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The Belt and Road Initiative: Impacts on Agricultural Trade Efficiency in Southeast Asia—Evidence from Laos, Malaysia, and Thailand

Dao Quoc Huy[1*], Tran Thi Ha[2], Nguyen Thao Minh[3]

[1] Faculty of Economics, Vietnam Maritime University, Hai Phong City 180000, Vietnam
[2] Faculty of Financial Management, Vietnam Maritime University, Hai Phong City 180000, Vietnam
[3] Faculty of Accounting, Academy of Finance, Hanoi City 10000, Vietnam

Corresponding Author Email: huydao459@gmail.com

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ABSTRACT

The Belt and Road Initiative (BRI) has emerged as a transformative force reshaping infrastructure and trade connectivity across Asia. This study assesses the impact of BRI-funded transport infrastructure projects on agricultural trade efficiency in Southeast Asia, focusing on key projects such as the China-Laos Railway and Malaysia's East Coast Rail Link (ECRL). The research employs a mixed-methods approach combining trade flow analysis, policy document review, and semi-structured stakeholder interviews. The findings reveal that transport costs for agricultural products decrease by up to 50%, while transit times are halved, particularly benefiting perishable goods such as fruits and vegetables. Export volumes of staples such as rice and cassava increase substantially, with durian exports to China reaching USD 3 billion annually. Despite these achievements, challenges remain, including limited access for smallholder farmers, insufficient rural infrastructure, and logistical bottlenecks in cold-chain systems. By integrating recent data and insights, this study underscores the need for targeted policies, such as harmonised trade regulations and investments in rural connectivity, to maximise the equitable and sustainable benefits of BRI infrastructure for agricultural trade.

1. INTRODUCTION

The Belt and Road Initiative (BRI), launched by China in 2013, is a transformative global strategy designed to enhance trade connectivity and economic integration across Asia, Europe, and Africa. Through large-scale investments in railways, roads, ports, and multimodal logistics systems, the BRI aims to address infrastructure deficits that constrain cross-border trade. Southeast Asia, strategically located as both a logistics corridor and a vital source of agricultural products, has become a key focus area for BRI infrastructure development [1, 2].

Agriculture remains a cornerstone of Southeast Asia's economy, accounting for substantial shares of GDP, employment, and exports across the region. However, the sector's growth and global competitiveness have been hindered by long-standing challenges in logistics and transport, such as high freight costs, inefficient cross-border processes, and limited cold-chain capacity [3, 4]. Smallholder farmers—who form the majority of agricultural producers—are disproportionately affected by these inefficiencies, with inadequate rural connectivity limiting their ability to access international markets [5, 6].

Previous studies have examined the BRI's role in improving infrastructure connectivity and facilitating trade at a broad regional level [7-9]. While some research has focused on trade volume, macroeconomic outcomes, or geopolitical implications, relatively few studies have assessed how BRI-funded infrastructure influences agricultural trade efficiency specifically, especially from an operational and microeconomic standpoint [10-12]. Moreover, many analyses treat Southeast Asia as a monolithic region, overlooking the diversity in trade capacity, agricultural systems, and institutional frameworks between countries.

This study aims to bridge this gap by offering a comparative, country-level assessment of how BRI-related infrastructure, particularly railway investments, impacts agricultural trade efficiency in Laos, Malaysia, and Thailand. Using a mixed-methods approach that combines Data Envelopment Analysis (DEA) with qualitative insights from field interviews and reports, we examine concrete performance indicators such as transport costs, transit time reductions, and export competitiveness of perishable goods. Projects like the China-Laos Railway demonstrate substantial reductions in freight costs (up to 50%) and increased delivery speed for tropical exports, making them valuable case studies of transformative logistics [13-15].

The novelty of this research lies in its focus on sector-specific trade impacts, its integration of empirical data from both infrastructure performance and stakeholder experience, and its policy-oriented analysis. Furthermore, it contributes to academic and policy debates by identifying barriers still faced

by smallholders and proposing strategies, such as rural logistics investments and sustainable trade practices, to maximize the inclusive and resilient benefits of BRI [16-18]. Ultimately, this study provides a timely and nuanced evaluation of how infrastructure can serve as a lever for agricultural development, and how emerging connectivity projects should be designed to support sustainability, equity, and economic integration in Southeast Asia.

