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PHÂN TÍCH MỐI QUAN HỆ NHÂN QUẢ GIỮA GSCI VÀ LPI: PHƯƠNG PHÁP TIẾP CẬN CB-SEM

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Tóm tắt

Nghiên cứu này khám phá ảnh hưởng của Năng lực Cạnh tranh Bền vững đến Chỉ số Hiệu suất Logistics (LPI) thông qua khung đánh giá toàn diện và mô hình CB-SEM (Mô hình cấu trúc tuyến tính dựa trên hiệp phương sai). Năng lực Cạnh tranh Bền vững được đánh giá qua sáu khía cạnh: Điểm Vốn tự nhiên, Điểm Cường độ Tài nguyên, Điểm Vốn xã hội, Điểm Vốn trí tuệ, Điểm Bền vững Kinh tế, và Điểm Quản trị. LPI, một chỉ số quan trọng phản ánh hiệu quả logistics quốc gia, được phân tích qua sáu yếu tố chính: Điểm Thủ tục hải quan, Điểm Hạ tầng, Điểm Vận chuyển quốc tế, Điểm Năng lực và Chất lượng Logistics, Điểm Thời gian, và Điểm Theo dõi và Truy xuất. Thông qua CB-SEM, phương pháp định lượng và dữ liệu thực nghiệm, nghiên cứu đã làm sáng tỏ mối quan hệ giữa các chỉ số này, mang lại những thông tin quý giá về ảnh hưởng của các yếu tố bền vững đến hiệu suất logistics. Kết quả đã nhấn mạnh vai trò quan trọng của quản trị và bền vững kinh tế trong việc nâng cao chỉ số LPI, đề cao sự cần thiết của các chiến lược tích hợp, đảm bảo sự cân bằng giữa các yếu tố môi trường, xã hội và kinh tế.

Từ khoá: năng lực cạnh tranh bền vững, chỉ số hiệu quả logistics, phân tích CB-SEM, chỉ số cạnh tranh bền vững toàn cầu

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ANALYZING THE CAUSAL RELATIONSHIP BETWEEN GSCI AND LPI: A CB-SEM APPROACH

Abstract

This study investigates the impact of Sustainable Competitiveness on the Logistics Performance Index (LPI) using a comprehensive evaluation framework and CB-SEM (Covariance-Based Structural Equation Modeling). Sustainable Competitiveness is assessed through six dimensions: Natural Capital Score, Resource Intensity Score, Social Capital Score, Intellectual Capital Score, Economic Sustainability Score, and Governance Score. The LPI, a critical indicator of a country's logistics efficiency, is analyzed through its six key components: Customs Score, Infrastructure Score, International Shipments Score, Logistics Competence and Quality Score, Timeliness Score, and Tracking and Tracing Score. By leveraging CB-SEM, quantitative methods, and empirical data, this research explores the correlation between these indices, providing valuable insights into how sustainability factors influence logistics performance. The findings highlight the pivotal role of governance and economic sustainability in enhancing LPI outcomes, emphasizing the need for integrative strategies that balance environmental, social, and economic priorities. This study contributes to the discourse on sustainable development and offers practical implications for policymakers and logistics stakeholders aiming to optimize performance while promoting sustainability.

Keywords: sustainable competitiveness, logistics performance index, CB-SEM analysis, global sustainable competitiveness index

1. Introduction

Logistics is a complex series of services enabling the movement of goods. It facilitates global trade through a set of activities, from material handling to order fulfillment, which is heavily reliant on several sectors. A territory without efficient supply logistics, such as infrastructure networks, can seriously compromise its economic development (Sergi et al., 2021). In today’s era of globalization, logistics efficiency plays an important role in facilitating international trade, reducing costs, and improving service quality. Simultaneously, the global shift toward green and sustainable development has also underscored the need for logistics systems that align with environmental and economic sustainability. At the same time, nations are under pressure to enhance their economic competitiveness against global competition. This is because, in today's era of global integration, every nation and business alike faces intense competition from both domestic and international rivals. To secure profitability and economic growth, these entities must continuously enhance their competitiveness. Those who can fully leverage their strengths, invest in development, and focus on addressing weaknesses will ultimately emerge as winners in this economic battle. Examining those issues from many different points of view, logistics efficiency and international competitiveness seem to have a mutual relationship.

