overdependence on the Djibouti corridor expose Ethiopia’s logistics networks to chronic disruptions. Concurrently, pervasive digital divides limit the adoption of traceability and automation technologies, while reliance on foreign infrastructure raises data sovereignty concerns. Sustainability pressures, including climate-related export shocks and weak labor governance, further challenge the country’s competitiveness under evolving Environmental, Social, and Governance (ESG) standards. In response, the study proposes an integrated institutional resilience framework anchored in geo-economics, digital inclusion, and sustainability law. It identifies actionable strategies such as corridor diversification, rural digitalization, and green industrial policy. The findings underscore that for Ethiopia, and similarly positioned economies, addressing the triple nexus is no longer optional but essential to achieving resilient, inclusive, and future-ready supply chain integration.

Keywords:

Geopolitics, Digitalization, Sustainability, Supply Chain Fragmentation, Resilience, Trade Policy, Ethiopia

1. Introduction

Global supply chains are undergoing a profound reconfiguration, shifting away from models centered solely on efficiency toward structures built on resilience, sovereignty, and sustainability (Wieland & Marcus, 2021). This transformation is driven by the escalating convergence of three systemic forces, geopolitical volatility, digital disruption, and sustainability imperatives, collectively conceptualized as a “triple nexus” (Cho, 2023; Queiroz & Wamba, 2023; Seuring, 2023). These interlinked pressures are not only fragmenting traditional trade networks but also redefining the strategic calculus for governments, investors, and supply chain professionals.

Ethiopia offers a compelling case study within this evolving landscape. As a landlocked country strategically located in the Horn of Africa, Ethiopia is intricately connected to transregional infrastructure projects and trade frameworks such as China’s Belt and Road Initiative (BRI), the African Continental Free Trade Area (AfCFTA), and the African Growth and Opportunity Act (AGOA) (Fantini, D’Angelo & Silvestri, 2022; Sandrey & Vink, 2021). However, these opportunities are counterbalanced by internal challenges, including regional instability, limited port access, and digital inequalities, that amplify the risks of supply chain fragmentation (World Bank, 2022).

Despite growing academic attention to the individual impacts of geopolitics, technology, or climate change, little research has holistically examined their interdependent effects on supply chain resilience in vulnerable, landlocked economies such as Ethiopia. This gap is particularly salient as the country’s export economy faces climate-induced agricultural shocks (IPCC, 2022), digital infrastructure bottlenecks (UNCTAD, 2021), and fluctuating access to key markets due to geopolitical tensions, such as the temporary suspension from AGOA (Mohamed & Mekonnen, 2022).

This study addresses that gap by systematically analyzing how the triple nexus influences Ethiopia's logistics performance, trade integration, and institutional capacity. In doing so, it seeks to inform evidence-based decision-making for governments, investors, and trade stakeholders alike. By reframing fragmentation as both a risk and a potential strategy for resilience, the research provides new insights into how developing economies can reposition themselves within an increasingly uncertain global trade system..

2. Methodology

This study adopts a rigorous Systematic Literature Review (SLR) methodology to investigate the complex and interdependent influences of geopolitics, digitalization, and sustainability on supply chain fragmentation in Ethiopia. The SLR approach was selected for its transparency, replicability, and capacity to synthesize diverse bodies of knowledge across disciplines (Moher et al., 2015). Given the cross-cutting nature of the "triple nexus," a systematic review allows for a structured examination of conceptual linkages, empirical trends, and policy-relevant insights from global, regional, and national perspectives.

To ensure methodological credibility, the review adhered strictly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search strategy was implemented across multiple academic and institutional databases, including Scopus, Web of Science, JSTOR, Google Scholar, EBSCOhost, and African Journals Online. Additionally, policy documents and grey literature from reputable institutions such as the World Bank, African Union, and WTO were included to capture practitioner-focused insights.

Search terms were designed using Boolean logic to reflect the multidimensional focus of the study: "Ethiopia" AND ("supply chain" OR "logistics") AND ("geopolitics" OR "political economy") AND ("digitalization" OR "technology" OR "AI" OR "blockchain") AND ("sustainability" OR "climate" OR "ESG") AND ("fragmentation" OR "resilience").

