Improving the Logistics for Shipping Second-hand Mobile Phones from China to Thailand

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Abstract

This study investigates the optimization of cross-border logistics for shipping second-hand mobile phones from China to Thailand, focusing on logistical bottlenecks, cultural and regulatory constraints, and the effectiveness of innovative solutions. Using a qualitative case study approach stakeholder interviews, field simulations of ten shipments, and comparative benchmarks we identify inefficiencies in mode selection, customs clearance (including IMEI and HS-code misclassification), and reverse logistics (i.e., returns and repair flows). Evaluated strategies include IMEI pre-registration, blockchain-enabled customs processing, augmented reality (AR) inspection support, and rail-centered multimodal logistics with a Chiang Mai smart-warehouse node.

Results show measurable performance gains: IMEI pre-registration reduces order-change rates by 67% and accelerates clearance by up to 40%; blockchain shortens processing time from 96 to 36 hours (≈62.5%); AR cuts physical-inspection time and port delays by >60%; rail lowers line-haul cost by 18%, while warehouse sorting efficiency improves by 40%. Comparative benchmarks indicate Thailand's competitive rework capability but higher unit cost ($0.38/kg vs. $0.25/kg to Vietnam) and slower clearance (76%), highlighting scope for policy and process reform. We recommend aligning HS codes to distinguish refurbished devices from e-waste, mandating digital preprocessing (IMEI + blockchain), and localizing last-mile operations; together, these measures provide a practical roadmap for a more resilient, efficient, and culturally adaptive logistics framework for the circular electronics trade.

Keywords: Cross-border logistics, Second-hand mobile phones, Customs clearance

Introduction

The second-hand mobile phone industry has emerged as a vital pillar of the global circular economy, driven by consumers seeking affordable alternatives to new devices and a rising focus on sustainable consumption. In 2022, global shipments of refurbished and second-hand smartphones increased by 11.5%, reaching approximately 282.6 million units, and are projected to maintain a 10.3% compound annual growth rate (CAGR) through 2026 (Digital Information World, 2023). In 2023, sales exceeded 310 million units worldwide, accounting for roughly 23% of total smartphone sales, with the Asia-Pacific region leading this growth by contributing more than 45% of global transactions (Market Growth Reports, 2023).

Within Southeast Asia, Thailand has emerged as a particularly important market, supported by its expanding middle class, high levels of digital connectivity, and policies promoting green technology and e-waste reduction. At the same time, the country has strengthened its environmental safeguards. In June 2025, Thailand implemented a sweeping ban on electronic waste imports, broadening the list of prohibited hazardous items under new ministerial regulations (Nation Thailand, 2025; and HKTDC Research, 2025). Before this ban, loopholes had allowed the import of nearly 28.85 million kilograms of used electronics into Thailand between late 2021 and early 2022 (Fair Planet, 2022).

Thailand plays a pivotal role in regional second-hand mobile-phone flows, with many used devices arriving from China. In July 2017, China notified the WTO that it would restrict imports of multiple categories of solid waste, with measures taking effect from late 2017 (WTO, 2017; Reuters, 2017). China then completed a nationwide ban on all solid-waste imports effective 1 January 2021 (Ministry of Ecology and Environment of the PRC, 2020; Ministry of Ecology and Environment of the PRC, 2022). Evidence from international monitoring indicates these restrictions re-routed transboundary movements of used electronics and e-waste toward Southeast Asia (Forti et al., 2020). Despite Thailand's significance in the sector, the China–Thailand logistics corridor faces persistent challenges. These include underdeveloped transport infrastructure in segments of the China, Laos, Myanmar routes, regulatory complexities in Thai customs procedures including stringent standards and certification requirements and relatively high rates of cargo damage and delays. These constraints reduce supply chain reliability and increase operational costs.