As countries face various challenges in navigating their complex economic environments, understanding the relationship between logistics and competitiveness becomes increasingly

essential. While existing studies have highlighted the role of logistics in economic growth, there is a notable gap in understanding how GSCI, which stands for sustainable competitiveness, interacts with LPI, which stands for logistics performance. By addressing this gap, the paper aims to explore the bidirectional causal relationship between international competitiveness and logistics efficiency, focusing on how the GSCI influences the LPI and vice versa. Through this study, the authors want to provide recommendations for policymakers and practitioners who want to implement effective strategies for enhancing logistics performance in the global market. The study recommends several strategic actions, which not only support economic growth but also contribute to the sustainable positioning of nations on the global stage, by providing valuable evidence of the interplay between logistics performance and sustainable competitiveness. Bridging the research gap between GSCI and LPI offers theoretical contributions and practical recommendations that can help nations achieve their long-term economic success.

2. Literature review

2.1. Logistics Performance Index (LPI)

2.1.1. Context and definition

In a globalized economy, efficient logistics systems are essential for reducing trade costs and supporting economic integration. However, before the introduction of LPI, many countries faced significant challenges in logistics performance due to the lack of standardized, comparable metrics for assessing logistics performance across countries. Therefore, the LPI was developed to fill this gap, providing actionable data and a framework for identifying areas of improvement.

The Logistics Performance Index (LPI) was developed by the World Bank in 2007 to help countries assess their trade logistics performance and identify challenges and opportunities (World Bank, 2023). It reflects the effectiveness and efficiency of supply chain logistics in specific countries. LPI can help governments identify areas needing to sign logistics-oriented development programs and allow countries to compare their logistics capabilities with others globally to identify reliable logistics hubs and supply chain partners.

2.1.2. Data collection

The LPI is based on data collected through a global survey of logistics professionals, such as freight forwarders and express carriers (World Bank, 2023). Respondents rate it on six core logistics performance components on a scale of 1 (low) to 5 (high), which can offer a detailed picture of a country's trade logistics environment and its ability to support international commerce effectively. For answered questions, missing responses are interpolated using the respondent's average deviation from the country mean.

Table 1: LPI's indicators

Indicators	Definitions

Customs	The efficiency, transparency, and predictability of the processes
Infrastructure	The quality of transport and trade-related infrastructure (ports, roads, IT systems,...)
International shipments	The ease of arranging cost-effective and reliable international shipments
Logistics competence	The competence and quality of logistics service providers
Tracking and tracing	The availability and reliability of tracking systems for shipments
Timeliness	The frequency of shipments arriving within the scheduled or expected delivery time

Source: World Bank (2023)

2.2. Global Sustainable Competitiveness Index (GSCI)

2.2.1. Context and definition

These days, there are more and more environmental and social challenges. Sustainable competitiveness is essential for achieving long-term economic growth while preserving natural resources and ensuring social stability. Before having the GSCI, countries lacked a comprehensive framework to evaluate their competitiveness through the lens of sustainability, making it difficult to balance economic growth with environmental protection. That is why The Global Sustainable Competitiveness Index (GSCI) was created, providing actionable insights and a multidimensional framework for assessing sustainable development.

The Global Sustainable Competitiveness Index (GSCI), developed by SolAbility and first introduced in 2012, serves as a tool to evaluate the ability of nations to generate and sustain economic growth while maintaining social and environmental balance. It is a measure designed to assess a country's ability to sustain economic growth while ensuring social, environmental, and governance factors. It evaluates how well a nation utilizes its resources to achieve sustainable development and long-term competitiveness in the global economy. The GSCI is used for countries to assess their strengths and weaknesses in sustainable competitiveness, which can provide insights for governments to develop policies that balance economic growth with environmental preservation and social progress for long-term goals.

2.2.2. Data collection

SolAbility collects data for the Global Sustainable Competitiveness Index (GSCI) from reliable international organizations like the UN, World Bank, IMF, WHO, UNESCO, WIPO,... The GSCI comprises six core components that provide a realistic view of a country's sustainable development capabilities.

Table 2: GSCI's indicators

Indicators	Definitions
Natural capital	Measures the availability and sustainability of natural resources, including biodiversity, water, land, and climate resilience
Resource efficiency	Evaluates how efficiently a country utilizes its natural and economic resources, such as energy intensity and recycling rates.
Social capital	Focuses on societal well-being, including health, security, equality, and education outcomes
Intellectual capital	Assesses innovation capacity, research and development investments, patent outputs, and education quality
Economic sustainability	Examines GDP growth, employment stability, industrial diversification, and financial robustness
Governance performance	Analyzes governance quality, regulatory frameworks, corruption levels, and judicial independence

Source: SolAbility (2023)