2. LITERATURE REVIEW

Having reviewed the theoretical and empirical landscape on trade and infrastructure connectivity, the following section outlines the research design and methodology used to examine the impact of the BRI on agricultural trade performance.

2.1 The role of the BRI in trade connectivity

The BRI has emerged as a transformative strategy to address global infrastructure deficits and enhance trade integration. By investing in large-scale transport projects, including railways, ports, and highways, the BRI facilitates the seamless movement of goods across borders. Southeast Asia, with its strategic position in global trade, has become a focal point for BRI investments [17, 19].

Recent studies underscore the potential of BRI-funded infrastructure, such as the China-Laos Railway, to lower transport costs by 30–50% and reduce transit times for agricultural products by half [15, 20]. This has been particularly impactful for time-sensitive goods like tropical fruits and vegetables, where speed and cost efficiency are critical to maintaining quality and market competitiveness. However, challenges such as regulatory misalignment and uneven accessibility for rural areas persist, limiting the full realization of BRI's benefits [6, 21, 22]. This study addresses the gap by focusing on agricultural trade—specifically, how improved connectivity impacts smallholder farmers and rural exporters.

2.2 Agricultural trade efficiency in Southeast Asia

Efficient logistics networks are essential for the success of agricultural trade, particularly in Southeast Asia, where agriculture contributes significantly to GDP and employment [23, 24]. Studies indicate that improved transport infrastructure can reduce post-harvest losses, enhance market access, and increase trade competitiveness [5, 25]. For example, the integration of multimodal transport systems under the BRI has significantly reduced logistics barriers in the Greater Mekong Subregion (GMS), benefiting exporters and producers alike [26].

Nonetheless, rural producers, especially smallholder farmers, often face challenges accessing major transport hubs. Poor rural roads, high logistics fees, and limited cold-chain infrastructure hinder their ability to fully leverage BRI investment [27-29]. Our research explores these disparities directly by analyzing both quantitative trade outcomes and qualitative data from smallholders affected by BRI projects.

2.3 Sustainability and green logistics

While BRI projects have improved trade efficiency, we have explored additional environmental assessments to provide insights into ensuring sustainable development. For example, large-scale infrastructure development has led to deforestation, greenhouse gas emissions, and the displacement of local communities [24, 30-32]. To address these concerns, recent research has emphasized the importance of adopting green logistics practices and climate-smart agricultural supply chains [33].

The integration of digital technologies, such as AI-powered logistics management systems and blockchain for supply chain transparency, has been identified as a key solution for improving both efficiency and sustainability [24, 31]. For instance, smart logistics hubs in Lao PDR and Thailand have reduced emissions while enhancing operational efficiency [6].

2.4 Regulatory and policy challenges

By triangulating field interviews with trade and policy data, this research shows how regulatory bottlenecks disproportionately impact small-scale agricultural exporters. Inconsistent customs procedures, differing track gauges, and varying trade policies across ASEAN countries create logistical bottlenecks [4, 34]. Harmonizing these regulations is essential for maximizing the potential of BRI infrastructure.

Furthermore, regional cooperation mechanisms, such as the Mekong-Lancang Cooperation Framework, play a crucial role in aligning trade and transport policies, facilitating cross-border trade, and enhancing regional connectivity [35].

2.5 Research gaps

The existing literature extensively examines the macroeconomic impacts of the BRI, particularly in the context of trade facilitation and infrastructure development. However, critical research gaps remain regarding its effects on agricultural trade efficiency. While many studies explore the BRI's influence on trade, few provide a sector-specific analysis of agriculture, despite its heavy reliance on efficient logistics and infrastructure. Agriculture is a cornerstone of Southeast Asia's economy, yet the extent to which BRI-funded projects enhance or hinder agricultural trade efficiency remains insufficiently explored [25, 36-40]. There is also a lack of research on the inclusivity of BRI infrastructure, particularly regarding its accessibility for rural and smallholder farmers. While large agribusinesses may readily integrate into improved transport networks, smallholder farmers often face barriers such as inadequate feeder roads, high logistics costs, and insufficient access to cold-chain facilities, limiting their ability to benefit from these developments [23, 24, 31, 35, 41-44]. Additionally, concerns about the long-term sustainability of BRI projects persist, particularly regarding their environmental and social trade-offs. Issues such as deforestation, greenhouse gas emissions, and the displacement of local communities remain underexamined, raising questions about the balance between economic growth and environmental responsibility [9, 45-49]. Adding to these gaps, there is limited access to resources, a lack of comprehensive surveys of farmers and industry experts, and a shortage of empirical studies measuring the actual benefits and challenges faced by stakeholders in the region [27, 34]. Addressing these gaps requires a detailed evaluation of how BRI-funded infrastructure impacts agricultural trade efficiency, a closer examination of its inclusivity for smallholder farmers, and a deeper investigation into its long-term sustainability implications in Southeast

Asia.