While cultural and religious compliance is a distinctive consideration, the dominant constraints are logistical. Road–rail flows from China to Thailand frequently traverse the China–Laos corridor, where segments in Northern Laos and adjacent crossings remain underdeveloped, driving up cargo damage, lengthening transit times, and weakening network connectivity. Illustratively, the estimated cargo loss rate on the China–Laos–Thailand corridor is 5.7% versus 3.2% on the China–Vietnam route (Sun & Mei, 2025). At the maritime end, Laem Chabang Port despite being Thailand's primary deep-water gateway faces operational delays, with average demurrage times exceeding Haiphong Port by about 1.8 days (UNCTAD, 2023), further eroding schedule reliability and raising costs. Given these logistical inefficiencies, the need for a tailored, market-specific logistics model becomes clear. A Thailand-specific logistics evaluation framework is essential to quantify performance gaps, streamline transport and customs processes, and develop innovative logistics solutions. Addressing these bottlenecks will not only reduce costs and improve delivery timelines but also support sustainable trade practices aligned with global green economy goals (César Tadeo & Medina-Solís, 2020). Therefore, this research is both timely and necessary, offering insights and practical strategies for enhancing the efficiency and reliability of second-hand mobile phone trade between China and Thailand. Thus, this study aims to provide a comprehensive analysis of logistics bottlenecks and propose practical

innovations to improve the efficiency and sustainability of the China–Thailand second-hand mobile phone trade.

To address these issues, this study proposes the development of a Thailand-specific logistics evaluation framework to assess transport and customs performance and identify opportunities for innovation. By resolving key bottlenecks, the framework seeks to improve cost efficiency, enhance delivery reliability, and foster sustainable practices aligned with global green economy and circular economy objectives.

Research Objectives

1. To explore logistics bottlenecks (transportation, reverse logistics, customs clearance)
2. To identify the impact of cultural and regulatory constraints.
3. To evaluate the effectiveness of optimization strategies (e.g., blockchain customs, IMEI systems, AR inspections).
4. To recommend solutions for improving logistics performance in the cross-border second-hand electronics trade.

Literature Review

Analysis of the Current Situation

The logistics framework for second-hand mobile phone trade between China and Thailand is undergoing considerable pressure due to rapid market expansion, yet it remains constrained by outdated infrastructure, fragmented regulations, and inconsistent customs processes. Despite growing demand in Thailand driven by affordability and digital inclusion policies, the logistics system lacks synchronization between trade partners. According to Statista (2023), second-hand mobile phone circulation in Southeast Asia is rising at a CAGR of 11.7%, but infrastructure and regulatory adaptation have not kept pace. The customs process is heavily reliant on manual documentation and suffers from delays due to IMEI mismatches, missing invoices, and misclassification of used phones as e-waste (Thailand Customs Report, 2023). From ERIA, 2023; Euro Commerce, 2023 Studies show reverse logistics in ASEAN remain underdeveloped and fragmented (e.g., heavy reliance on informal collection and limited formal take-back systems), leading to slower return cycles; by contrast, European merchants typically process refunds within 10 days of a return, setting a faster benchmark. Transport inefficiencies such as underutilized rail corridors and recurring delays at Laem Chabang Port further impact delivery performance (UNCTAD, 2023). The logistics cost per unit remains high at $0.38/kg compared to $0.25/kg in Vietnam. Additionally, religious holidays, such as Songkran, and cultural sensitivities regarding Buddhist imagery contribute to disruptions and rework costs. Stakeholders face additional burdens due to the absence of centralized transit and return hubs, limited digital tracking, and poor real-time coordination. These structural limitations reveal a pressing need for digitized customs systems, improved multimodal transport integration, and cultural adaptation strategies. Without systemic reform, the China–Thailand second-hand electronics corridor risks losing competitiveness despite strong market demand and regional trade potential.

Optimizing the Logistics Transportation Methods

Optimizing logistics transportation methods for second-hand mobile phones between China and Thailand requires a shift toward multimodal and technology-enhanced solutions. Rail transport via the China–Laos–Thailand corridor can cut transport costs by about one-third (and over 40% in some scenarios) relative to all-road trucking on the Kunming–Laem Chabang route, while emitting far less CO_2 per tonne-kilometre than road freight (World Bank, 2018; International Energy Agency, 2023). Integrating smart transit warehouses, especially in Chiang Mai, improves cargo sorting speed and supports regional distribution. Additionally, combining sea freight with last-mile delivery via bilingual logistics teams boosts customer satisfaction in rural areas. Real-time tracking and IMEI pre-recording further expedite customs processes. A flexible, data-driven transport network aligned with trade volumes and market priorities is essential to enhance reliability, efficiency, and sustainability.