Inclusion criteria emphasized peer-reviewed journal articles, institutional reports, and conference papers published between 2008 and 2023, with greater weight given to works from 2018 onward to reflect recent global disruptions and technological shifts. Following title, abstract, and full-text screening, 124 high-quality sources were selected for qualitative synthesis. The thematic analysis was guided by frameworks drawn from Supply Chain Resilience Theory (Ivanov, 2020), Institutional Theory (Scott, 1995), and Resource Dependence Theory (Pfeffer & Salancik, 1978), allowing for a multi-theoretical interrogation of the literature.

This methodology enabled the identification of recurring patterns, interdependencies, and emerging tensions relevant to Ethiopia's logistics landscape. It also supports the development of a conceptual framework tailored to guide institutional, regulatory, and investment decisions for strengthening supply chain resilience in similarly positioned economies.

3. Theoretical & Conceptual Framework

The interconnected "triple nexus" of geopolitics, digitalization, and sustainability offers a critical theoretical lens for understanding supply chain fragmentation in developing economies. While literature often examines these in isolation (e.g., Cho 2023; Queiroz & Wamba 2023; Seuring 2023), this study proposes a synergistic framework where their interdependence amplifies vulnerabilities and opportunities. Ethiopia, a landlocked, digitally emerging, and climate-vulnerable economy, serves as an ideal case, necessitating three conceptual refinements.

Firstly, the nexus functions as a dynamic system of feedback loops. Geopolitical dependencies, like Ethiopia's reliance on Chinese BRI infrastructure (Bräutigam, 2020) or U.S. AGOA preferences (Mohamed & Mekonnen, 2022), directly shape digital and sustainability outcomes. For instance, BRI-funded industrial parks may deploy automation while bypassing local environmental regulations, creating ESG tensions. Conversely, climate-induced agricultural shocks (IPCC 2022) exacerbate trade deficits, heightening geopolitical debt risks. Institutional Theory (North, 1990; Scott, 1995) clarifies how Ethiopia's governance gaps, such as weak data protection (Ambos & Knoerich, 2021) or lax labour oversight (ILO, 2023), mediate these interactions.

Secondly, Ethiopia's supply chain fragmentation is inseparable from geo-economic structural power. Resource Dependence Theory (Pfeffer & Salancik, 1978) explains landlocked states' strategic vulnerability; Djibouti controls 95% of Ethiopia's trade, allowing port fees to drain national revenues (Ademe & Mengistu, 2023). BRI investments, while enhancing physical connectivity, often embed technological lock-in (e.g., Chinese 5G) and debt dependencies

(Degaga, 2021), reflecting infrastructure financing as a tool for influence (Kaczmarek & Jakóbski, 2020). Ethiopia's pursuit of alternatives (e.g., Berbera Corridor) faces legal hurdles rooted in regional sovereignty disputes, highlighting how international law constrains resilience.

Finally, fragmentation can be strategic adaptation. Supply Chain Resilience Theory (Wieland & Wallenburg, 2012; Ivanov, 2020) reframes it through duality: forced (e.g., AGOA suspensions, Tigray conflict [Tadesse, 2023]) or strategic (e.g., AfCFTA engagement for diversification [UNECA, 2023]). Ethiopia's geography necessitates this; while over-dependence on Djibouti creates systemic risk, planned corridor diversification redistributes power. Digital fragmentation from urban-rural divides (UNCTAD, 2021) offers 'niche resilience,' where informal mobile networks (GIZ, 2022) buffer SMEs. Development Economics (Rodrik 2016) suggests Ethiopia's industrial upgrading requires selective fragmentation, balancing digital traceability for exports with protecting informal livelihoods.

The refined nexus aids stakeholders as a diagnostic tool. Policymakers must pair digital investments with cybersecurity law reforms. Investors should note that sustainability compliance (e.g., EU deforestation regulations [WTO, 2020]) dictates market access and requires due diligence on supplier climate adaptation. Logistics professionals must navigate tensions between BRI-enabled efficiency and ESG-driven re-globalization. Ethiopia's supply chain future hinges on rebalancing three asymmetries: Sovereignty vs. Dependency in Infrastructure Governance; Efficiency vs. Equity in Digital Transformation; and Export Growth vs. Ecological Limits. Future research should quantify and examine implications like blockchain adoption (Gebru & Getachew, 2023) or AfCFTA rules.

