Logistics connectivity, foreign investments and trade relationships in ASEAN countries

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Abstract

Purpose – This study examines the causal relationships among the export volume index, the liner shipping connectivity index (LSCI) and foreign direct investment (FDI, net inflows as % of GDP) for the five founding members of ASEAN–Indonesia, Malaysia, the Philippines, Singapore and Thailand–during the 2006–2021 period.

Design/methodology/approach – The analysis applies the panel bootstrap causality test developed by Kónya (2006), which allows for country-specific inferences without requiring cross-sectional independence or parameter homogeneity. Three models are estimated to identify the direction and nature of causal linkages among the variables.

Findings – The results show evidence of Granger causality from LSCI and FDI to exports in the Philippines, Singapore and Thailand, with positive estimated coefficients indicating that stronger maritime connectivity and investment inflows are associated with higher export performance. Causality also runs from exports to LSCI in Indonesia and the Philippines, suggesting that trade expansion stimulates infrastructure improvements. While FDI negatively affects LSCI in Indonesia, a positive coefficient is observed for the Philippines. In addition, LSCI Granger-causes FDI in the Philippines and Singapore, reflecting the role of maritime connectivity in attracting investment. These results highlight substantial cross-country heterogeneity in trade, logistics and investment dynamics.

Research limitations/implications – The analysis is limited to five ASEAN founding members and to the 2006–2021 period due to the availability of the LSCI data. Future research may extend the analysis to other ASEAN economies or incorporate additional macroeconomic factors.

Practical implications – The findings provide valuable insights for policymakers seeking to enhance maritime infrastructure, attract FDI and strengthen regional trade integration through improved logistic connectivity.

Originality/value – This study contributes to the literature by simultaneously examining the bidirectional and country-specific causal linkages among maritime connectivity, trade and investment using a robust panel bootstrap approach, offering new empirical evidence on the structural heterogeneity of ASEAN economies.

Keywords ASEAN countries, Logistics connectivity, Foreign direct investment (FDI), Trade performance, Bootstrap panel causality analysis

Paper type Research article

1. Introduction

With the rapid expansion of international trade driven by globalization, the infrastructure supporting trade flows—particularly maritime logistics—has become a central determinant of economic competitiveness (UNCTAD, 2023; Fugazza and Hoffmann, 2017). Over 80% of world trade by volume and 70% by value moves through maritime routes, placing ASEAN at the crossroads of global supply chains and controlling critical corridors like the Strait of Malacca (Germir, 2022). Among the measures of global logistics integration, the Liner Shipping Connectivity Index (LSCI) stands out as the most direct indicator of a country's maritime network access and trade-cost efficiency. Unlike complementary indicators such as the Logistics Performance Index (LPI) and Global Competitiveness Index (GCI), which are

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composite measures influenced by macroeconomic or survey-based variables, LSCI captures the operational dimension of maritime transport—including the number of vessels, container capacity, service frequency, and number of shipping companies (World Bank, 2023). Because ASEAN economies are heavily dependent on seaborne trade, LSCI serves as the most appropriate proxy for analyzing how maritime connectivity directly influences trade flows and investment attractiveness (UNCTAD, 2024).

However, the region exhibits significant structural heterogeneity—from Singapore's highly developed logistics ecosystem (LPI rank 7th, score 4.00) to the relatively weak infrastructure of Vietnam and Myanmar (ranks 39th and 137th, respectively; World Bank, 2018). Among ASEAN members, Indonesia, Malaysia, the Philippines, Singapore, and Thailand—known as the founding members of ASEAN—represent the region's most established maritime economies, each with distinct logistical and industrial structures. These countries not only account for the majority of ASEAN's seaborne trade but also differ sharply in port infrastructure, shipping capacity, and investment orientation. This diversity provides an ideal empirical setting for examining how variations in maritime connectivity translate into trade and investment outcomes.

The theoretical foundation of the study is grounded in both classical and modern growth perspectives emphasizing the nexus between trade, infrastructure, and development. Solow's (1956) neoclassical growth model and Nurkse's (1952) concept of the "vicious cycle of poverty" highlight the critical role of capital accumulation and infrastructure investment. In the classical tradition, Smith's absolute advantage and Ricardo's (1817) comparative advantage theories explain welfare gains from trade, while Romer (1990) and Grossman and Helpman (1991) in their endogenous growth frameworks underscore technology diffusion and knowledge transfer through trade and FDI. Within this analytical framework, maritime transport emerges as the backbone of global supply chains, providing cost efficiency and scalability that directly enhance national competitiveness (Bottasso *et al.*, 2018). Empirical evidence supports this mechanism: Fugazza and Hoffmann (2017) show that higher LSCI scores increase trade volumes, while Limão and Venables (2001) demonstrate that better infrastructure reduces trade costs and improves performance.