Customs Clearance Optimization

Customs clearance optimization is crucial to improving cross-border logistics efficiency in the second-hand mobile phone trade between China and Thailand. Key challenges include delays caused by manual IMEI verification, outdated HS code usage, and cultural inspection requirements. Implementing digital customs preprocessing such as blockchain and IMEI pre-registration—has been shown to reduce clearance time by up to 40% (UNCTAD, 2024a, 2024b, and World Customs Organization & World Trade Organization, 2022, and Department of Telecommunications [India], 2023). AR-based inspections allow customs officers to verify device conditions remotely, minimizing physical handling and damage. Misclassification of goods as e-waste remains a major barrier, with 42.6% of shipments affected in 2023 (Thai Customs Department, 2023). AI-powered tagging systems can help accurately classify goods before shipment. Harmonizing Thailand's regulatory standards with international norms will improve predictability and reduce compliance costs. A shift toward automated, transparent, and synchronized customs systems is essential for accelerating the clearance process and supporting sustainable trade flows.

Transport Network

The transport network plays a crucial role in determining the efficiency and reliability of cross-border logistics between China and Thailand. The China–Laos–Thailand railway, while offering cost advantages and lower emissions, remains underutilized due to limited frequency, customs bottlenecks, and weak integration with local distribution hubs (Sun & Mei, 2025). Road transport remains dominant but faces challenges from congestion and border delays, particularly at Nong Khai and Mohan checkpoints. Sea transport via Laem Chabang Port is used for high-volume shipments but suffers from delays and demurrage costs that exceed regional averages (UNCTAD, 2023). Air transport, though fastest, is expensive and avoided by most SMEs. The fragmented nature of multimodal links reduces overall responsiveness. Moreover, poor coordination among stakeholders weakens network resilience during disruptions. Transport losses and delivery variances remain high due to inadequate infrastructure in Laos and Northern Thailand. Strategic investments in multimodal hubs and smart logistics corridors are essential to optimize the transport network.

Research Framework

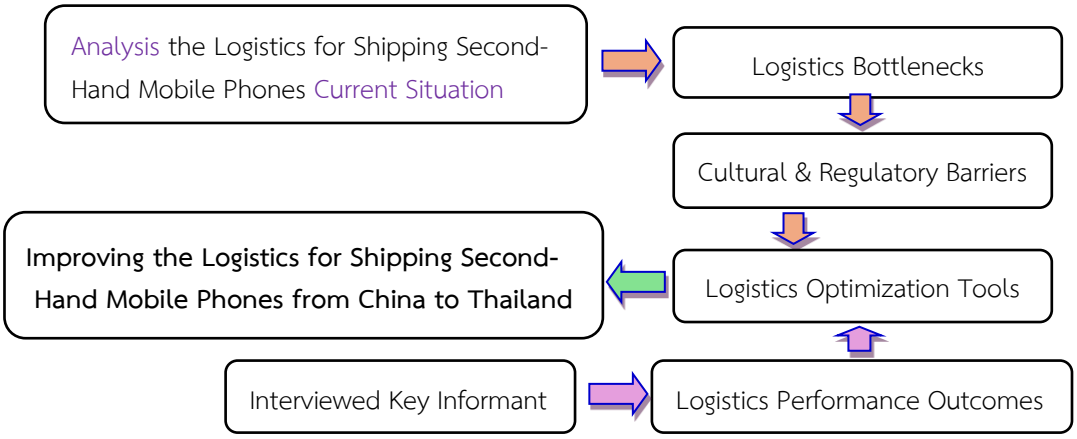

Figure 1 Research Framework (Researcher, 2025)

This framework explains how contextual conditions in the China–Thailand corridor namely regulatory requirements, cultural factors, and infrastructure/network capacity shape the feasibility and payoff of three operational drivers: (i) digital preprocessing (pre-arrival IMEI and e-invoice submission; secure EDI/blockchain), (ii) technology-assisted inspection (AR/AI), and (iii) network design (rail paired with a smart transit warehouse, plus consolidation/backhaul planning).