2.3. Empirical studies linking LPI and GSCI

This paper aims to analyze the relationship between the Logistics Performance Index (LPI) and the Global Sustainable Competitiveness Index (GSCI) to explore a nation's ability to meet the impact of sustainable competitiveness on logistics performance and vice versa. To better understand this relationship, we have reviewed GCI and GSCI, which provide different perspectives on a country's competitiveness. Specifically, the World Bank defines the GCI as a set of institutions, policies, and factors that determine a country's productivity level. There are 12

pillars, which capture the microeconomic and macroeconomic foundations of national competitiveness (World Bank, 2024). While the GCI is an appropriate tool for measuring traditional competitiveness, it does not fully address the sustainability challenges countries face today. In contrast, the Global Sustainable Competitiveness Index (GSCI) incorporates more comprehensive metrics to better align with current global sustainability trends. The GSCI integrates indicators such as Natural Capital, Resource Intensity, and Social Capital, providing a more comprehensive framework for assessing a country's readiness for sustainable development. The inclusion of these sustainability metrics allows for a better understanding of how countries can be both competitive and environmentally responsible. The GSCI also presents a broader view of competitiveness and considers factors beyond economic growth including social and environmental aspects that are critical for long-term success. The move to using GSCI instead of GCI is an important reason why this article focuses on analyzing the relationship between GSCI and LPI.

To investigate the relationship between GSCI and LPI, we look into some studies that researched the impact of GSCI on logistics performance and the performance of logistics on sustainable competitiveness, respectively. Ang Dy Pay (2024) determined whether the GSCI has a significant impact on logistics performance, noting that the GSCI sub-indices of resource intensity, social capital, and governance have a significant impact on the Logistics Performance Index (LPI). Social capital, which includes health, equality, freedom, and life satisfaction, exhibits a clear positive relationship with the LPI. A country with higher social stability and well-being, such as Sweden, is more likely to have a more efficient logistics system. This is consistent with the view that better health care, reduced crime, and increased equality directly contribute to economic and logistics performance. Governance, a measure of the effectiveness of a country's regulatory environment and infrastructure, also plays an important role in enhancing logistics performance. Governance Performance provides a foundation for sustained and sustainable wealth generation through resource allocation, infrastructure, market, and employment structure guidance. Strong governance ensures reduced corruption, improved ease of doing business, and better infrastructure investment, all of which are key drivers of high LPI scores.

In addition, some researchers have analyzed the impact of some factors equivalent to the components of GSCI on logistics performance. Corporate governance, as mentioned in the study of Banda (2024), acts as a moderating effect on the relationship between good governance and logistics performance. The study found that public governance negatively impacts the performance of the logistics sector in both the short and long run. However, when moderated with corporate governance, this effect becomes positive as it shows that the percentage improvement in the corporate-public governance relationship leads to 1.01% and 2.09% improvement in the performance of the logistics sector in the short and long run, respectively. This underscores the importance of a balanced corporate-public governance dynamic in enhancing logistics outcomes.

Following this, another study investigated the direct impact of national governance quality on international logistics performance and recognized how good governance can improve logistics

outcomes (Le & Na, 2024). The findings highlighted that government effectiveness, the strength of the legal system, anti-corruption efforts, and regulatory quality have a greater impact on logistics aspects. Furthermore, research shows that effective governance has a greater impact on supply chain inputs such as customs clearance and infrastructure. This highlights the fundamental role of governance in shaping the logistics environment.

In terms of intellectual capital, Al-Omoush, Palacios-Marqués, and Ulrich (2022) explore the relationship between intellectual capital, supply chain flexibility, and related factors during unprecedented crises such as the COVID-19 pandemic. Intellectual capital - including human capital, structural capital, and social capital - plays an important role in enhancing supply chain flexibility and resilience. The results show that intellectual capital significantly impacts supply chain flexibility and other factors. From the findings of this study, organizations can successfully leverage intellectual capital to adapt more quickly to disruptions caused by the pandemic, ensuring that their logistics systems can continue to operate despite the challenges.

Similarly, the Economic Sustainability Score is also important when calculating the stability of a country's logistics infrastructure in the long term. Countries with a high Economic Sustainability Score are more likely to invest in building strong, resilient infrastructure. This helps ensure that logistics systems can handle changes in trade volumes but remain resilient. As can be seen, economic sustainability helps logistics companies stay competitive, even in tough economic times. The Resource Intensity Score indicates how efficiently a country uses its resources, which impacts logistics services. Using resources efficiently not only helps cut costs but also improves the quality and efficiency of logistics. Additionally, Track and Trace Scores often depend on the level of technology used in logistics, which is related to a country's resource intensity. When resources are used more efficiently, it becomes easier to introduce advanced tracking technologies, making the logistics chain more transparent and traceable. Khan et al. (2023) indicated that traceability and transparency allow businesses to achieve complete operational control, which can increase stock rotation, maximize warehouse space, reduce labors required for each shift, and lower inventory levels.