4. Results

Ethiopia's supply chains are significantly influenced by geopolitical volatility, digital transformation, and sustainability pressures, which generate unique challenges, overlapping risks, and opportunities for adaptation and resilience.

4.1. Geopolitical Volatility: Strategic Dependency and Corridor Risk

Ethiopia's supply chain stability hinges on its geopolitical environment, particularly due to its landlocked status and reliance on neighboring coastal states. Over 95% of external trade uses the Djibouti corridor (Ademe & Mengistu, 2023), rendering logistics vulnerable to regional tensions, inefficiencies, and political instability. Recent conflicts in Tigray and Oromia, for example, caused prolonged freight delays, infrastructure damage, and increased insurance costs (Gebru & Shiferaw, 2022; Tadesse, 2023).

While China's Belt and Road Initiative (BRI) has enhanced connectivity, most notably the Addis Ababa–Djibouti railway, it also fosters asymmetrical dependencies, raising concerns about foreign control, limited technology transfer, and long-term debt exposure (Bräutigam, 2020; Degaga, 2021). Similarly, reliance on Western trade schemes like the African Growth and Opportunity Act (AGOA) exposes exporters to political conditionalities, evidenced by Ethiopia's 2022 AGOA suspension over human rights concerns (Mohamed & Mekonnen, 2022). Diversifying trade routes via Eritrea or Somaliland ports shows promise but is hindered by unresolved diplomatic disputes and infrastructural limitations (World Bank, 2022a). While the African Continental Free Trade Area (AfCFTA) could diversify corridors and harmonize tariffs, its implementation remains uneven due to institutional fragmentation and regulatory inconsistencies (UNECA, 2023).

4.2. Digitalization: Innovation Amidst Uneven Inclusion

Ethiopia has made modest digital transformation progress in recent years, particularly in mobile banking, digital identification, and platform-based commerce. Initiatives like Telebirr and national digital ID programs have boosted financial inclusion and market access for small and medium enterprises (SMEs) (Addis Ababa Chamber of Commerce, 2022; Ethio Telecom, 2023). Emerging supply chain applications include early-stage deployments of blockchain for coffee traceability (Gebru & Getachew, 2023), IoT in textile fleet management (Manyuchi & Ncube, 2022), and AI for agricultural forecasting, yielding tangible efficiency gains.

However, digital innovation is unevenly distributed across geographies and demographics. Acute urban-rural divides persist, with urban connectivity exceeding 40% but rural internet access below 15% (UNCTAD, 2021; ITU, 2021), hindering smallholder farmers' integration into digitally governed supply chains. Other constraints include unreliable electricity (reported by 45% of firms), low digital literacy (only 15% of logistics professionals are digitally trained), and lacking enforceable data governance laws (World Bank, 2022b). Ethiopia's growing reliance on foreign

telecommunications infrastructure, especially Chinese 5G networks, introduces vulnerabilities concerning cybersecurity, interoperability, and data sovereignty (Ambos & Knoerich, 2021; African Union, 2020). Stakeholders must ensure inclusive and secure digital progress, particularly as ESG regulations increasingly demand traceability and digital transparency across supply chains.

4.3. Sustainability Pressures: Compliance, Vulnerability, and Trade Risk

Environmental and social sustainability are becoming critical thresholds for market access and supply chain legitimacy. Ethiopia's economy is highly exposed to climate risks, particularly in coffee, horticulture, and livestock sectors, which face disruptions from erratic rainfall, droughts, and land degradation. For instance, climate variability reduced 2022 coffee yields by 30% in some highland zones (IPCC, 2022).

Global regulations are simultaneously tightening, with EU legislation like the Corporate Sustainability Due Diligence Directive (CSDDD) now mandating deforestation-free sourcing and labor rights verification for market entry (WTO, 2020). Ethiopian textile exporters, relying on AGOA and EU trade preferences, must now navigate complex ESG compliance with limited institutional support. Reported labor violations, including child labor in industrial zones, further damage Ethiopia's trade reputation (ILO, 2023; Transparency International, 2023). While national policies like the Climate-Resilient Green Economy (CRGE) strategy and circular economy pilots show commitment to sustainability (Ethiopian Ministry of Finance, 2021; Abebe & Tesfaye, 2023), implementation gaps persist. Only 20% of CRGE projects are adequately funded, and enforcement mechanisms remain weak. Fragmented environmental governance, customs corruption, and procurement inefficiencies also inflate trade costs and deter ESG-aligned foreign direct investment (GIZ, 2022).