These interventions primarily work by lowering exception incidence, represented by the exception loop *(IMEI mismatch ⟶ HS reclassification ⟶ cultural/imagery rework)*. Breaking this loop produces better process outcomes (shorter inspections, reduced dwell/demurrage) and, in turn, improves six performance indicators: time, cost, security, connectivity, clearance efficiency, and service quality. The magnitude of these effects is moderated by AEO/broker accreditation, ASEAN Single Window/ACTS usage, seasonality, and firm IT/compliance capability. Finally, demonstrated performance gains feed back into wider adoption and supportive policy for logistics of second-hand mobile phone shipments between China and Thailand.

Research Methodology

Research Design

This study employs a qualitative case study design to investigate the optimization of logistics for shipping second-hand mobile phones from China to Thailand. The purpose is to understand logistical inefficiencies and evaluate strategies that can enhance customs clearance, transportation efficiency, and service quality. The research incorporates empirical data, expert insights, and cross-border logistics performance benchmarks to formulate actionable recommendations.

The design integrates field-based evidence collection with comparative analysis, enabling a deeper understanding of cultural, regulatory, and infrastructural influences unique to the China-Thailand corridor.

Data Sources and Collection

To ensure comprehensive insights according to research framework, the study utilizes both primary and secondary data sources:

Primary data:

Semi-structured interviews with seven key Informants (stakeholders), including logistics managers, customs officials, and second-hand mobile phone traders. These interviews provided nuanced perspectives on cultural constraints, customs delays, and route optimization, and field simulations of 10 shipment batches from Shenzhen to Bangkok, Ho Chi Minh City, and Dubai, which were tracked for comparative analysis. (Krueger & Casey, 2015, p. 6)

Secondary Data:

Analysis of the Logistics for Shipping Second-Hand Mobile Phones Current Situation to find out the logistics bottlenecks, cultural & regulatory barriers and logistics optimization tools as below.

1. WTO Cross-border Electronic Trade Reports (2023)
2. Thailand Customs Reports (2023)
3. Academic literature (2015–2025)
4. Company-level documentation from Siam Express, Mingwei Electronics, and Kesun Group

Evaluation Metrics

To assess the effectiveness of proposed logistics improvements, the study uses a custom Thailand-specific logistics evaluation model based on six indicators 1) Transportation Time, 2) Transportation Cost, 3) Cargo Security, 4) Logistics Network Connectivity, 5) Customs Clearance Efficiency, and 6) Service Quality and Customer Satisfaction

Data Analysis

1. The data collected from document studies were analyzed using content analysis and presented in a descriptive format.

2. The data obtained from interviewed Key Informant were analyzed through analytic induction. The data was systematically organized and classified, and the collected information was summarized and analyzed to address the research questions.

Comparative Methodology

The study benchmarks Thailand's logistics performance against other trade corridors such as China–Vietnam, China–Europe (Railway Express), and China–Middle East

Comparisons use four key dimensions: timeliness, cost, compliance, and reliability. These data-driven comparisons are supported by charts and tables, such as clearance rates, rework frequency, port capacity, and last-mile costs (from WTO Cross-border Electronic Trade Report 2023).

Validity and Reliability

We enhanced the credibility of our research by employing a triangulation method that included interviews, field simulations, administrative records, and existing literature. We verified our sample sizes (7 interviews and 10 shipping batches) with participants through key informant checks. To ensure reliability and dependability, we maintained an audit trail that included a codebook,

analytical memos, and versioned logs. Additionally, we provided detailed, context-rich descriptions to support the transferability of our findings.

Ethical Considerations

All interview participants were briefed on the study purpose, and informed consent was obtained. Data was anonymized to protect confidentiality, and findings were used solely for academic analysis.

Scope and Limitations

The study is confined to the second-hand mobile phone logistics route between China and Thailand. While comparative benchmarks were gathered from other regions, the primary data are specific to China-Thailand trade. Limitations include evolving customs policies and restricted access to internal customs system data

Research Results

This research results of this study according to research objectives by following:

1. The explore logistics bottle necks:

Underutilization of Truck Transport Utilization: Interviews indicated operational constraints at land borders (document checks, inspection queues), driver shortages, and fuel-price volatility, Lack of synchronized cross-border procedures and checkpoint variability along the China–Laos–Thailand route were frequently reported, Survey data on 2023 showed 29% of trucks returned empty due to limited backhaul arrangements, contributing to higher per-trip costs and vehicle idle time, and For short-haul segments, respondents noted potential speed advantages of road, but cited inconsistent scheduling and limited consolidation points.