Overall, a broader perspective on the relationship between the Global Supply Chain Index (GSCI) and the Logistics Performance Index (LPI) is necessary in the current context, especially given the complexity of the global supply chain and sustainable challenges. Most existing studies investigate the impacts between GCI and LPI instead of GSCI, which fails to capture challenges in the view of sustainability. Therefore, our study aims to fill this gap by exploring the role of GSCI as a new variable and offering a deeper insight into how these variables impact others. By integrating sustainable factors into the analysis, policymakers and governments can develop more informed and strategic plans to promote national competitiveness and improve logistics performance, while also aligning with long-term sustainable development goals.

The competitiveness of a country plays an important role in positioning its logistics performance by allowing its infrastructure, trade policies, and economic stability. Çemberci et al. (2015) have also demonstrated that countries with higher Global Competitiveness Index (GCI)

scores tend to perform better in key logistics dimensions, such as international transportation, tracking and tracing, and timeliness of shipments. The Global Sustainable Competitiveness Index (GSCI), a more comprehensive metric compared to GCI, incorporates six fundamental pillars of logistics development. In GSCI's six pillars, governance is an important determinant affecting logistics performance, because a strong functioning government ensures regulatory stability, facilitates trade, and encourages investments in infrastructure. Secondly, economic sustainability, another determinant of GSCI, can significantly impact a country's ability to develop resilient logistics systems. It is clear that countries with economic stability have more opportunities to attract investments. Those investments in transport infrastructure, such as roads, ports, and railways, directly contribute to a country's ability to facilitate trade (Kabak et al., 2019). Thirdly, studies indicate that excessive energy consumption in logistics operations, particularly through fossil fuel use, exacerbates environmental degradation and increases supply chain costs. That is why prioritizing renewable energy and green supply chain management, such as optimizing transportation routes and implementing energy-efficient infrastructure, improves logistics performance while minimizing environmental damage (Yu et al., 2021). Besides that, countries with higher social capital, which is measured by factors such as education, health, and workforce stability, tend to have more skilled labor forces, leading to increased efficiency in supply chain management (Kabak et al., 2019). Intellectual capital can support supply chain flexibility and resilience by improving logistics processes, as it fosters innovation and facilitates technology adoption (Sergi et al., 2021). Firms and nations that invest in intellectual capital tend to have better logistics coordination, improved tracking technologies, and stronger supply chain adaptability. Sergi et al. (2021) believe the adoption of advanced logistics technologies, such as automated tracking systems and AI-driven supply chain management positively impacts a nation's logistics performance. Lastly, resource intensity directly affects logistics performance by influencing how efficiently a country uses its resources in supply chain operations. The ability to allocate resources effectively affects cost reduction and logistics efficiency. Given these insights, we propose the hypothesis below.

Hypothesis: Global Sustainable Competitiveness has positively impacted Logistics Performance Index