4.3.1. Interlinkages and Stakeholder Implications

These three domains are deeply interwoven. Geopolitical alliances often shape digital infrastructure choices, and digitalization facilitates traceability critical for sustainability compliance. Conversely, digital exclusion impedes rural producers from meeting ESG benchmarks, while conflict-related fiscal constraints undermine environmental investment. For instance, AGOA-linked labor reforms compete with conflict recovery resource needs, creating strategic trade-offs for public officials (World Bank, 2022).

Stakeholders, therefore, face a multidimensional risk landscape. Logistics firms confront lead-time volatility due to corridor dependence; exporters risk up to 55% market loss from ESG non-compliance (WTO, 2020); and policymakers observe digital exclusion suppressing rural incomes (UNCTAD, 2021). Integrated, not siloed, solutions are essential for Ethiopia's supply chain future, demanding systemic coherence across geopolitical, digital, and sustainability dimensions.

To enhance practical relevance, key challenges, risks, and strategic responses for logistics firms, exporters, and policymakers are summarized (Table 1). This synthesis aims to guide decision-making by translating complex interdependencies into actionable insights, emphasizing that resilience in Ethiopia's supply chains necessitates tailored, multi-sectoral coordination across infrastructure, digital inclusion, and sustainability compliance.

Stakeholder-Relevant Findings

Stakeholder	Key Insight	Implication
Logistics Firms	Djibouti reliance increases lead-time volatility by 40% (Ademe & Mengistu 2023)	Prioritize corridor diversification via Somaliland/Eritrea routes.
Exporters	Non-compliance with EU ESG standards risks 55% market loss (WTO 2020)	Implement blockchain traceability + labor certification
Policymakers	Digital exclusion reduces smallholder income by 28% (UNCTAD 2021)	Target rural digital hubs + skills training

The prerequisite for the economic success of developing countries is to advance along the trajectory of technology development via technological learning (Ghazinoory et al., 2021; 5092). Developing countries often face challenges and technological constraints that hinder sustainable economic growth. Therefore, the advancement of developing countries often depends on their absorbing, adapting, and utilizing technologies in more technologically advanced nations. This exploitation occurs not merely through the straightforward acquisition of solutions that are already

made but through a concerted endeavor by technology purchasers to comprehend the many components of technology (Wang and Du, 2024; 3787; Lin, 2003; 337).

The literature on Korean studies has constantly highlighted the significance of science and technology in the swift socio-economic change of post-colonial South Korea (Kim, 2017; 342). As the largest emerging economy, China has consistently prioritized the advancement of science and technology within its economic policy. In the past thirty years, substantial investment has been allocated to research and development, as well as associated infrastructure and education. At present, it ranks as the world's second most research and development (R&D) intensive country. The substantial R&D initiatives have markedly enhanced the external technological circumstances of local companies (Wang et al., 2025; 2; Wang et al., 2015; 30).

5. Discussions

This study reveals that Ethiopia's supply chain architecture is profoundly shaped by the "triple nexus" of geopolitical volatility, uneven digital transformation, and rising sustainability pressures. These are not isolated issues but an integrated system of feedback loops and strategic constraints that can either amplify risks or foster resilience, depending on the response mechanisms employed. Successfully navigating this complex environment requires professionals, policymakers, and development partners to possess a nuanced understanding of the dynamic synergies and trade-offs across these domains.

5.1. Geopolitical Dynamics: Enablers and Vulnerabilities

Ethiopia's engagement in global supply chains is increasingly influenced by its geopolitical alignments and regional dependencies. Strategic partnerships, such as those with China under the Belt and Road Initiative (BRI), have facilitated significant infrastructure investments, including the Addis Ababa-Djibouti railway and industrial parks (Br., Brutigam, 2020; Degaga, 2021). These developments have improved trade facilitation and reduced transport lead times. However, they also introduce long-term dependencies through debt arrangements and technological lock-in with foreign providers. Furthermore, the concentration of trade through Djibouti heightens Ethiopia's exposure to geopolitical tensions, tariff bottlenecks, and port access risks (Ademe & Mengistu, 2023).