Underutilization of Air Transport Utilization: Reported barriers: higher average freight rates (e.g., ≈ $3.20/kg vs $0.38/kg by road in cited examples), priority allocation to perishables/medical goods, and limited specialized handling for used electronics, Interviews referenced 48–72 hours of average airport-clearance time at Suvarnabhumi for this product category, reducing the nominal transit-time advantage, and Air carried <12% of corridor volume (IATA, 2023).

Port and Corridor Performance: Laem Chabang Port recorded longer operational delays than Haiphong, with demurrage averaging +1.8 days (UNCTAD, 2023) and Corridor loss/damage and connectivity issues were noted on the China–Laos–Thailand route; one estimate placed the cargo loss rate at 5.7% versus 3.2% on the China–Vietnam route (Sun & Mei, 2025).

Reverse Logistics (Returns); Interview and diagnostic evidence described fragmented take-back channels and limited formal return infrastructure (ERIA, 2023), Country-level assessments reported low formal collection rates and system bottlenecks for ICT returns (ITU & UNITAR, 2024), The average return/exchange cycle ≈ 27 days (field reports), compared with a 14-day European benchmark cited in documentation, and Reported contributors included unclear return documentation, limited reverse-flow capacity, re-entry treatment of returns as new imports, reclassification, and repeated IMEI checks.

2. The impact of Cultural and Regulatory Constraints:

The logistics operations between China and Thailand are uniquely impacted by cultural sensitivities and stringent regulatory requirements, making compliance both complex and costly. This study identified the following key constraints:

Content screening: Requirements to remove religious imagery/symbols on devices and packaging were reported by interviewees and trade documents; firms described manual inspection steps prior to export (TISI Report, 2023).

Holiday effects: Religious/national holidays (e.g., Songkran) coincided with temporary delivery and port slowdowns; delays of up to ~72 hours were reported in peak periods (Thailand Transport Ministry, 2023).

Documentation: IMEI pre-submission and original invoices were commonly cited as causes of delay when incomplete; one source reported 41% of shipments affected in 2023 (Thailand Customs Report, Q2 2023).

Certification: TISI certification requirements for used phones add safety compliance steps beyond identity verification.

HS coding: Continued use of older HS versions was associated with misclassification as e-waste, with one audit citing 42.6% of 2023 entries affected (Thailand Customs Audit, 2023).

3. Evaluate the Effectiveness of Optimization Strategies:

Multiple innovative strategies were proposed and evaluated based on interview feedback and document reviews:

IMEI pre-recording: Reported order-change reductions (~67%) and clearance time improvements (up to ~40%) in pilot contexts.

Blockchain-based customs flows: Documentation described transparency gains and a shift from ~96h to ~36h processing in test lanes.

AR visual inspection: Reduced open-box inspections and handling risk; applied mainly to model/grade/accessory verification.

Multimodal (Rail + Chiang Mai warehouse): Reported cost reductions (~18%) on selected lanes and ~40% faster sorting at a smart-warehouse pilot.

Localized delivery practices: Temple/community drop-off points and bilingual teams were associated with higher acceptance rates and improved last-mile satisfaction in regional districts.

4. Recommend solutions for improving logistics performance in the cross-border second-hand electronics trade:

One of the most disruptive regulatory bottlenecks in the China–Thailand second-hand mobile phone trade is the persistent misclassification of devices during customs clearance, which directly stems from the continued use of outdated Harmonized System (HS) codes and lack of clarity in categorizing refurbished electronics.

Using the Thailand-specific evaluation model, the study compared logistics performance across four corridors as show on table 1:

Table 1 Results from Comparative Benchmarks

Corridor	Time Lag (Days)	Clearance Rate	Cost/KG	Rework Rate
China–Thailand	8–12	76%	$0.38	2.3%
China–Vietnam	5–7	63%	$0.25	4.1%
China–Europe	18–22	91%	$0.42	1.2%
China–Middle East	10–14	88%	$0.42	1.8%

These comparisons highlight that while Thailand has competitive rework rates, it lags in clearance speed and transport costs.