3. Research Model and Methodology

3.1. Research Model

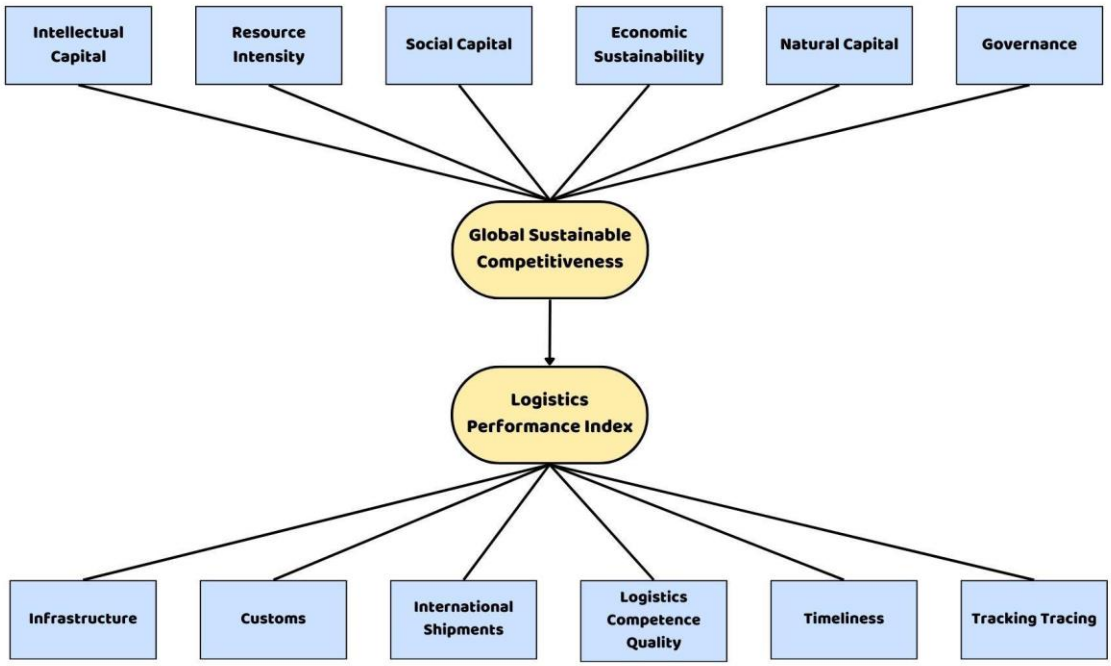

Figure 1: Research model

Source: Synthesized by the authors (2024)

3.2. Structural equation model (SEM)

This study utilizes the Structural Equation Model (SEM) to examine the impact of the Global Sustainable Competitiveness Index (GSCI) on the Logistics Performance Index (LPI). SEM is a powerful multivariate statistical technique that combines factor analysis and multiple regression to analyze complex relationships between observed variables and latent constructs while accounting for measurement errors. This makes SEM particularly effective in testing theoretical models involving numerous pathways, mediators, moderators, and hierarchical relationships and in validating measurement scales (Hair et al., 2010). Its ability to handle multidimensional constructs is particularly valuable for exploring the interplay between the GSCI and LPI.

This study employs AMOS (Analysis of Moment Structures) as the primary software to conduct Covariance-Based Structural Equation Modeling (CB-SEM), a methodology widely recognized for its robust capabilities in testing and validating theoretical models. CB-SEM, compared to Partial Least Squares Structural Equation Modeling (PLS-SEM), is particularly suitable for research focused on theory confirmation rather than prediction, as it emphasizes the evaluation of covariance structures and overall model fit. While PLS-SEM is advantageous for exploratory research and predictive accuracy in cases of small sample sizes, CB-SEM is preferred

for its ability to assess the relationships between latent variables comprehensively, especially when the objective is to validate hypotheses within a well-established theoretical framework.

AMOS enhances the implementation of CB-SEM by offering an intuitive, user-friendly interface for constructing complex path diagrams, facilitating efficient visualization and modeling of relationships. It addresses common challenges in multivariate analysis, such as multicollinearity, through its advanced computational tools. Moreover, AMOS calculates an array of model fit indices, including the Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI), which are critical for evaluating the adequacy and fit of the proposed model. These indices enable researchers to ensure that the model aligns with the observed data while meeting established thresholds of statistical rigor. Additionally, AMOS supports advanced statistical techniques such as bootstrapping, which is particularly valuable for estimating indirect effects, validating mediation models, and assessing parameter stability in complex conditions. This feature allows researchers to gain deeper insights into the structural relationships and refine the model to improve its explanatory power.

The decision to utilize CB-SEM, executed through AMOS, reflects the study's emphasis on theory-driven research and the necessity of rigorously evaluating the interplay between theoretical constructs. By leveraging AMOS's comprehensive capabilities, the study aims to produce reliable and precise findings that contribute meaningfully to the existing body of knowledge (Byrne, 2016).

3.3. Data sample

The study obtained the publicly available data of logistics performance and global sustainable competitiveness of countries in 2023. The data was collected from two sources: World Bank (2023) and SolAbility (2023). The initial data set of records for LPI and GSCI included records for 139 and 180 countries respectively. However, the data set of two variables contained several missing observations when compared to each other, thus, these records were removed. Consequently, the sample size consists of data from 134 countries.

A conceptual research model outlines the hypothesized relationships between GSCI dimensions and LPI factors, reflecting causal relationships derived from the literature. Hypotheses are tested through SEM to identify both direct and indirect effects of global sustainable competitiveness on logistics performance. This methodological approach ensures a rigorous evaluation of the influence of sustainable competitiveness on logistics performance. By leveraging SEM and AMOS, the study addresses potential data complexities, ensures reliable measurement, and delivers actionable insights to advance global logistics and sustainability research.