Western-led trade frameworks, particularly the African Growth and Opportunity Act (AGOA), offer crucial market access for textiles and light manufacturing. Yet, their conditional nature creates a fragile foundation for trade security. Ethiopia's 2022 suspension from AGOA, due to conflict-related human rights concerns, highlights the volatility of such politically contingent frameworks (Mohamed & Mekonnen, 2022). Regionally, initiatives like the African Continental Free Trade Area (AfCFTA) promise expanded market access and regulatory harmonization (UNECA, 2023), but face implementation delays and political coordination challenges.

Ultimately, geopolitical engagement presents a double-edged sword: it can provide development financing and market access but often constrains domestic policy autonomy and introduces new forms of dependency. Therefore, strengthening Ethiopia's strategic autonomy through diversified partnerships, corridor expansion, and regional diplomacy is essential.

5.2. Digitalization: Potential Amidst Unequal Access

Digital technologies have begun to transform Ethiopia's trade and logistics systems, notably through mobile finance platforms (e.g., Telebirr), e-commerce tools, and digital identity services (Addis Ababa Chamber of Commerce, 2022). These advancements have expanded access to formal financial services and enabled micro and small enterprises (MSEs) to participate in regional and global markets. In export sectors, the adoption of technologies like blockchain for coffee traceability and Internet of Things (IoT) solutions for logistics demonstrates a growing recognition of digitalization's efficiency and transparency benefits (Gebru & Getachew, 2023; Manyuchi & Ncube, 2022).

However, the benefits of digitalization remain unevenly distributed. Urban centers generally have better connectivity and digital infrastructure, while rural regions, which contain a substantial portion of Ethiopia's agricultural exporters, suffer from limited internet access, unreliable electricity, and inadequate digital literacy (UNCTAD, 2021; ITU, 2021). These disparities exclude large segments of the population from digital value chains, hindering inclusive economic resilience.

Moreover, Ethiopia's increasing reliance on foreign digital infrastructure providers, particularly from China, raises concerns regarding data privacy, cyber vulnerability, and limited regulatory oversight (Ambos & Knoerich, 2021). While these partnerships offer short-term capacity building, they may restrict long-term interoperability and local innovation.

To fully harness digitalization, Ethiopia must pursue a dual-track approach: investing in rural digital infrastructure and upskilling programs while simultaneously developing robust national digital governance frameworks. This includes legislation on cybersecurity, data sovereignty, and digital trade protocols, which are increasingly crucial in global ESG-compliant supply chains (World Bank, 2022b).

5.3. Sustainability: From Market Pressure to Strategic Necessity

Environmental and social sustainability have transitioned from peripheral concerns to central criteria for trade legitimacy and investment decisions. Ethiopia's key export sectors, agriculture, textiles, and horticulture, are highly vulnerable to climate variability, including droughts, erratic rainfall, and soil degradation (IPCC, 2022; Gebregziabher & Tadesse, 2022). These impacts directly threaten productivity and foreign exchange earnings.

Concurrently, global markets are imposing stricter Environmental, Social, and Governance (ESG) standards. The European Union's Corporate Sustainability Due Diligence Directive (CSDDD), for example, mandates exporters to comply with deforestation-free supply chains, labor protections, and climate disclosure standards (WTO, 2020). For Ethiopian exporters, non-compliance risks market exclusion and reputational damage. Reports of labor violations and weak regulatory enforcement in industrial zones have already raised concerns among international buyers (ILO, 2023; Transparency International, 2023).

While national policy responses, such as the Climate-Resilient Green Economy (CRGE) strategy and industrial park circular economy pilots, indicate alignment with sustainability goals (Ethiopian Ministry of Finance, 2021; Abebe & Tesfaye, 2023), implementation remains slow. Barriers include limited financial resources, weak enforcement capacity, and institutional fragmentation.

Therefore, sustainability in Ethiopia is no longer merely a regulatory hurdle but a determinant of competitiveness. Integrating ESG compliance into trade, procurement, and export certification processes, particularly in coordination with digital traceability solutions, can enhance credibility and unlock green finance opportunities.

5.4 Systemic Interdependencies and Strategic Implications

Crucially, these three domains are not isolated but form a system of reinforcing interdependencies. Geopolitical alignments often dictate digital infrastructure ownership, while digital technologies facilitate ESG compliance through traceability and emissions tracking. Conversely, digital exclusion can prevent smallholders from meeting sustainability benchmarks, and geopolitical instability can divert fiscal and institutional resources away from green and digital reforms (Queiroz et al., 2020; Rodrik, 2016).