Despite these insights, existing literature has largely examined logistics performance and trade outcomes in isolation, with limited attention to the joint causal dynamics among LSCI, FDI, and exports, particularly in maritime-dependent regions such as ASEAN.

Despite these insights, existing literature has largely examined logistic performance and trade outcomes in isolation. Specifically, previous empirical studies frequently analyze these variables in pairwise isolation, such as LSCI and exports or FDI and exports, with limited attention to the joint causal dynamics among LSCI, FDI, and exports simultaneously. Furthermore, existing cross-regional analyses often overlook the significant structural heterogeneity within ASEAN—such as differences in logistics maturity and investment orientation (e.g. manufacturing vs. service)—which necessitates country-specific validation rather than simple extrapolation from global patterns. This gap, particularly the lack of joint, dynamic, and country-specific causal analysis in maritime-dependent regions like ASEAN, motivates the present study, which seeks to answer the following questions: (1) Does maritime connectivity (LSCI) significantly influence export performance in ASEAN founding members? (2) How does LSCI affect foreign direct investment inflows, and does FDI, in turn, enhance trade capacity? (3) Are these relationships symmetric across ASEAN economies, or do structural and geographical differences lead to heterogeneous outcomes?

To address these questions, the study applies the panel bootstrap causality method of Kónya (2006), which allows for country-specific inferences without assuming cross-sectional independence or homogeneity. This approach enables an in-depth understanding of how maritime logistics, investment, and trade interact under differing national conditions.

The study contributes in two major ways. First, it provides theoretical integration by combining the comparative advantage and endogenous growth frameworks to explain how maritime connectivity shapes trade-led development through investment and technology channels. Second, it offers new empirical evidence specific to the ASEAN-5, identifying cross-country variations in the LSCI–FDI–export nexus and highlighting policy pathways to strengthen regional integration, attract sustainable FDI, and enhance maritime transport efficiency in response to global trade dynamics.

2. Literature review

The interplay among the Liner Shipping Connectivity Index (LSCI), foreign direct investment (FDI), and exports constitutes a critical nexus in understanding the global dynamics of trade competitiveness and logistics efficiency. While early studies broadly explored the effects of logistics and infrastructure on trade performance, recent research has begun to unravel specific linkages between LSCI, FDI, and exports within different economic contexts. However, comparative and ASEAN-focused analyses remain limited.

Empirical studies generally confirm that higher shipping connectivity enhances trade openness and export competitiveness. Mohamad *et al*. (2015) highlighted that among Southeast Asian countries, container-related variables such as "ship size" and "services provided" strongly influenced trade volumes. Similarly, Atacan *et al*. (2022) and Canbay (2024) found that rising LSCI values substantially increase containerized exports in the Türkiye and BRICS-T economies, revealing a bidirectional relationship between LSCI and exports. Del Rosal (2023), using a global gravity framework, showed that LSCI significantly boosts agricultural trade irrespective of development level, whereas Sakyi and Immurana (2021) reported that improved LSCI strengthens Africa's trade balance both in the short and long run. These findings collectively suggest that maritime connectivity remains a universal determinant of export capacity, yet the degree of responsiveness differs by geography and income level—a pattern particularly relevant to ASEAN's mixed composition of archipelagic and continental economies.

Evidence linking LSCI to inward FDI remains emergent but consistent in direction. Jouili (2018) and Saidi *et al*. (2020) confirmed that better logistic performance and maritime infrastructure attract greater foreign investment in developing economies. Halaszovich and Kinra (2020) emphasized that multimodal transport networks enhance both trade and FDI across Asian countries, while Vechiu (2023) demonstrated that international connectivity (measured by LSCI) exerts a stronger influence on FDI than domestic infrastructure. Importantly, Park *et al.* (2019) provided cross-country evidence from OECD and non-OECD nations that maritime transport plays a significantly stronger role in promoting growth and FDI than land or air transport, particularly in developing contexts. These insights indicate that LSCI functions not only as a trade facilitator but also as a signal of infrastructural reliability that attracts long-term investment.