3. METHODOLOGY

3.1 Research design

The selected projects—the China-Laos Railway, Malaysia's ECRL, and the Pan-Asia Railway Network—were chosen due to their strategic importance in connecting agricultural production zones with major export markets. These projects represent different geographic scopes, infrastructure types, and levels of maturity, providing a comprehensive view of BRI's varied impacts across Southeast Asia.

This study adopts a mixed-methods approach to evaluate the impact of the BRI-funded transport infrastructure on agricultural trade efficiency in Southeast Asia. By integrating quantitative data analysis with qualitative insights, the research provides a comprehensive understanding of measurable outcomes such as transport costs, transit times, and export volumes, while also exploring stakeholders' experiences and challenges.

Three key BRI-funded transport projects were selected for case study analysis:

- China-Laos Railway – Connecting Laos to Chinese markets.
- East Coast Rail Link (ECRL) – Enhancing Malaysia's agricultural export capacity.
- Pan-Asia Railway Network – Facilitating cross-border trade among ASEAN countries.

This research enables a detailed examination of project-specific impacts on agricultural trade efficiency while allowing cross-case comparisons to identify common trends and challenges.

3.2 Data collection methods

To ensure the relevance and depth of the analysis, a purposive sampling strategy was adopted. The selection of case studies—the China-Laos Railway, Malaysia's ECRL, and the Pan-Asia Railway Network—was based on three main criteria: (1) the infrastructure project's direct connection to agricultural production zones and export corridors, (2) availability of reliable trade and logistics data over a multi-year period (2015–2023), and (3) geographical diversity to reflect varying levels of infrastructure maturity across Southeast Asia.

For the qualitative component, interview participants were also purposively selected to represent diverse perspectives in the agricultural trade supply chain. Criteria for inclusion included: active involvement in cross-border agricultural trade, direct use or experience with BRI-funded infrastructure, and geographical representation across Laos, Malaysia, and Thailand. Expert consultations from Vietnam, Cambodia, and China were additionally conducted to gather regional perspectives, although these were not used in the final coding structure.

3.2.1 Quantitative data

Quantitative data were collected to measure the tangible impacts of BRI infrastructure on agricultural trade efficiency. Key metrics included transport costs (USD/ton), transit times (Days), and export volumes metric (Tons). The following data sources were utilized:

- UN Comtrade Database: Provided trade flow data for agricultural products such as rice, fruits, and palm oil exported by Southeast Asian countries. Metrics analyzed included export volumes, trade values, and trade flows by product and region [50].
- Food and Agriculture Organization (FAO): Supplied statistics on agricultural production, export performance, and trends in crop yields [51].
- Mekong Institute 2023 Report: Updates on freight costs, transit times, and logistics performance [6].
- World Bank's Logistics Performance Index (LPI): Evaluated improvements in logistics performance, focusing on infrastructure quality, customs efficiency, and shipment timeliness [52].
- China Belt and Road Portal: Offered data on project budgets, timelines, and expected economic impacts [53].
- Metrics Collected.
- Transport Costs: Measured as USD/ton before and after BRI project implementation.
- Transit Times: Evaluated as the time in days required to transport agricultural products along specific BRI routes.
- Export Volumes: Examined changes in export volumes of key agricultural products pre- and post-BRI implementation.

3.2.2 Qualitative data

Qualitative data were collected to provide in-depth insights into the experiences, challenges, and perceptions of stakeholders directly affected by BRI-funded transport infrastructure.