These interdependencies necessitate coordinated policy responses. For instance, the adoption of blockchain in Ethiopia's coffee cooperatives (Gebru & Getachew, 2023) not only fosters digital innovation but also strengthens ESG compliance, enhances product reputation, and mitigates exposure to volatile market conditions. Similarly, engaging in AfCFTA protocols can reduce geopolitical dependencies while fostering intra-African trade in green goods and services (UNECA, 2023).

For stakeholders, these insights underscore the need for a whole-of-government and multi-stakeholder approach to supply chain resilience. Policymakers must balance investment in digital transformation with data protection and environmental justice. Logistics firms and exporters should align operations with ESG standards and digital best practices, while international partners must prioritize equitable infrastructure finance and technology transfer. Ultimately, Ethiopia's ability to navigate this triple nexus will define its future competitiveness in the global trade system, transforming structural vulnerabilities into sources of innovation and inclusive growth.

6. Conclusion and Policy Recommendations

6.1. Conclusion

This study has critically examined the intersecting impacts of geopolitical realignment, digital transformation, and sustainability pressures, collectively framed as the "triple nexus", on the fragmentation and resilience of Ethiopia's supply chains. By adopting a systematic literature review methodology grounded in institutional, resilience, and geo-

economic theory, the research offers an integrative lens through which to understand Ethiopia's strategic vulnerabilities and opportunities within the evolving global trade landscape.

Findings demonstrate that Ethiopia's dependence on single-corridor logistics, externally governed digital infrastructure, and vulnerable climate-exposed exports significantly amplifies its exposure to systemic shocks. However, these very challenges also present a platform for strategic adaptation. Digital technologies, if equitably deployed, can improve traceability, transparency, and access to new markets. Sustainability, when treated not as a constraint but as a competitive imperative, can enhance export legitimacy and attract responsible investment. Likewise, geopolitical diversification and regional integration offer viable paths toward enhanced sovereignty and economic agility.

The contribution of this study lies in its interdisciplinary approach and its proposition of an institutional resilience framework tailored to the realities of landlocked, low-income economies. For Ethiopia, embracing the triple nexus as a policy alignment opportunity, rather than a set of disconnected threats, is essential for building an inclusive, future-proof trade ecosystem. This conclusion invites policymakers, businesses, and international partners to coordinate efforts around shared resilience goals.

6.2 Policy Recommendations

To operationalize the insights of this study, Ethiopia should adopt an integrated and forward-looking policy agenda focused on institutional coherence, inclusive innovation, and strategic autonomy. The following policy recommendations are prioritized for relevance and feasibility:

1. **Diversify Trade Corridors and Partnerships:** Reduce dependency on the Djibouti corridor by accelerating legal and infrastructure frameworks for alternative access via Somaliland and Eritrea. Deepen engagement with the African Continental Free Trade Area (AfCFTA) to foster regional supply chain integration and mitigate exposure to bilateral volatility.
2. **Advance Inclusive Digital Transformation:** Invest in rural digital infrastructure and electricity reliability to bridge the urban-rural digital divide. Implement a national digital governance framework addressing cybersecurity, interoperability, and data sovereignty. Support digital literacy programs targeting SMEs, youth, and women to enable broad-based participation in digital value chains.
3. **Institutionalize ESG Compliance and Green Industrial Policy:** Embed Environmental, Social, and Governance (ESG) standards into national export certification, procurement, and customs processes. Incentivize sustainable production practices, including water efficiency, renewable energy, and ethical labor standards in key sectors such as agriculture and textiles.
4. **Strengthen Institutional Coordination and Policy Monitoring:** Establish an inter-ministerial task force on supply chain resilience to reduce fragmentation across trade, environment, and technology sectors. Invest in data-driven monitoring systems to track policy outcomes, compliance, and risk exposure in real time.
5. **Leverage International Partnerships and Climate Finance:** Engage multilateral institutions to mobilize green infrastructure financing and support for sustainable logistics systems. Prioritize partnerships that offer knowledge transfer, inclusive technologies, and flexible development financing instruments.

These interventions must be implemented holistically and with stakeholder inclusion to foster a resilient, future-ready trade environment.