The relationship between FDI and exports is well-established yet heterogeneous. Jawaid *et al*. (2016) found a bidirectional causal link in Pakistan, while Ahmad *et al*. (2018) detected a short-run unidirectional causality from FDI to exports within ASEAN-5. Lakshani *et al*. (2023) extended this relationship globally, showing robust two-way linkages across 110 countries. Such findings imply that FDI can stimulate export performance by introducing technology and managerial know-how, but the strength of this effect depends on host-country logistics capacity and trade facilitation mechanisms—both unevenly developed across ASEAN members.

Despite the abundance of cross-regional studies, empirical research explicitly addressing the LSCI–FDI–export triad in ASEAN remains sparse. Prior works often treat these variables pairwise and overlook the region's structural heterogeneity—coastal vs. landlocked, developed vs. developing, and island vs. continental members. Furthermore, differences in logistics maturity and FDI orientation (e.g. manufacturing-based in Malaysia vs. service-based in Singapore) warrant country-specific validation rather than direct extrapolation from global patterns. This study therefore fills a crucial gap by jointly testing the dynamic interactions among LSCI, FDI, and exports for the ASEAN-5 using the panel bootstrap Granger causality approach, offering new comparative evidence tailored to the region's maritime-dependent economic structure.

3. Material

In this study, data for the period 2006–2021 for ASEAN founding members Indonesia (IDN), Malaysia (MYS), Philippines (PHL), Singapore (SGP) and Thailand (THA) will be analyzed. In the study, export volume index (EXP), Liner Shipping Connectivity Index (LSCI) and inward FDI (FDI) variables will be used (World Bank, 2025). The main limitation of the study lies in the availability of LSCI data, which spans only from 2006 to 2021. Nonetheless, this period coincides with ASEAN's most dynamic phase of regional integration and logistics modernization, making it highly relevant for evaluating the evolving relationship among maritime connectivity, FDI, and trade.

The variables used in this study and their meaning in economic analysis can be explained as follows: EXP represents the export volume index, which measures changes in the physical quantity of a country's total merchandise exports over time, taking the base year (2015) as 100. This index was preferred over export values because it captures real trade activity and production-related fluctuations rather than nominal changes influenced by price effects, exchange rate volatility, or global commodity price movements. Therefore, it better reflects the causal channel through which logistic connectivity and foreign investment affect trade performance in real terms (World Bank, 2025).

LSCI is an index developed by the United Nations Conference on Trade and Development (UNCTAD) that measures the level of integration of countries into global maritime transport networks. It is calculated based on five main components: total number of vessels, container carrying capacity, maximum vessel size, number of services, and the number of companies operating container ships in ports. LSCI is selected over broader logistics indicators such as the Logistics Performance Index (LPI) because it directly captures international maritime connectivity—the most relevant dimension for analyzing trade and investment linkages in maritime-dependent economies. Furthermore, the LPI is published only at irregular intervals (2007, 2010, 2012, 2014, 2016, 2018), making it unsuitable for continuous time-series or panel analysis. Hence, LSCI provides a more consistent and theoretically aligned measure of international connectivity for the causal framework established in this study (World Bank, 2025).

FDI represents foreign direct investment, net inflows (% of GDP), which measures the value of direct investment made by non-resident investors in a country as a percentage of its gross domestic product. This indicator reflects the scale of foreign investment relative to national economic size, allowing meaningful cross-country comparisons over time. Because the data are already expressed as a ratio, logarithmic transformation was not applied. Using FDI as a share of GDP minimizes the influence of country size and nominal value differences, ensuring greater comparability across the ASEAN-5 sample and consistency with previous empirical studies (World Bank, 2025).

Table 1 presents the descriptive statistics for the variables included in the analysis. The mean value of the Liner Shipping Connectivity Index (LSCI) is 3.93, indicating moderate maritime connectivity across the ASEAN-5 countries, while the average FDI value of 6.26 reflects varying investment inflows among them. The export index (EXP) has an average of 97.07, with a relatively higher dispersion (standard deviation of 13.85) compared to LSCI,

Table 1. Descriptive statistics

	LSCI	FDI	EXP
Mean	3.925790	6.262635	97.07513
Maximum	4.734223	31.62074	137.1148
Minimum	2.952007	−0.857990	67.43675
Std. Dev	0.544488	8.425509	13.85460
Observations	80	80	80

suggesting notable differences in trade performance. The minimum and maximum values reveal considerable heterogeneity across countries, particularly in FDI, which ranges from negative inflows to over 31%. Overall, the descriptive statistics confirm the diversity of economic and logistical structures within the ASEAN-5 sample, supporting the suitability of a heterogeneous panel approach.

The models of the study and the relationships between the variables can be expressed as follows:

Model 1: EXP = f(LSCI, FDI)

In this model, EXP is taken as the dependent variable and explained by LSCI and FDI.