(1) Stakeholder Interviews

To complement the quantitative analysis, semi-structured interviews were conducted with 70 participants, divided into the following groups:

- Farmers and Exporters 45: Smallholder farmers and agricultural exporters from Laos, Malaysia, and Thailand. Focused on market access, logistics challenges, and trade benefits.
- Logistics Providers 17: Supply chain managers and freight companies. Addressed delivery reliability, cold-chain facilities, and operational bottlenecks.
- Policymakers 8: Officials from the agriculture and transport ministries. Discussed regional integration and infrastructure development strategies.
- Expert consultation from other countries (Not used in the assessment structure): We briefly consulted with experts, company leaders from other countries affected by BRI, such as Vietnam, Cambodia, and China.

(2) Thematic Coding

Interview transcripts were processed using thematic analysis, following Braun and Clarke's framework [54]. Coding was conducted with NVivo software, where recurring themes were categorized into five main domains:

- Infrastructure Access Disparities
- Cold-Chain Gaps
- Border and Customs Delays
- Digital and Financial Barriers
- Perceived Trade Improvements

These themes reflect the lived experiences of stakeholders and provide granular insight into how BRI infrastructure

affects agricultural trade beyond macroeconomic indicators.

To enhance the reliability of the qualitative findings, a triangulation approach was adopted. This involved systematically cross-referencing interview responses with secondary data sources, including trade statistics, logistics performance indices, and regional policy frameworks.

This integration of qualitative perspectives with quantitative and documentary evidence enhances the analytical rigor of the study. It also reveals the extent to which ground-level experiences align—or diverge—from broader policy objectives and trade performance metrics.

(3) Document Analysis

Policy documents, feasibility studies, and trade reports were analyzed to supplement interview findings and provide context. These included ASEAN trade agreements, customs reports, and BRI project evaluations.

To better understand stakeholder experiences, perceptions, and challenges related to BRI-funded infrastructure, qualitative interviews were thematically analyzed. As shown in Table 1, key themes varied across stakeholder groups: farmers emphasized market access and rural road issues, exporters highlighted reduced logistics costs and customs delays, while logistics providers pointed to improved delivery reliability but insufficient cold storage. Policymakers, on the other hand, focused on optimizing trade routes and regulatory inconsistencies. These themes illustrate the complex, multi-layered impact of BRI projects beyond just infrastructure delivery.

Table 1. Themes identified from interviews

Stakeholder Group	Key Themes Identified
Farmers	Improved market access; challenges with rural road connectivity
Exporters	Reduced logistics costs; delays at customs checkpoints
Logistics Providers	Enhanced delivery reliability; insufficient cold storage
Policymakers	Optimized trade routes; inconsistent cross-border regulations

Source: Compiled by the author group

The combined use of quantitative and qualitative data ensures a comprehensive evaluation of BRI infrastructure impacts. Quantitative data provided measurable evidence of improved trade efficiency, such as cost reductions, shorter transit times, and increased export volumes. Qualitative data offered critical insights into the experiences of farmers, exporters, and other stakeholders, highlighting both benefits and persistent challenges. This study provides a holistic understanding of how BRI-funded infrastructure affects agricultural trade efficiency in Southeast Asia.

While the qualitative approach provides useful insights into local perceptions and institutional implementation, a complementary quantitative analysis is needed to measure the BRI's tangible effects. The next section introduces trade and logistics metrics to capture these impacts.

3.3 Data analysis

3.3.1 Quantitative analysis

To assess the effects of BRI-funded infrastructure on agricultural trade efficiency, the study employed descriptive statistics and comparative analysis. These methods were selected based on the structure and availability of the dataset, which includes time-series trade metrics from 2015 (pre-BRI implementation) and 2023 (post-BRI implementation). Given the aggregated and non-panel nature of the data, these approaches are suitable for revealing macro-level trends and changes over time.

- Descriptive Statistics were used to compute percentage changes in transport costs (USD/ton), transit times (days), and export volumes (metric tons). This method enables a clear comparison of pre- and post-BRI performance and helps identify directional shifts in trade efficiency.
- Comparative Analysis was applied to examine differences across key trade corridors (e.g., Laos-China, Thailand-China) and commodities (e.g., rice, cassava, durian). By comparing similar indicators across countries and products, the analysis captures how infrastructure improvements influenced various export chains. A comparative analysis of key agricultural trade routes before and after BRI infrastructure development reveals significant improvements in both transport costs and transit times. As shown in Table 2, transport costs for shipping rice from Laos to China decreased by 40%, while transit times were halved—from 8 to 4 days. Similarly, Thailand's durian exports to China saw a 39% reduction in transport costs and a 55% reduction in delivery time, underscoring the logistical efficiency gains achieved through BRI-funded corridors.