- Common reports across roles: pre-recorded IMEIs accelerated clearance; holiday periods required proactive scheduling; e-waste misclassification produced significant delays and added costs; bilingual teams and centralized return hubs supported service quality.
- Technology mentions included AI document tagging, AR-assisted inspection, and tracking visibility for returns.

Conclusion Discussion and Recommendations

Conclusion

This study set out to improve the logistics of shipping second-hand mobile phones from China to Thailand by addressing key objectives: identifying logistics bottlenecks, examining cultural and regulatory constraints, evaluating optimization strategies, and proposing viable recommendations. The findings confirm that while the second-hand mobile phone market is growing due to circular economy trends, significant logistical inefficiencies still hinder the full realization of trade potential in the China–Thailand corridor.

In response to Objective 1.2.1, the study revealed that transportation bottlenecks persist, particularly the underutilization of rail and air transport, inefficiencies at Laem Chabang Port, and reverse logistics delays due to inadequate infrastructure and customs re-entry barriers. Customs clearance inefficiencies especially misclassification and lack of IMEI integration further compound delivery delays.

Regarding Objective 1.2.2, cultural and regulatory constraints play a non-trivial role. Religious content filtering and disruptions during Buddhist holidays, along with stringent TISI certification, IMEI documentation, and outdated HS codes, contribute to high compliance burdens and logistical unpredictability.

To meet Objective 1.2.3, the study examined optimization strategies such as IMEI pre-recording, blockchain-based customs systems, AR visual inspection, and multimodal logistics integration via the China-Laos-Thailand railway. Results showed significant improvement in clearance speed, cost reduction, and customer satisfaction.

Finally, in response to Objective 1.2.4, strategic recommendations were proposed to streamline customs processes, improve transportation mode usage, localize logistics operations,

and strengthen reverse logistics. These actions collectively aim to enhance the efficiency, reliability, and sustainability of cross-border second-hand electronics logistics.

Discussion

The discussion below links the empirical results to those objectives, situates them in relevant theory (trade facilitation, multimodal/network design, circular economy/reverse logistics), and aligns with prior evidence while grounding all points in the corridor's regulatory, cultural, and infrastructural realities.

1) Customs modernization and digital preprocessing (Objective i & ii)

Persistent delays around IMEI registration and invoice verification corroborate regional findings that uneven adoption of trade-facilitation and cross-border paperless trade measures sustains friction and raises costs (UNESCAP & ASEAN Secretariat, 2023; ERIA, 2023; World Bank, 2023). Within this context, Thailand's consumer-protection and cultural-safeguard rules are legitimate yet add procedural steps that stretch clearance time. The study's recommended countermeasures—pre-arrival IMEI and e-invoice submission, secure EDI/blockchain, and technology-assisted inspections—mirror global customs-modernization practice and the evidence base on advanced technologies in border management (WCO & WTO, 2022; UNCTAD, 2024; Department of Telecommunications, Government of India, 2023). These findings are consistent with Panitda Saiyarod, (2023). found that the Mekong region has seen an increase in infrastructure projects aimed at improving transportation and connectivity between China and neigh boring countries. These projects feature border control points, customs checkpoints, and security forces, leading to state control over cross-border trade mobility. Logistical power has gradually penetrated the social life in border trading, selectively facilitating certain groups while excluding others. Despite the overarching influence of state control, local traders still assert their agency in shaping cross-border trade practices, and consistent with The Study Report on Disruptive Technologies (WCO, 2019) shows that a few advanced technologies that have completely changed the way things are done (i.e. disruptive technologies) have had a significant impact on customs procedures. These technologies will continue to benefit the work of customs authorities in the future and include developments in blockchain, IoT, big data analytics, AI and machine learning, biometrics, drones, virtual and augmented reality, and 3-D printing of these, three areas of advanced technology in particular play a significant role in the future work of customs authorities and in facilitating cross-border trade

2) Theoretical contribution: embedding culture as an operational variable (Objective ii)

A core theoretical contribution is treating cultural constraints (e.g., religious-imagery screening; holiday slowdowns) as model inputs that influence exception probability, last-mile outcomes, and rework. This extends logistics and circular-economy theory traditionally technical and infrastructure-centric by showing that culturally responsive operating practices (e.g., community/temple pickup points, bilingual Thai Chinese teams) can raise service quality and compliance in settings where cultural

norms are operationally salient. These findings are consistent with Mentzer et al. (2001), described transportation as the most visible logistics component to customers, directly impacting their perception of service quality., and consistent with Rushton et al. (2014) assert that optimized distribution supports service quality, even if not always directly visible to customers.