Model 2: LSCI = f(EXP, FDI)

This model examines the relationship between LSCI and EXP and FDI.

Model 3: FDI = f(EXP, LSCI)

In this model, FDI is taken as the dependent variable and explained by EXP and LSCI. These models allow for an analytical examination of the interrelationships between variables.

4. Methods and results

In this study, the panel bootstrap causality test developed by Kónya (2006) is employed to examine the causal relationships among EXP, LSCI, and FDI. This method is particularly suitable for the research questions, as it allows for country-specific causal inferences while accounting for cross-sectional dependence and heterogeneity among ASEAN economies. One of its key advantages is that it does not require a co-integration relationship or identical integration orders across variables, which is particularly relevant given the mixed stationarity levels typically observed in macroeconomic and trade-related time series. Moreover, unlike conventional panel causality tests that assume homogeneity, the bootstrap approach proposed by Kónya (2006) provides robust and individualized results by applying Seemingly Unrelated Regressions (SUR) for each cross-section. Prior to implementation, horizontal cross-section dependence and coefficient heterogeneity were tested to ensure the method's appropriateness for the ASEAN-5 dataset. Following these diagnostic steps, a panel bootstrap causality analysis is conducted to identify the direction and strength of causal linkages among maritime connectivity, foreign investment, and trade performance.

4.1 Cross-section dependence test

Ignoring horizontal cross-sectional dependence, which implies that a shock affecting one of the countries in the panel may also affect other countries, may lead to inaccurate analysis results (Pesaran, 2004). Therefore, in this study, the methods commonly used in the literature will be applied to test the horizontal cross-sectional dependence among the countries in the sample. These methods include Breusch and Pagan's (1980) BP_{LM} test, Pesaran's (2004) CD_{LM} test, Pesaran *et al*. (2008) LM_{adj} test, Baltagi *et al.* (2012) LM_{BC} test.

The hypotheses for testing horizontal cross-section dependence are defined as follows:

H_0: There is no horizontal cross-section dependence in the model.

H_1: There is horizontal cross-section dependence in the model.

If the probability values of the test statistics obtained from each test are less than the statistical significance levels of 10%, 5 and 1%, the hypothesis H_0 is rejected. This result is interpreted as the presence of horizontal cross-section dependence in the model.

The results of the horizontal cross-section dependence test are presented in Table 2 in detail. This table includes the results of Breusch and Pagan's (1980) BP_{LM} test, Pesaran's (2004) CD_{LM} test, Pesaran *et al*.'s (2008) LM_{adj} test, Baltagi *et al.* (2012) LM_{BC} test and evaluates the

Table 2. Cross-section dependence test results

Models	Model 1		Model 2		Model 3	
Test	Test statistics	*p*-value	Test statistics	*p*-value	Test statistics	*p*-value
BP_{LM}	110.42*	0.001	24.74*	0.005	23.44*	0.009
LM_{adj}	21.33	0.001	2.17**	0.029	1.88***	0.058
LM_{BC}	21.17*	0.001	2.01**	0.044	1.72***	0.085
CD_{LM}	10.42*	0.001	*1.45*	*0.146*	1.79***	0.072

Note(s): * indicates the rejection of the null hypothesis at the *1%, **5%, and ***10% significance levels

probability values and statistical significance levels of each test. These findings will be discussed to determine the presence or absence of cross-sectional dependence in the model.

According to the test results, only the probability value of the CD_{LM} test in Model 2 is above the 10% significance level, while the other three tests provide significance levels below 10%.

The main reason for this difference is that each test is based on different methodological assumptions in determining cross-sectional dependence. Although the CD_{LM} test is known to provide more reliable results as the size of the panel increases (Pesaran, 2004), it may be less sensitive than other methods in detecting dependence when cross-sectional dependence is weaker. This may be due to a structural features specific to the construction of Model 2 or different variations of the dependent variable (LSCI) across countries. Indeed, Pesaran (2004) argues that the tests used to identify cross-sectional dependence may vary depending on the panel structure and the level of interaction of variables.

However, the fact that the other three tests (BP_{LM}, LM_{adj} and LM_{BC}) produce significant results below the 10% significance level strongly supports the existence of horizontal cross-section dependence in Model 2. In the literature, applying more than one test is considered as an approach that increases the robustness of the findings and strengthens methodological consistency (Baltagi *et al.*, 2012). Therefore, evaluating the results of the CD_{LM} test together with other tests does not weaken the overall findings of the study; on the contrary, it provides methodological diversity and depth.