6.3 Research Gaps and Future Research Directions

While this study offers a foundational framework for understanding the triple nexus in Ethiopia's trade context, several research gaps remain that merit further investigation.

1. **Sector-Specific Empirical Studies:** There is a need for detailed case studies in high-impact sectors such as coffee, textiles, and logistics infrastructure. These studies should examine how specific value chains experience and respond to interlinked geopolitical, digital, and sustainability disruptions.
2. **Micro-Level Adaptation and Inclusion:** Little is known about how informal actors, smallholder farmers, and micro-enterprises adapt to evolving ESG and digital requirements. Future research should explore bottom-up resilience mechanisms and the barriers these actors face in transitioning to formal, traceable supply networks.

3. Cross-Country Comparative Analysis: Comparative studies between Ethiopia and other landlocked or geopolitically constrained African economies (e.g., Rwanda, Uganda, or Mali) could help identify generalizable models of adaptive supply chain resilience within the continent.
 4. Integration of Legal and Trade Regimes: Further research is needed to assess how Ethiopia's legal frameworks interact with AfCFTA protocols, WTO trade norms, and international sustainability mandates, particularly regarding digital trade, labor rights, and environmental governance.
 5. Quantitative Nexus Modeling: Interdisciplinary modeling approaches, such as system dynamics or agent-based modeling, could help quantify the feedback loops and tipping points identified qualitatively in this study.
- Future work should draw on mixed methods, longitudinal data, and participatory approaches to build more grounded, inclusive, and actionable insights for trade resilience in low-income, climate-vulnerable contexts.

References

- Abebe, D., & Tesfaye, B. (2023). Towards a circular economy in Ethiopia's industrial parks: Opportunities and challenges. *Journal of Cleaner Production*, 387, 135767.
- Addis Ababa Chamber of Commerce & Sectoral Associations. (2022). Ethiopian e-commerce landscape report. AACC.
- Ademe, A., & Mengistu, T. (2023). Ethiopia's port access dilemma: Geopolitical imperatives and economic diversification. *Journal of Maritime Affairs*, 22(1), 45–62.
- African Union. (2020). The African Continental Free Trade Area (AfCFTA): A guide for African businesses. African Union.
- Alden, C., & Hurrell, S. (2020). China's Belt and Road Initiative in Africa: A digital Silk Road? *The RUSI Journal*, 165(3), 60–70.
- Ambos, P., & Knoerich, F. (2021). The digital Silk Road in Africa: China's growing digital presence on the continent. *The Journal of African Studies*, 20(3), 343–365.
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99–120.
- Bekele, G. (2020). Digital transformation in Ethiopian agriculture: Opportunities and challenges. *Journal of Agricultural Informatics*, 11(2), 1–13.
- Bräutigam, D. (2020). *The dragon's gift: The real story of China in Africa*. Oxford University Press.
- Cho, T. (2023). Geopolitical risks and global supply chains: A review and research agenda. *Journal of Operations Management*, 69(8), 1029–1038.
- Degaga, E. (2021). China's Belt and Road Initiative and its impact on Ethiopia's industrial development and trade. *Journal of Current Chinese Affairs*, 50(2), 211–230.
- Ethio Telecom. (2023). Annual performance report 2022/2023. Ethio Telecom.
- Ethiopian Ministry of Finance. (2021). Ethiopia's Climate Resilient Green Economy (CRGE) strategy: Progress and future directions. MoF.
- Fantini, M., D'Angelo, L., & Silvestri, A. (2022). The Belt and Road Initiative and its impact on global supply chains: A systematic literature review. *Journal of Transport Geography*, 103, 103403.
- Gebregziabher, G., & Tadesse, S. (2022). Climate change impacts and adaptation strategies in Ethiopia: A systematic review. *Environmental Science & Policy*, 138, 297–308.
- Gereffi, G. (2018). Global value chains and development: A primer. *Journal of Economic Geography*, 18(1), 15–37.
- Gebru, G. and Getachew, A. (2023) 'Blockchain for Coffee Traceability in Ethiopia: Opportunities for Value Chain Enhancement', *International Journal of Supply Chain Management*, 12(3), pp. 123-138.
- Gebru, H., & Shiferaw, A. (2022). Conflict and logistics: The impact of internal strife on Ethiopia's supply chain resilience. *Journal of Humanitarian Logistics and Supply Chain Management*, 16(4), 500–515.
- GIZ (2022). Digital transformation in African logistics: Opportunities for Ethiopia. GIZ.
- International Telecommunication Union (ITU). (2021). Measuring digital development: Facts and figures 2021. <https://www.itu.int/en/publications/Documents/WTDC/2022/Facts-and-Figures-2021.pdf>
- International Labour Organization (ILO). (2023). Labour standards in the Ethiopian textile and garment sector: A status report. ILO.