3) Multimodal integration and network resilience (Objective ii)

Under-utilization of the China–Laos–Thailand Railway and gateway delays are consistent with literature on weak multimodal integration in emerging corridors. The proposed smart transit warehouse in Chiang Mai coupled with rail–truck scheduling and digital yard/process visibility fits network-design principles that buffer variability, shorten domestic lead times, and shift flows from road-only patterns toward more reliable combinations (World Bank, 2023). These findings are consistent with Panitda Saiyarod, (2023). found that the dynamic relationship between state control and various actors in cross-border trade in the Mekong region. It calls for an inclusive strategy in developing border infrastructure, aiming to ensure equitable benefit distribution and actively integrate the voices and experiences of those most impacted by these changes into the planning and execution of regional projects., and consistent with Bowersox et al. (2013) and Christopher (2016), who argued that integrated logistics processes enhance operational efficiency, reduce variability, and raise service expectations.

4) Reverse logistics and circular value retention (Objective i & ii)

Comparisons with European benchmarks highlight under-developed reverse-logistics infrastructure in Southeast Asia, with fragmented take-back channels and low formal collection rates (ERIA, 2023; ITU & UNITAR, 2024). The study's practical measures certified return centers, IMEI-linked return tracking, and clearer re-entry procedures are consistent with circular-economy logic: faster loops, higher recovery value, and improved customer experience. These findings are consistent with Rushton et al. (2014) assert that optimized distribution supports service quality, even if not always directly visible to customers., and Zeithaml et al. (2020) emphasized that consistent service performance enhances trust and emotional confidence, both essential to long-term relationships.

5) Thailand-specific evaluation model (Objective iii)

The six-indicator framework (time, cost, security, connectivity, clearance efficiency, service quality) answers calls for localized performance measurement in heterogeneous corridors, enabling office-/node-level benchmarking rather than relying on national averages (World Bank, 2023; UNESCAP & ASEAN Secretariat, 2023). It operationalizes the corridor's exception loop (IMEI mismatch ⟶ HS reclassification ⟶ cultural/imagery rework) as a mediator linking interventions to outcomes. These findings are consistent with Gatton (2015) suggested, modern supply chains must adapt to rising customer expectations for fast, transparent, and reliable service. Organizations that invest in real-time tracking, inventory visibility, and delivery precision will be better equipped to deliver superior experiences.

6) Policy implications (Thailand and ASEAN)

Thailand: Institutionalize pre-arrival paperless submission (IMEI lists, e-invoices), expand risk-management lanes, and deploy AR-enabled inspections at high-volume gateways (WCO & WTO, 2022; UNCTAD, 2024). Issue guidance/sub-headings distinguishing refurbished devices from e-waste; broaden AEO/broker accreditation for refurbished-device chains.

ASEAN/regional: Accelerate ASEAN Single Window (ASW) interoperability for device documentation; use ACTS for multimodal transit; pursue mutual recognition of refurbishment/testing certificates and AEO MRAs; align with the UNESCAP Framework on Cross-border Paperless Trade to standardize data elements (UNESCAP & ASEAN Secretariat, 2023; ERIA, 2023).

7) Limitations and future research (scope & generalizability)

The evidence base is corridor-specific and relies on a small, purposefully selected sample during a period of evolving regulations, which may limit external validity. To strengthen generalizability, future work should build multi-year shipment-level panels across modes and gateways; use Difference-in-Differences/Triple-Difference designs around digital policy rollouts; and integrate mixed-methods (interviews, time-and-motion) to validate mechanisms and quantify heterogeneous effects.

Recommendations

Recommendations for the Business

To improve logistics performance in the cross-border second-hand mobile phone trade, the following recommendations are presented:

1. Streamline Customs Processes (Pilot); Launch a pre-arrival data pilot: mandatory IMEI pre-recording + e-invoices; run a blockchain/secure-EDI proof-of-concept with one broker + one refurbishes; create HS-code quick guides for entries most at risk of misclassification.