4.2 Homogeneity tests

Another important precondition of the Kónya (2006) panel bootstrap causality test is that the coefficients of the models should be heterogeneous. If the slope coefficients of each country in the sample are equal to a single value, the model is homogeneous, whereas if the slope coefficients differ across countries, the model is heterogeneous. In this study, the homogeneity or heterogeneity of the coefficients will be evaluated with the delta (Δ) and adjusted delta (Δadj) test statistics proposed by Pesaran and Yamagata (2008) based on the “Random Coefficients Model” developed by Swamy (1970).

For example, to test the homogeneity of Model 2, the hypotheses are defined as follows:

H_0: The model is homogeneous.

H_1: The coefficient for at least one country is different; the model is heterogeneous.

If the probability values obtained from these test statistics are less than the statistical significance levels of 10%, 5% or 1%, H_0 is rejected and this result indicates that the slope coefficients of the model differ across countries, i.e. the model is heterogeneous.

The homogeneity test results are presented in Table 3:

When the homogeneity test results presented in Table 3 are evaluated in terms of the applicability of the Kónya (2006) panel bootstrap causality test, it is concluded that the coefficients are heterogeneous. In the analysis using Δ and Δadj test statistics, the Δ test for

Table 3. Homogeneity test results

Models	Model 1		Model 2		Model 3	
Test	Test statistics	*p*-value	Test statistics	*p*-value	Test statistics	*p*-value
Δ	−1.42	0.150	−1.91**	0.056	−1.73**	0.084
Δadj	−3.17*	0.001	−4.27*	0.001	−3.86*	0.001

Note(s): * indicates the rejection of the null hypothesis at the *1%, and **10% significance levels

Model 1 fails to reject the homogeneity assumption at 10%, 5 and 1% significance levels (*p*-value 0.150). However, the Δadj test strongly rejected the homogeneity assumption at the 1% significance level with a *p*-value of 0.001. This indicates that the coefficients in Model 1 are heterogeneous.

In the analysis for Model 2, *Δ* rejected the homogeneity assumption at 10% significance level with a *p*-value of 0.056. Moreover, the Δadj test strongly rejected the homogeneity assumption at the 1% significance level with a *p*-value of 0.001, indicating that the coefficients of Model 2 have a heterogeneous structure. Similarly, for Model 3, *Δ* rejected the homogeneity assumption at 10% significance level with a *p*-value of 0.084 and Δadj test strongly rejected the homogeneity assumption at 1% significance level with a *p*-value of 0.001. This finding clearly indicates that the coefficients of Model 3 are heterogeneous.

These results confirm that the coefficients of all models are heterogeneous, especially based on the Δadj test results. Since the Kónya (2006) panel bootstrap causality test requires the coefficients of the models to be heterogeneous as a prerequisite, these results indicate that the methodological conditions for applying the Kónya (2006) test are met in this study.

4.3 Kónya (2006) Panel bootstrap causality test

Kónya (2006) proposed a causality test based on the SUR estimator developed by Zellner (1962), arguing that the Seemingly Unrelated Regression (SUR) method provides more efficient estimates compared to the Ordinary Least Squares (OLS) method. This method is since each equation in the SUR system is based on Sims' (1980) Vector Autoregressive (VAR) approach. In this context, the test developed by Kónya (2006) makes it possible to efficiently analyze causality relationships between variables in panel data sets through the SUR estimator.

In this study, the relationships between the variables used (Model 1, Model 2 and Model 3) are modeled using the SUR system within the framework of Kónya (2006) method as follows:

$$\left.\begin{aligned}
EXP_{1,t} &= \varphi_{1,1} + \sum_{l=1}^{ml_EXP_1} \alpha_{1,1,l} EXP_{1,t-1} + \sum_{l=1}^{ml_LSCI_1} \beta_{1,1,l} LSCI_{1,t-1} + \sum_{l=1}^{ml_FDI_1} \gamma_{1,1,l} FDI_{1,t-1} + \xi_{1,1,t} \\
EXP_{2,t} &= \varphi_{1,2} + \sum_{l=1}^{ml_EXP_1} \alpha_{1,2,l} EXP_{2,t-1} + \sum_{l=1}^{ml_LSCI_1} \beta_{1,2,l} LSCI_{2,t-1} + \sum_{l=1}^{ml_FDI_1} \gamma_{1,2,l} FDI_{2,t-1} + \xi_{1,2,t} \\
&\vdots \\
EXP_{N,t} &= \varphi_{1,N} + \sum_{l=1}^{ml_EXP_1} \alpha_{1,N,l} EXP_{N,t-1} + \sum_{l=1}^{ml_LSCI_1} \beta_{1,N,l} LSCI + \sum_{l=1}^{ml_FDI_1} \gamma_{1,N,l} FDI_{2,t-1} + \xi_{1,N,t}
\end{aligned}\right\} \quad (1)$$