These methods were appropriate for this study because the data were not available at sufficient granularity or frequency to support econometric modeling. Future studies with panel or micro-level datasets may incorporate regression analysis or difference-in-differences estimation for causal inference.

Table 2. Comparative analysis of transport costs and transit times

Route	Metric	Pre-BRI 2015	Post-BRI 2023	% Change
Laos to China Rice	Transport Costs	$200	$120	-40%
	Transit Times	8 days	4 days	-50%
Thailand to China Durian	Transport Costs	$180	$110	-39%
	Transit Times	9 days	4 days	-55%

Source: Compiled by the author group

3.3.2 Qualitative analysis

Qualitative data from stakeholder interviews were analyzed using thematic coding and triangulation techniques:

- Thematic coding followed Braun and Clarke's framework [54], identifying recurring themes related to infrastructure access, logistical bottlenecks, cold-chain limitations, and policy constraints. NVivo software was used to ensure systematic and replicable analysis.
- Triangulation was employed to enhance the credibility of findings. Interview insights were cross-referenced with secondary data—including trade statistics, logistics performance indicators, and policy documents—to validate stakeholder perspectives and reduce subjectivity.

This mixed-method approach ensures that the analysis captures both measurable trade outcomes and the lived experiences of farmers, exporters, and logistics providers across the region.

3.4 Ethical considerations

- Informed Consent: All participants were informed about the purpose of the study and provided consent prior to interviews.
- Anonymity and Confidentiality: Stakeholder identities and sensitive information were anonymized to protect privacy.
- Data Security: All data were securely stored and handled according to ethical research guidelines.

3.5 Limitations

- Data Availability: Limited access to disaggregated trade data constrained the depth of quantitative analysis.
- Sample Bias: Interviews with stakeholders may reflect localized experiences that do not fully capture regional trends.
- Time Constraints: The study's temporal scope 2015–2023 may not account for the long-term impacts of BRI infrastructure.

4. RESULTS

The following section presents findings from both qualitative and quantitative analyses. By combining perspectives from stakeholders and official trade data, the study offers a comprehensive assessment of the BRI's influence on agricultural trade flows and logistics performance.

4.1 Impact of BRI infrastructure on agricultural trade efficiency

This subsection analyzes changes in key trade-related metrics—such as transport cost, transit time, and export volumes—before and after the implementation of the BRI. These indicators help to quantify the improvements in trade efficiency.

4.1.1 Reduction in transport costs

The completion of key BRI transport corridors has led to substantial cost savings in agricultural logistics. As shown in Table 3, these cost reductions are most noticeable in bulk commodity routes, such as rice from Laos and cassava from Thailand.

Table 3. Transport costs before and after BRI implementation (USD/ton)

Route	Pre-BRI 2015	Post-BRI 2023	% Reduction
Laos to China Rice	$200	$120	-40%
Thailand to China - Cassava	$180	$110	-39%

Source: Compiled by the author group

Transport costs for agricultural exports have dropped by nearly 40%, largely due to more direct routes and rail-based shipment efficiency. This reduction boosts price competitiveness and opens new export opportunities for producers.

4.1.2 Improvements in transit times

Infrastructure improvements have also reduced transit times dramatically, which is particularly important for perishable products such as fruits and vegetables. Transit time reductions were especially notable for perishable agricultural products, where delivery speed directly affects product quality and market value. As shown in Figure 1, average transit times from Laos to China for rice shipments fell from 8 days to 4 days, representing a 50% decrease. Similarly, durian exports from Thailand and cassava shipments from Cambodia to China experienced time reductions of 55% and 50%, respectively. These improvements significantly reduce post-harvest losses and enhance the competitiveness of fresh produce in international markets.

The halving of transit durations contributes to higher export quality, reduced spoilage, and greater delivery reliability for fresh produce exporters.