4. Empirical analysis

4.1. Descriptive analysis

Descriptive statistics of the data are presented in **Table 3**. The slight standard deviation of 0.585 and 6.825 shows that data points for the Logistics performance index (LPI) and Global sustainable competitiveness index (GSCI) respectively are highly clustered around the mean.

The mean of GSCI is 45.002, Governance has the highest mean score (53.304), followed by Social Capital (45.363), Natural Capital (45.249), Economic Sustainability (42.567), Intellectual Capital (42.458), and Resource Intensity (41.071). Sweden recorded the maximum global sustainable competitiveness of 59.607, while the minimum score of 32.056 for global sustainable competitiveness was recorded in Somali. The Governance score is highest in Estonia (75.972), reflecting the country's strong institutional quality, transparency, and digital governance. Estonia is recognized for its e-government systems, low corruption levels, and high public trust in institutions (World Bank, 2023). Its emphasis on rule of law and regulatory efficiency enhances its sustainable competitiveness, making it one of the top performers in governance-related indices (Transparency International, 2023).

The Global Sustainable Competitiveness Index (GSCI) reaches its highest value in Sweden (59.607), indicating the country's leadership in environmental sustainability, economic resilience, and social equity. Sweden ranks among the world's most sustainable economies due to its renewable energy transition, strong environmental regulations, and circular economy strategies (Schwab, 2023). Additionally, its high investment in research and development (R&D), green technologies, and education strengthens its sustainable competitiveness (OECD, 2022).

On the other hand, Iran records the lowest Resource Intensity score (18.895), suggesting inefficiencies in resource management and a heavy reliance on non-renewable energy sources such as oil and gas. Iran's environmental challenges, including water scarcity, air pollution, and deforestation, contribute to its low resource intensity score (OECD, 2022). Additionally, economic sanctions and limited access to international sustainability initiatives hinder improvements in resource efficiency and sustainability efforts (IMF, 2023).

Countries with lower scores in sustainability-related indicators often face institutional weaknesses, economic instability, and environmental degradation. For instance, nations with rich natural capital but weak governance structures struggle with long-term sustainability due to poor policy implementation and resource mismanagement. Addressing these challenges requires a shift toward stronger governance frameworks, increased investment in green technologies, and enhanced regional cooperation to ensure sustainable development.

Regarding the LPI with a mean of 3.000, Timeliness has the highest mean value of 3.241, followed by Tracking and Tracing (3.048), Logistics Competence and Quality (3.028), International Shipments (2.925), Infrastructure (2.922), and Customs (2.804). Specifically, the highest logistics performance index of 4.3 was recorded in Singapore, while the lowest index of 1.9 was recorded in Afghanistan. Contributing to the first rank in LPI, Singapore also ranked first

in four sub-indicators including Infrastructure, Logistics Competence and Quality, Tracking and Tracing, and Timeliness as well as ranked second in two sub-indicators, Customs, and International Shipments. Indeed, Singapore's port - PSA Singapore is the world's second-largest port offering connectivity to more than 600 ports in 123 countries. In 2023, Singapore's port handled 39.01 million TEU witnessing a 4.6% increase compared to 2022. Besides, the Maritime and Port Authority of Singapore (MPA) is also constructing an automated container terminal - Tuas Terminal. This terminal with an annual capacity of 65 million TEU, is planned to be fully operational in 2040 (Nilson, 2024). With the highest score in Tracking and Tracing, Singapore has developed and introduced a Just-In-Time (JIT) Planning and Coordination platform combined with DigitalPort@SG to reduce waiting time and streamline processes for shipping lines and services since October 2023 (Government of Singapore, 2024). In terms of Customs, Singapore equipped a Single Window System along with TradeNet and Trade Web to streamline customs procedures by enabling seamless and paperless transactions and eliminating redundant paperwork and repetitive processes (Wijaya, 2023). Therefore, more than 99% of TradeNet declarations are processed within 10 minutes, and customs duty or Goods and Services Tax (GST) refunds are issued within five working days if supporting documents are not required (Singapore Customs, 2025). On the other hand, Afghanistan had the lowest value in LPI, Tracking and Tracing, and Infrastructure Score since it faced numerous difficulties in logistics areas. Regarding customs processes and infrastructure quality, complex and unpredictable clearance procedures as well as the lack of developed trade and transport infrastructure such as ports, railroads, roads, and information systems cause delays, inefficient operations, and increased costs in trade logistics. According to the UNCT in Afghanistan (2023), Afghanistan has suffered from many years of conflict, the COVID-19 pandemic, the global economic slowdown, especially the suspension of non-humanitarian international assistance, and the isolation from the international financial system due to the Taliban takeover. Consequently, Afghanistan's political and economic instability leads to various issues in society, economy, trade, and logistics procedures.