$$
\left.\begin{aligned}
LSCI_{1,t} &= \varphi_{2,1} + \sum_{l=1}^{ml\_LSCI_2} \beta_{2,1,l} LSCI_{1,t-1} + \sum_{l=1}^{ml\_EXP_2} \alpha_{2,1,l} EXP_{1,t-1} + \sum_{l=1}^{ml\_FDI_2} \gamma_{2,1,l} FDI_{1,t-1} + \xi_{2,1,t} \\
LSCI_{2,t} &= \varphi_{2,2} + \sum_{l=1}^{ml\_LSCI_2} \beta_{2,2,l} LSCI_{2,t-1} + \sum_{l=1}^{ml\_EXP_2} \alpha_{2,2,l} EXP_{2,t-1} + \sum_{l=1}^{ml\_FDI_2} \gamma_{2,2,l} FDI_{1,t-1} + \xi_{2,2,t} \\
&\vdots \\
LSCI_{N,t} &= \varphi_{2,N} + \sum_{l=1}^{ml\_LSCI_2} \beta_{2,N,l} LSCI_{N,t-1} + \sum_{l=1}^{ml\_EXP_2} \alpha_{2,N,l} EXP_{N,t-1} + \sum_{l=1}^{ml\_FDI_2} \gamma_{2,N,l} FDI_{1,t-1} + \xi_{2,N,t}
\end{aligned}\right\} \quad (2)
$$

$$
\left.\begin{aligned}
FDI_{1,t} &= \varphi_{3,1} + \sum_{l=1}^{ml\_FDI_3} \gamma_{3,1,l} FDI_{1,t-1} + \sum_{l=1}^{ml\_EXP_3} \beta_{3,1,l} EXP_{1,t-1} + \sum_{l=1}^{ml\_LSCI_3} \alpha_{3,1,l} LSCI_{1,t-1} + \xi_{3,1,t} \\
FDI_{2,t} &= \varphi_{3,2} + \sum_{l=1}^{ml\_FDI_3} \gamma_{3,2,l} FDI_{2,t-1} + \sum_{l=1}^{ml\_EXP_3} \beta_{3,2,l} EXP_{2,t-1} + \sum_{l=1}^{ml\_LSCI_3} \alpha_{3,2,l} LSCI_{1,t-1} + \xi_{3,2,t} \\
&\vdots \\
FDI_{N,t} &= \varphi_{3,N} + \sum_{l=1}^{ml\_FDI_3} \gamma_{3,N,l} FDI_{N,t-1} + \sum_{l=1}^{ml\_EXP_3} \beta_{3,N,l} EXP_{N,t-1} + \sum_{l=1}^{ml\_LSCI_3} \alpha_{3,N,l} LSCI_{1,t-1} + \xi_{3,N,t}
\end{aligned}\right\} \quad (3)
$$

Model 1 is used to test the causality from LSCI and FDI variables to the EXP variable; Model 2 is used to test the causality from EXP and FDI variables to LSCI variable; and Model 3 is used to test the causality from EXP and LSCI variables to FDI variable. In the equations, N represents the number of countries ($i = 1,2, \ldots,5$) and t represents the time interval ($t = 2006, 2007, \ldots, 2021$). Also, ml denotes the lag length. These lag lengths are determined using the optimal combination that minimizes the Akaike Information Criterion (AIC) and Schwartz Information Criterion (SC) values.

Table 4 presents the bootstrap panel causality test results.

According to the test results for Model 1 presented in Table 4, there is evidence of Granger causality running from LSCI and FDI to EXP for the Philippines (PHL), Singapore (SGP), and Thailand (THA). No statistically significant causal relationship was detected for Indonesia (IDN) and Malaysia (MYS). The estimated coefficients associated with these causal links are positive, indicating that improvements in maritime connectivity and increases in FDI are accompanied by higher export performance in the affected countries. This finding regarding the positive coefficient of LSCI is consistent with the results of Canbay (2024) and Ayesu *et al.* (2024), while the positive coefficient of FDI aligns with the evidence reported by Jawaid *et al.*

Table 4. Model (1) test results

H_0: LSCI and FDI have no granger causality effect on EXP						
Countries	Coefficients		Calculated values	Critical values *		
	LSCI	*FDI*	Wald	10%	5%	1%
IDN	–	–	0.10	8.26	13.04	27.99
MYS	+	–	8.94	11.51	17.28	32.37
PHL	+	+	*11.96***	*6.62*	*9.85*	*20.09*
SGP	+	+	*10.86***	*6.77*	*10.35*	*22.98*
THA	+	+	*18.69***	*7.44*	*11.34*	*22.67*

Note(s): * 10.000 bootstrap coefficients and critical values are derived
** There is causality at 10% significance level

(2016), Ahmad *et al*. (2018), Lakshani *et al*. (2023), Acar and Benli (2021), and Ayesu *et al.* (2024).