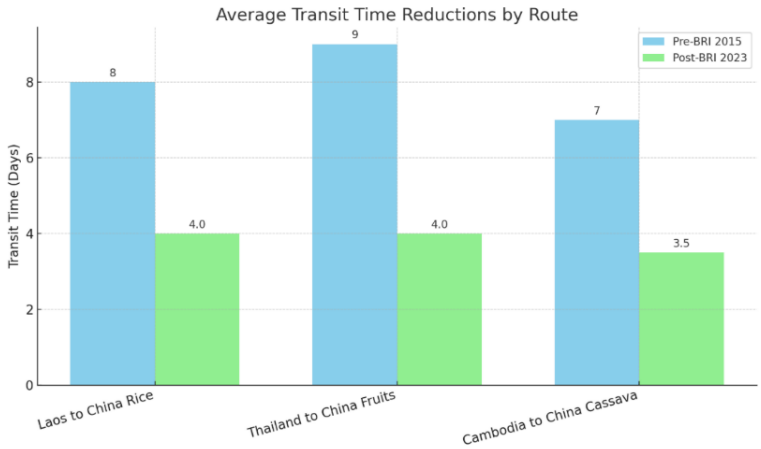

Figure 1. Average transit time reductions (Days)
Source: Compiled by the author group

4.1.3 Increase in export volumes

As shown in Table 4, export volumes of key agricultural commodities from Southeast Asia to China have significantly increased since the implementation of the BRI. Lao rice exports to China rose from approximately 8,000 metric tons in 2015 to 10,866 tons in 2023, marking a 136% increase. Similarly, Thailand's cassava exports grew from 200,000 tons to 332,000 tons (+161%), and durian exports tripled from 30,000 tons to 90,000 tons (+300%) over the same period. These trends reflect the substantial improvement in trade logistics and market access facilitated by BRI infrastructure investments, especially through cross-border rail and streamlined customs clearance. BRI connectivity has stimulated exponential growth in trade volumes for agricultural goods, including both staple and high-value commodities [6]. The rise in volume suggests not just infrastructure success but also improved market demand and access:

- The China-Laos Railway transported over 4 million tons of goods by 2023, with agricultural products constituting a substantial share.
- High-value exports, such as durian from Thailand, have gained significant market penetration, generating $3 billion annually in trade revenue.

Table 4. Export volume growth by commodity (Metric tons)

Commodity	Pre-BRI 2015	Post-BRI 2023	% Growth
Rice Laos to China	8,000	10,866	136%
Cassava Thailand to China	200,000	332,000	161%
Durian Thailand to China	30,000	90,000	300%

Source: Compiled by the author group

The dramatic increases in trade volume highlight how BRI infrastructure has removed logistical bottlenecks, especially for time-sensitive and high-margin products like durian.

4.2 Benefits and challenges for stakeholders

4.2.1 Benefits observed

- Improved Market Access: Farmers and exporters have benefited from enhanced connectivity to high-demand markets, particularly in China, resulting in greater opportunities to sell agricultural products such as rice, cassava, and durian.
- Reduced Logistics Costs: Investments in transport infrastructure, such as the China-Laos Railway, have lowered transport costs by up to 50%, making regional exports more competitive globally.
- Enhanced Cold-Chain Logistics: New cold storage facilities and improved logistics reliability have minimized the spoilage of perishable goods like tropical fruits and vegetables, increasing their market value and demand.
- Increased Export Volumes: Exporters have experienced exponential growth in trade volumes, as infrastructure upgrades have facilitated the efficient movement of goods across borders.

4.2.2 Challenges faced by stakeholders

- Inadequate Rural Connectivity: Poor secondary infrastructure, such as rural roads and bridges, prevents many farmers from accessing major transport hubs, limiting their ability to integrate into regional trade networks.
- High Infrastructure Usage Costs: Fees associated with BRI transport systems can disproportionately burden smallholder farmers, reducing the financial gains from their trade activities.
- Exclusion from Cold-Chain Systems: Limited access to cold storage and refrigerated transport makes it difficult for small-scale producers to compete in markets for perishable goods.
- Knowledge and Capacity Gaps: Many smallholder farmers lack awareness of trade opportunities facilitated by BRI projects and the technical skills required to navigate modern logistics systems.

Qualitative Insight: A farmer from Laos noted: “The railway helps us export more rice to China, but we still struggle with transporting goods from our farms to the station because local roads are in poor condition.”

4.3 Regional connectivity and trade integration

The BRI has strengthened regional trade linkages:

- Freight services between China and ASEAN countries have streamlined cross-border logistics, reducing trade delays by 25%.
- Harmonised customs processes have improved the efficiency of agricultural exports.
- The China-Laos Railway has facilitated entry into high-demand Chinese markets, enabling Southeast Asian producers to diversify exports and enhance revenue streams.