Table 3: Descriptive analysis of variables (N=134)

Variables	Mean	Std. Dev.	Min	Max
GSCI	45.002	6.825	32.056	59.607
Natural Capital	45.249	7.905	25.736	62.418
Resource Intensity	41.071	8.654	18.895	59.567

Variables	Mean	Std. Dev.	Min	Max
Social Capital	45.363	10.360	25.904	65.763
Intellectual Capital	42.458	11.874	22.692	75.223
Economic Sustainability	42.567	6.701	27.165	56.459
Governance	53.304	11.433	26.189	75.972
LPI	3.000	0.585	1.900	4.300
Customs	2.804	0.618	1.500	4.200
Infrastructure	2.922	0.715	1.700	4.600
International Shipments	2.925	0.508	1.700	4.100
Logistics Competence and Quality	3.028	0.639	1.800	4.400
Timeliness	3.241	0.553	2.100	4.300
Tracking and Tracing	3.048	0.661	1.600	4.400

Source: World Bank (2023) & SolAbility (2023)

4.2. SEM analysis

This study applies SEM analysis to assess the relationship between the Logistics Performance Index (LPI) and the Global Sustainable Competitiveness Index (GSCI). Maximum Likelihood (ML) estimation was conducted in the analysis, which is suitable for small sample sizes. The results of the model fit index were illustrated in **Table 4** respectively showing that $\chi 2$/df was 1.888, the Goodness of Fit Index (GFI) was 0.901, the Comparative Fit Index (CFI) was 0.978, the Tucker-Lewis Index (TLI) was 0.969, and the Root Mean Square Error of Approximation (RMSEA) was 0.082, thus confirming the quite good model-fit. The SEM analysis also provides a different perspective on how logistics performance impacts sustainable competitiveness, which will be explained later.

The result of the causal effects between GSCI and LPI is shown in **Table 5, Table 6,** and **Figure 2**. To accept and reject the hypothesis structural model assessment, the authors considered β-value, t-statistics, p-value, and standard error. Hypothesis 1 states that global sustainable competitiveness has positively impacted logistics performance with β=0.05; t-statistics=13.266; p<0.001; and standard error=0.004. Therefore, the authors accepted the proposed hypothesis of the direct effect between GSCI and LPI. Besides, the value 0.584 of R^2 the Logistics Performance Index also stated that the Global Sustainable Competitiveness Index meaningfully and statistically predicts the Logistics Performance Index, and 58.4% of changes in LPI result from fluctuations of GSCI. Besides, the SEM analysis also investigates the impact of logistics performance on global sustainable competitiveness showing that with β=1, thus, proving that logistics performance has positively affected global sustainable competitiveness.

Table 4: Model Fit Indexes

Fit Index	Results	Criteria	Fit (Yes/No)
χ^2	90.602		
df	48		
P-value	0.000		
χ^2/df	1.888	1.00 - 5.00	Yes
GFI	0.901	>0.09	Yes
CFI	0.978	>0.09	Yes
TLI	0.969	>0.09	Yes

Fit Index	Results	Criteria	Fit (Yes/No)
RMSEA	0.082	<0.08	No

Source: Synthesized by the authors (2024)

Table 5: Correlationship between GSCI and LPI

Effects	Coefficient	Covariance	T-statistics	P-value	Results
GSCI ↔ LPI	0.816	5.062	6.452	***	Accepted

**Indicates significant paths: *** p < 0.001*

Source: Synthesized by the authors (2024)

Table 6: Two-way effects between GSCI and LPI

Effects	β	Standard Error	T-statistics	P-value	Results
GSCI → LPI	0.05	0.004	13.266	***	Accepted
LPI → GSCI	1				Accepted

Source: Synthesized by the authors (2024)