2. Integrate pre-arrival pipelines with the national single window; full blockchain/secure-EDI rollout across suppliers; connect IMEI verification to national CEIR/telecom databases where available.

3. Enhance Reverse Logistics Infrastructure (Start); Stand up two certified return centers (Bangkok, Chiang Mai) with standardized RMA intake, diagnostic benches, and grade-repacking; contract regional carriers for scheduled return sweeps.

4. Promoting Multimodal Transport; Shift selected lanes to rail + short-haul truck; align with China–Laos–Thailand timetables; start transit cross-dock in Chiang Mai for northern distribution.

5. Integrate Cultural Sensitivity in operations; Train bilingual Thai Chinese dispatch & customer care; pilot community parcel points (e.g., permitted community/temple centers) with clear SOPs; pre-check for culturally sensitive imagery in listings/packaging.

6. Develop the Chiang Mai transit hub into a bonded facility (as feasible); negotiate rail block-space agreements; create sea-rail routings for peak smoothing.

7. Build an HS/IMEI/TISI playbook (device grades, sample photos, accessory lists); enforce documentation checklists with suppliers; map HS extensions likely to apply to refurbished vs. waste categories; keep evidence folders per SKU.

8. Update HS codes to differentiate refurbished devices from e-waste and harmonize TISI and IMEI requirements with ASEAN partners.

9. Adopt AR and AI Technologies Scale; AR-assisted checks for grade verification and accessories; AI tagging of invoices/packing lists to flag HS & IMEI anomalies before handover to brokers.

With implementation roadmap priorities.

- Quarter 1–2: Pre-arrival pilot (IMEI + e-invoice), AR lane at one gateway, set up Bangkok/Chiang Mai return centers, initiate ASW/ACTS coordination.
- Quarter 3–4: Rail block-space agreements, expand AR to second gateway, publish first KPI bulletin; begin AEO/broker accreditation intake.
- Year 2–3: Full blockchain/EDI rollout, bonded Chiang Mai hub, ASEAN MRAs progress, national dashboard public release, scale green corridors.

Recommendations for Future Research

1. Conduct quantitative modeling of logistics cost savings by adoption intensity; business case (NPV/IRR) under conservative vs. aggressive rollouts; policy brief on clearance-time reductions from AR and blockchain implementation.

Extending research scope to include other second-hand electronics such as multinomial/ conditional logit for mode choice (air/rail/sea-road) as a function of value density, delivery SLAs, and inspection risk.

2. Develop a national logistics performance dashboard (Thailand-specific model) by set up a secure ETL pipeline ingesting customs EDI, port/rail terminal logs, and broker/carrier milestones; publish open, aggregated KPIs with privacy safeguards or establish a data dictionary and API for monthly corridor metrics; align with national digital-customs standards.

New knowledge gained from research studies

1. Empirical contribution. This study moves beyond generic "digitalization" to show where and how targeted changes deliver measurable gains. We identify structural causes of under-utilization (e.g., 29% empty backhauls, 48–72 h airport clearance), node-specific reliability gaps (Laem Chabang demurrage; China–Laos–Thailand loss rates), and a hidden reverse-logistics bottleneck (~27 days). Mechanistically, we surface an exception-loop triad—IMEI mismatch ⟶ HS reclassification ⟶ cultural/imagery rework—that better explains tail delays than volume alone. Tested interventions—pre-arrival IMEI/e-invoices, blockchain/secure-EDI, AR inspection, and rail + inland smart warehousing—reduce time and cost while improving service.

2. Theoretical & methodological contribution. We position culture as an operational variable and foreground tail-risk (P95) performance as a core efficiency metric, extending logistics and circular-economy models beyond purely technical constraints. Methodologically, a Thailand-specific,

six-indicator evaluation model links qualitative mechanisms to operational KPIs, enabling office- and node-level benchmarking.

3. Policy & managerial implications. Immediate priorities include clarifying HS codes for refurbished vs. e-waste, institutionalizing pre-arrival paperless trade, deploying AR lanes at high-volume gateways, and advancing ASEAN harmonization (ASW/ACTS interoperability, mutual recognition of refurbishment/testing certificates, AEO MRAs). For managers: prioritize pre-arrival + AR at delay hot spots, establish certified return hubs, and shift eligible flows to rail + cross-dock.

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