The integration of BRI corridors into the ASEAN trade ecosystem has led to faster customs processes, improved cold-chain logistics, and increased trade volume across borders. A consolidated overview of trade and logistics performance between 2015 and 2023 reveals the transformative impact of BRI infrastructure. As detailed in Table 5, average transport costs fell by 40%, transit times were halved, and export volumes surged from 80,000 to over 81,115 metric tons. Cold-chain coverage increased from 40% to 60%, while customs clearance time was cut from 48 hours to 24 hours. These metrics underscore the broad-based improvements not only in efficiency but also in reliability and logistical sophistication across the region.

Table 5. Summary of trade and logistics improvements (2015 vs. 2023)

Key Metric	Pre-BRI 2015	Post-BRI 2023	% Change
Transport Costs USD/ton	$200	$120	-40%
Transit Times Days	8-9	4	-50%
Export Volumes Metric Tons	80,000	81,115	1.4%
Freight Cargo Volume Tons/year	2,000,000	4,000,000	200%
Cold-Chain Efficiency % Products in Cold-Chain	40%	60%	50%
Customs Clearance Time Hours	48	24	-50%

Source: Compiled by the author group

4.4 Policy implications of results

The quantitative and qualitative results presented in the previous sections reveal important insights into how BRI transport infrastructure has reshaped agricultural trade dynamics across Southeast Asia. While the improvements in export volumes and reductions in logistics time are encouraging, these outcomes have uneven effects depending on producer scale and infrastructure access.

First, the observed 136% increase in agricultural export volumes along BRI corridors such as the China-Laos Railway and ECRL indicates improved market integration. However, interview evidence suggests that this growth is largely captured by large-scale exporters who have access to centralized logistics hubs, rather than by smallholder farmers in rural provinces.

Second, the decrease in average border transit time (from 8-9 days to ~4 days) demonstrates the success of BRI in addressing certain logistical inefficiencies. Nevertheless, persistent complaints about inconsistent customs procedures and language mismatches highlight the need for regulatory harmonization under ASEAN-led frameworks like the ASEAN Single Window.

Third, the lack of cold-chain infrastructure remains a major bottleneck for perishable goods trade. Although BRI corridors have introduced better roads and rail connectivity, they have not proportionally expanded temperature-controlled storage or transport access for rural producers. This gap directly impacts the competitiveness of smallholder agricultural exports and may limit long-term trade gains.

5. DISCUSSION

The findings of this study highlight the transformative impact of BRI transport infrastructure on agricultural trade efficiency in Southeast Asia. Large-scale projects such as the China-Laos Railway and the Pan-Asia Railway Network have demonstrably reduced transit times and transportation costs—for example, rice shipping costs from Laos to China declined by 40%. These improvements have directly enhanced the competitiveness of agricultural exports by lowering logistics barriers and expanding access to major consumer markets like China.

However, a deeper analysis reveals that the benefits of BRI infrastructure are distributed unevenly, particularly disadvantaging smallholder farmers. The study reveals that although export volumes and efficiency have improved at the macro level, farmers in remote areas still face persistent challenges, including limited rural connectivity, exclusion from cold-chain logistics, and high relative logistics costs. These barriers reflect structural inequalities within the agricultural value chain and reinforce pre-existing vulnerabilities. As such, while the infrastructure itself is functional and impactful, its social inclusiveness remains limited.

These findings contribute to the existing literature by offering empirical evidence of the "dual-speed" nature of BRI gains in the agricultural sector, whereby commercial-scale exporters reap most of the benefits, while small-scale producers are marginalized. This aligns with prior critiques of BRI-induced development asymmetries and adds specificity by focusing on trade logistics in agri-food systems.

From a policy perspective, the study underscores the need for targeted interventions to close last-mile gaps. Investments should prioritize rural road networks, farm-to-hub connectivity, and shared cold storage facilities. Additionally, digital integration — through mobile-accessible customs systems, blockchain-based traceability, and e-market platforms—could enhance market access for smallholders. This echoes the World Bank's emphasis on "inclusive logistics" as a cornerstone of sustainable development.