According to the test results for Model 2 presented in Table 5, there is evidence of Granger causality running from EXP and FDI to LSCI in Indonesia (IDN) and the Philippines (PHL). The estimated coefficients for exports are positive in both countries, suggesting that rising export volumes are associated with improvements in maritime connectivity. In contrast, the estimated coefficient for FDI is negative in Indonesia but positive in the Philippines, implying that the direction of the relationship between foreign investment and maritime transport differs across economies. For Malaysia (MYS), Singapore (SGP), and Thailand (THA), no statistically significant causal relationship is detected. The finding that higher export activity is accompanied by stronger maritime connectivity is consistent with the results of Canbay (2024), indicating that trade expansion can generate infrastructure-driven feedback effects in developing economies.

According to the test results for Model 3 presented in Table 6, there is evidence of Granger causality running from EXP and LSCI to FDI in the Philippines (PHL) and Singapore (SGP). The estimated coefficients for LSCI are positive in both countries, indicating that stronger maritime connectivity is associated with higher levels of foreign direct investment. However, the estimated coefficient for exports is negative in the Philippines and positive in Singapore, suggesting that the trade–investment linkage operates differently across these economies. For Indonesia (IDN), Malaysia (MYS), and Thailand (THA), no statistically significant causal relationship is observed from EXP and LSCI to FDI. The positive estimated effect of LSCI on FDI aligns with the findings of Jouili (2018) and Vechiu (2023), whereas the export-driven enhancement of FDI observed in Singapore is consistent with Jawaid *et al*. (2016) and Lakshani *et al.* (2023).

Table 5. Model (2) test results

H_0: EXP and FDI have no Granger causality effect on LSCI						
Countries	Coefficients		Calculated values	Critical values *		
	EXP	*FDI*	Wald	10%	5%	1%
IDN	+	−	*12.78***	*9.62*	*15.17*	*36.55*
MYS	+	−	1.93	8.70	13.78	29.78
PHL	+	+	*12.41***	*9.47*	*14.80*	*31.28*
SGP	+	+	0.15	8.29	12.89	28.47
THA	+	−	0.29	8.69	13.50	26.75

Note(s): * 10.000 bootstrap coefficients and critical values are derived
** There is causality at 10% significance level

Table 6. Model (3) test results

H_0: EXP and LSCI have no Granger causality effect on FDI						
Countries	Coefficients		Calculated values	Critical values *		
	EXP	*LSCI*	Wald	10%	5%	1%
IDN	+	−	1.07	8.41	12.53	27.65
MYS	−	+	0.17	7.31	11.26	24.10
PHL	−	+	*10.88***	*7.47*	*11.32*	*23.69*
SGP	+	+	*7.66***	*7.26*	*11.47*	*24.76*
THA	−	−	2.94	7.51	12.41	25.76

Note(s): * 10.000 bootstrap coefficients and critical values are derived
** There is causality at 10% significance level

5. Discussion

This study examined the causal relationships among export volume, maritime transport connectivity (LSCI), and foreign direct investment (FDI) for the founding ASEAN members—Indonesia, Malaysia, the Philippines, Singapore, and Thailand—over the period 2006–2021. Using the panel bootstrap causality approach, country-specific dynamics were identified, reflecting the heterogeneity of logistics structures, trade orientation, and investment patterns across the region.

The findings show evidence of Granger causality running from LSCI and FDI to export performance in the Philippines, Singapore, and Thailand. The estimated coefficients for these causal relationships are positive, indicating that improvements in maritime connectivity and increases in FDI are associated with higher export performance. These results align with Shao *et al*. (2023) and Siautama *et al*. (2024), who emphasized that maritime infrastructure upgrades strengthen regional trade integration. For Singapore, already positioned as a global logistics hub, and for the Philippines and Thailand—both central to maritime corridors—strong connectivity and inflows of FDI have contributed to export growth. Conversely, the absence of causality in Indonesia and Malaysia suggests structural limitations. Indonesia's archipelagic geography and fragmented infrastructure constrain the translation of maritime connectivity into trade performance (Jouili, 2018), while Malaysia's resource-based export structure limits the responsiveness of trade to logistics and investment (Vidya and Taghizadeh-Hesary, 2021).