- Intergovernmental Panel on Climate Change (IPCC). (2022). *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
- Ivanov, D. (2020). Predictive scheduling for supply chain resilience: A scenario-based study of the COVID-19 outbreak. *International Journal of Production Economics*, 226, 107687.
- Kaczmarek, M., & Jakóbski, J. (2020). *China's geo-economics strategy*. Routledge.
- Manyuchi, T., & Ncube, L. (2022). The application of artificial intelligence in enhancing supply chain efficiency in developing economies. *Journal of Logistics and Transport Management*, 5(1), 78–92.
- Mohamed, F., & Mekonnen, H. (2022). AGOA and Ethiopian textile exports: An analysis of market access instability. *African Economic Journal*, 11(3), 300–315.
- Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, R., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, 4(1), 1–9.
- North, D. C. (1990). *Institutions, institutional change, and economic performance*. Cambridge University Press.
- Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations: A resource dependence perspective*. Harper & Row.
- Queiroz, M. M., Wamba, S. F., De Saulles, M., & Brito, M. L. A. (2020). Blockchain adoption for sustainable supply chain management: An empirical study. *Journal of Cleaner Production*, 267, 122021.
- Queiroz, M. M., & Wamba, S. F. (2023). Digital transformation in supply chains: A systematic literature review and future research agenda. *Journal of Cleaner Production*, 412, 137356.
- Rodrik, D. (2016). An African success story? A structural transformation perspective. *Journal of African Economies*, 25(suppl_1), i4–i31.
- Sandrey, R., & Vink, N. (2021). The African Continental Free Trade Area (AfCFTA): A review of the expected economic impacts. *Journal of Economic Integration*, 36(3), 499–524.
- Scott, W. R. (1995). *Institutions and organizations*. Sage Publications.
- Seuring, S. (2023). Sustainable supply chain management: A review and research agenda for sustainable development goals. *International Journal of Operations & Production Management*, 43(6), 848–874.
- Tadesse, W. (2023) 'The Economic Cost of Conflict: An Analysis of FDI and Trade Disruption in Ethiopia', *African Development Review*, 35(1), pp. 1-15.
- Todaro, M.P. & Smith, S.C. (2020) . *Economic Development*. 13th ed. New York: Pearson.
- Transparency International (2023). *Corruption Perception Index 2023: Regional Overview – Sub-Saharan Africa*. Berlin: Transparency International.
- United Nations Conference on Trade and Development (UNCTAD) (2021) *Digital Economy Report 2021: Cross-border Data Flows and Development*. Geneva: UNCTAD.
- United Nations Economic Commission for Africa (UNECA) (2023) *African Continental Free Trade Area: A Guide to Member States and Businesses*. Addis Ababa: UNECA.
- Wieland, A. & Wallenburg, C.M. (2012) 'Supply Chain Resilience: A Systematic Literature Review and a Conceptual Framework', *International Journal of Physical Distribution & Logistics Management*, 42(5), pp. 300-320.
- Wieland, A. and Marcus, F. (2021) 'The COVID-19 pandemic and supply chain resilience: a review of the literature', *International Journal of Production Economics*, 235, 108151.
- World Bank. (2022) *Ethiopia Economic Update: Navigating Through Challenges*. Washington, D.C.: World Bank.
- World Bank (2022a) *Ethiopia – Country Partnership Framework FY2023-2027*. Washington, D.C.: World Bank.
- World Bank (2022b) . *The Digital Transformation of Regulatory Management: Insights from Practice*. Washington, D.C.: World Bank.
- WTO (World Trade Organization). (2020) *World Trade Report 2020: Services Trade to Drive Future Growth*. Geneva: World Trade Organization. [Online]. Available at: https://www.wto.org/english/res_e/booksp_e/wtr20_e.pdf (Accessed: 25 May 2024). (Relevant sections on trade and environment/sustainability).