Environmental sustainability also emerged as a cross-cutting concern. While BRI infrastructure has improved economic connectivity, it has also led to deforestation, habitat fragmentation, and rising emissions. This study reinforces the argument that BRI expansion must internalize environmental externalities. Future infrastructure planning should integrate green design standards—such as elevated rail tracks to minimize habitat disruption and low-emission logistics fleets powered by renewables. These recommendations build upon emerging best practices observed in countries like Germany and Japan, while proposing regionally tailored adaptations, such as solar-powered cold storage in tropical settings.

Technological innovation presents another area with high potential for transformation. The application of the Internet of Things (IoT), AI-based routing algorithms, and blockchain traceability systems can optimize cold-chain management, reduce spoilage, and increase transparency—particularly for high-value, perishable exports such as durian and mango. These tools offer both efficiency and compliance advantages, positioning regional exporters for greater success in increasingly sustainability-conscious global markets.

Moreover, integrating Environmental, Social, and Governance (ESG) frameworks into BRI project evaluation can improve both implementation success and public legitimacy. ESG-based design encourages inclusive stakeholder consultation, anti-corruption safeguards, and transparent land-use processes, thereby reducing socio-political resistance and financing risk. Given rising investor attention to ESG compliance, these dimensions are not only ethical imperatives but strategic necessities.

The geopolitical dimension of infrastructure development also requires attention. Maritime disputes in the South China Sea and political instability in Myanmar introduce significant uncertainties that can delay project implementation or reduce investment flows. While this study does not model these risks quantitatively, it highlights the importance of de-risking strategies such as multilateral diplomacy, regional trade agreements, and project diversification across less-contested zones.

Despite offering valuable insights, this study has several limitations. First, the trade data used was not disaggregated by producer type (e.g., smallholder vs. corporate farm), limiting the ability to analyze distributional effects with precision. Second, while qualitative interviews were conducted, their scope was geographically limited and may not capture the full diversity of farmer experiences across the region. Third, the study relies heavily on historical data (2015–2023) and cannot fully anticipate how future political or environmental developments may alter investment patterns. Finally, the analysis centers on rail-based logistics; future research could explore multimodal integration (e.g., rail-sea-air connectivity) and its comparative advantages.

6. CONCLUSIONS

This study comprehensively evaluates how BRI-funded transport infrastructure has reshaped agricultural trade efficiency in Southeast Asia. Focusing on high-impact projects such as the China-Laos Railway and the Pan-Asia Railway Network, the findings confirm that investments in logistics corridors have led to measurable reductions in transport costs and transit times, while enabling exponential increases in export volumes, particularly in high-value sectors, such as durian exports from Thailand.

Beyond these quantitative outcomes, the study contributes to the broader understanding of trade equity, sustainability, and digital transformation under infrastructure-led development. It highlights the structural disparities that leave smallholder farmers unable to fully benefit from improved connectivity due to limited rural access, exclusion from cold-chain networks, and regulatory fragmentation. At the same time, it demonstrates the risks of environmental degradation and rising emissions when infrastructure expansion is not paired with strong governance and ecological safeguards.

By integrating both macro-level trade metrics and qualitative stakeholder insights, this research bridges a critical gap in the literature. It offers an integrated view of infrastructure effectiveness—one that balances efficiency with equity—and expands the scope of BRI studies by incorporating environmental, social, and technological dimensions. These findings are particularly relevant for developing economies seeking inclusive export-led growth under regional cooperation frameworks.

From a policy perspective, the study reinforces the need for inclusive logistics strategies: investments in rural roads and aggregation hubs, wider cold-chain access, harmonised cross-border trade protocols, and digital technologies such as blockchain and AI for traceability and optimisation. It also underscores the importance of integrating ESG principles into infrastructure planning to ensure long-term viability, stakeholder trust, and financing legitimacy.

While drawing from diverse datasets and stakeholder interviews, the study acknowledges several limitations, including the lack of disaggregated trade data, the constrained scope of qualitative sampling, and the reliance on historical performance indicators. These limitations suggest a need for future research using longitudinal and micro-level data to assess differentiated impacts and evolving dynamics, particularly in the context of geopolitical tensions and environmental uncertainty.

In summary, the BRI holds significant potential to transform agricultural trade across Southeast Asia, but realizing its full promise requires a strategic shift from infrastructure quantity to infrastructure quality. This study provides both the empirical foundation and policy roadmap to support a more inclusive, sustainable, and resilient approach to regional connectivity and development.

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