In the second model, Granger causality from exports to LSCI is identified in Indonesia and the Philippines, with positive estimated coefficients suggesting that expanding trade volumes stimulate improvements in transport networks—a dynamic consistent with Limão and Venables (2001), who showed that trade expansion drives infrastructure development. However, the negative coefficient of FDI in Indonesia implies that certain investments may not align with the existing logistics structure or that high transport costs reduce efficiency (Sandee, 2016). In contrast, no significant causal relationship is found in Malaysia, Singapore, or Thailand, where logistics systems are already mature or shaped by broader macroeconomic factors (Oo *et al*., 2019). These results reinforce the asymmetric feedback loops between logistics and trade depending on each country's level of infrastructural advancement.

In the third model, Granger causality from LSCI to FDI is detected in the Philippines and Singapore, and the estimated coefficients are positive, indicating that stronger maritime connectivity attracts foreign investors by reducing transaction costs and ensuring access to global supply chains (Siautama *et al*., 2024). Singapore's advanced transport infrastructure strengthens its comparative advantage (Al-Diasti *et al*., 2024), while in the Philippines, improvements in connectivity enhance its attractiveness for foreign investors despite ongoing infrastructure challenges (Navarro, 2015; Llanto, 2016). The negative coefficient of exports in the Philippines, on the other hand, implies that export growth does not necessarily translate into greater investment inflows when export structures remain insufficiently diversified (Farshid *et al*., 2009). These heterogeneous outcomes align with Ridzuan *et al*. (2018), who emphasize that FDI patterns in ASEAN are influenced more by domestic market characteristics than by uniform regional trends.

Overall, the results reveal distinct country-specific causal relationships among trade, investment, and maritime logistics. This heterogeneity underscores the importance of policy coordination within ASEAN. Countries like Indonesia could benefit from regional funding mechanisms to address geographic constraints, while high-performing members such as Singapore and the Philippines could serve as knowledge-transfer and technological hubs for the region. Promoting green logistics and sustainable maritime transport technologies would further strengthen ASEAN's resilience and alignment with global sustainability goals. These findings contribute to the literature by demonstrating that although the direction and intensity of causality differ across countries, the underlying mechanism linking logistics, trade, and investment remains consistent with international evidence from Africa (Sakyi and Immurana, 2021) and BRICS-T countries (Canbay, 2024).

6. Conclusion

The empirical evidence confirms that maritime connectivity, foreign investment, and exports are interrelated in ASEAN economies, but the strength and direction of these relationships differ across countries. In nations with robust infrastructure and diversified economies such as Singapore and Thailand, connectivity and investment reinforce trade growth. In contrast, logistics fragmentation and sectoral concentration weaken these linkages in Indonesia and Malaysia. The results therefore support the argument that improving maritime infrastructure and aligning FDI policies with logistic modernization are key drivers of sustainable trade performance in ASEAN.

From a policy standpoint, regional coordination mechanisms should prioritize infrastructure financing for archipelagic members, develop joint maritime corridors, and harmonize investment incentives. ASEAN's integration agenda would also benefit from emphasizing technological innovation in port management, digital logistics systems, and green maritime strategies. Such actions would not only narrow intra-regional disparities but also strengthen the region's collective role in global trade networks.

6.1 Limitations and future research

While this study provides novel insights into the causal interplay among LSCI, FDI, and exports for the ASEAN-5, several limitations warrant consideration. First, the analysis is restricted to five founding members due to data availability, and therefore, the results cannot be generalized to all ASEAN countries. Future studies could expand coverage to include newer members such as Vietnam or Myanmar once comparable data become available. Second, the time frame (2006–2021) is limited by the availability of LSCI data; however, it coincides with ASEAN's most dynamic phase of trade and infrastructure development, offering meaningful insights despite the constraint. Third, the model focuses on three primary variables, which—while theoretically and empirically robust—exclude other potentially relevant determinants such as exchange rates, institutional quality, or trade openness. Incorporating these factors in future analyses could enrich our understanding of the logistics–trade–investment nexus. Finally, the study does not explicitly control for macroeconomic shocks (e.g. the global financial crisis or COVID-19 pandemic), which may have influenced short-term trade and investment dynamics. Future research could apply time-varying or structural break models to assess these impacts more precisely.

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