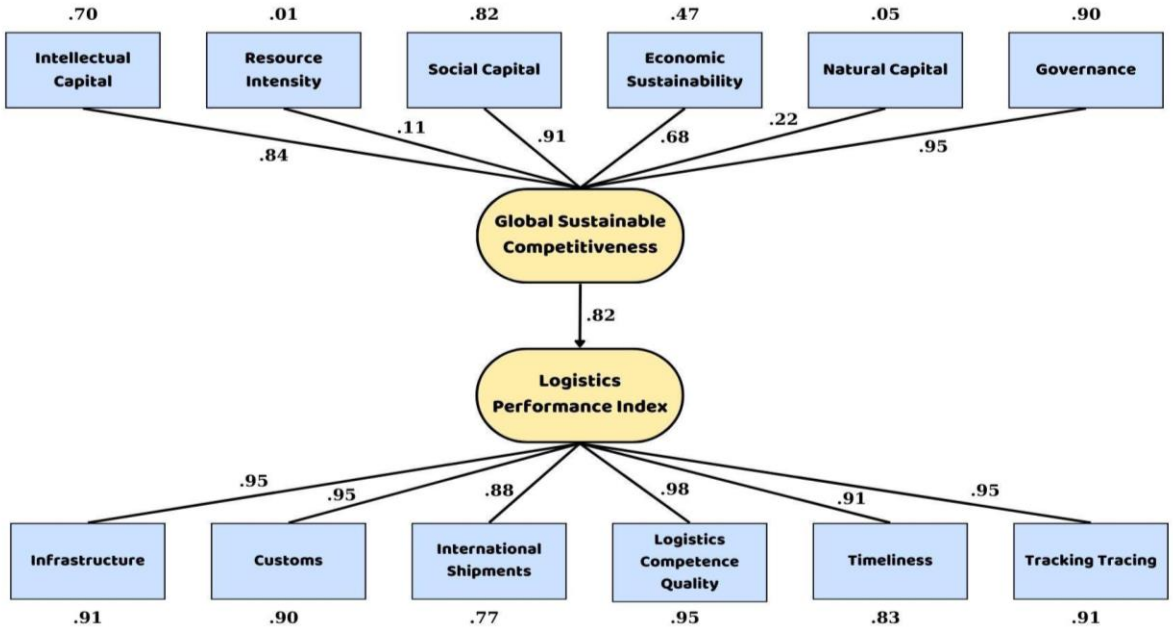

Figure 2: Standardized model

Source: Synthesized by the authors (2024)

5. Conclusions and Recommendations

This study explores the relationship between logistics performance and sustainable competitiveness, focusing on 134 countries in 2023. Using the Logistics Performance Index (LPI) and the Global Sustainable Competitiveness Index (GSCI), the research investigates causal links between these variables through Structural Equation Modeling (SEM). The findings demonstrate that sustainable competitiveness significantly and positively impacts logistics performance, highlighting the critical role of green competitiveness in boosting trade transactions and economic growth. Additionally, the study also reveals that improving logistics performance also has a significant positive effect on a country's sustainable competitiveness. This underscores the importance of investing in logistics research and development, which enhances competitiveness and drives economic growth.

The study indicates the importance of investing in the six components of GSCI—natural capital, resource efficiency, social capital, intellectual capital, economic sustainability, and governance. These elements collectively drive logistics performance, enabling countries to enhance their global competitiveness. As the global economy recovers from the pandemic, logistics investments emerge as a crucial tool for economic recovery. Practitioners are encouraged to allocate resources strategically and focus on sustainability-related investments. Policymakers and governments can leverage these findings to implement effective national logistics policies that prioritize economic recovery and sustainable growth. Additionally, the study also stresses the significance of improving the six dimensions of the LPI—customs efficiency, infrastructure quality, international shipment reliability, logistics competence, tracking systems, and timeliness. Policymakers should take these recommendations to develop comprehensive strategies that improve logistics performance and, consequently, enhance national competitiveness and economic growth.

While this paper provides valuable insights, it also has some limitations. Potential biases in data collection and SEM modeling may arise due to the authors' restricted access to comprehensive business data, particularly firm-level financial records, trade logistics specifics, or operational insights from logistics providers. These limitations could affect the accuracy of parameter estimations and the robustness of the model, potentially leading to an incomplete representation of the relationship between sustainable competitiveness and logistics performance. Future research could address these issues by incorporating additional variables or exploring region-specific dynamics to provide a more accurate understanding. Although the model has a quite solid theoretical foundation, it lacks practical robustness when analyzed bidirectionally. Specifically, the model demonstrates sustainability when assessing the impact of GSCI on LPI. However, when reversed to evaluate the impact of LPI on GSCI, the reliability is insufficient (RMSEA = 0.082). We hope future research can enhance the model's robustness by using time series analysis for a more comprehensive and accurate perspective.

In conclusion, these findings highlight the mutual relationship between logistics performance and sustainable competitiveness, offering practical recommendations for policymakers and

practitioners to drive long-term economic growth and global competitiveness, emphasizing the need for targeted and sustainable policies to improve logistics performance systematically.

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