Driving Growth with the Blue Economy: An Empirical Study of South China Sea Countries

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Abstract

Many South China Sea countries are developing nations that rely significantly on marine resources. Some areas within these countries still face poverty, particularly in rural or remote regions. Hence, the blue economy presents a significant opportunity for these nations to address the economic challenges and improve the well-being in the region. This study investigates the impact of blue economy elements on economic growth in South China Sea countries from 2000 to 2022 using panel ARDL. Focusing on aquaculture and fisheries production as key blue economy indicators, alongside control variables such as labour, capital, government expenditure, and trade openness. Findings reveal the significant long-run relationship between blue economy elements and economic growth, whereas no such relationship is observed in the short-run. The study may provide insights for policymakers to design effective policy and allocate resources strategically. The study focuses primarily on the economic impacts of the blue economy, the future researches may focus on the blue economy impacts social and environmental dimensions.

Keywords: Blue economy; South China Sea Countries; Panel ARDL

1. Introduction

The South China Sea is abundant in marine resources, including fisheries, oil, natural gas, and minerals. This aquaculture contributes to the economies of the countries bordering the South China Sea, such as Brunei Darussalam, China, Indonesia, Cambodia, Malaysia, the Philippines, Singapore, and Vietnam. It is also essential for regional cooperation and stability (Damayanti, 2017). Furthermore, the exploitation of these marine resources may generate revenue, attract investment, and support the growth of related industries (Zheng et al., 2018). China is the major contributor in this aquaculture. China's overall fish production has increased significantly in recent decades, with almost all of this growth coming from aquaculture (Cao et al., 2017). In 2019, China was the top aquaculture producer globally, with 48.2 million tons (Irshath et al., 2023). In 2022, marine GDP reached 300 billion yuan in Shenzhen city, accounting for 9.7% of the city's total GDP. This indicates the significant potential of marine industries to contribute to economic growth (He, 2023). These developments suggest a growing recognition of the importance of the blue economy in the South China Sea region.

The increasing focus on the blue economy in the South China Sea region, with countries like Indonesia actively promoting its optimization as a new driver for ASEAN's economic growth (Alatas & Liman, 2023). ASEAN's economic growth is currently experiencing a downward trend, creating a need for a new engine for economic growth. The blue economy presents a shared opportunity for ASEAN members to strengthen their economies. In Vietnam, marine cage lobster cultivation has been seen as a high return business (Hai & Speelman, 2019). However, in recent years, the ecological environment of the South China Sea has suffered significant damage, leading to a decline in fishery resources (Zhang, 2016). Overfishing and environmental degradation are key issues that that hinder sustainable economic growth. The loss of biodiversity and ecosystem services due to overfishing and environmental degradation can have significant long-term economic costs.

Today, more people living in coastal cities who needs higher energy, making the connection between people and oceans more important and complex. The world leaders are starting to focus more on how we use marine resources. If the countries manage these resources carefully, they can help to promote the economy. Even though the blue economy is a new idea, it is already important for South China Sea countries. The blue economy could help solve many social and economic problems (Cisneros-Montemayor et. al, 2019). Most of the South China Sea countries are developing countries, some areas within these countries (especially rural or remote regions) still face poverty. Hence, developing the blue economy could be an important way to improve life in the region. Therefore, the objective of the study is to explore the influence of blue economy elements on the economic growth of countries surrounding the South China Sea. In order to better understand how blue economy factors influence economic growth, a model was developed to examine the interactions between these variables across both short-run and long-run periods.

The study may help policymakers gain insights into how blue economy elements impact economic growth and enabling them to design more effective policies and allocate resources strategically. By understanding the relationships between different blue economy elements and economic growth, businesses can make more informed decisions about where to allocate capital and develop new ventures. Researchers can adapt the model to explore the unique characteristics of different regions and contexts, leading to a deeper understanding of the complex interactions within the blue economy worldwide.

The paper is structured as follows. It begins with an introduction that presents the research problem and provides the necessary background. This is followed by a literature review summarising existing research relevant to the study. Next, the methodology section details how the research was conducted. The results section then presents the findings of the study. Finally, the study concludes with the outcomes and discusses their implications.

2. Literature Review

The blue economy involves the responsible utilization of marine resources to drive economic development, enhance subsistence, and produce employment, while protecting the vitality of marine ecosystems (Stephenson & Hobday, 2024; Narwal et al., 2024;Pace et al., 2022; Germond-Duret et al., 2022). It involves a broad range of sectors, including fisheries, renewable energy (such as offshore wind and tidal energy), and marine biotechnology, shipping, tourism, and coastal protection. The blue economy holds particular significance for countries along the coastline due to their unique dependence on the ocean for economic, environmental, and social well-being (Stephenson & Hobday, 2024; Evans et al., 2023; Bax et al., 2021; Karani & Failler, 2020). Coastal countries typically have access to rich marine resources, making them central to the blue economy. The countries chosen in this study is the countries along the South China Sea.

The South China Sea is a vast, tropical sea in Southeast Asia well known for its strategic location, rich natural resources, and vital ecosystem (Zhao et al., 2020). The South China Sea is bordered by several countries, including China to the north, Brunei and Malaysia to the south, Taiwan in the northeast, Vietnam to the west, and Philippine to the east. Besides having rich marine biodiversity, the South China Sea is believed to hold substantial oil and gas reserves. It is also a major global shipping route that allows the transit for one third of the global marine trade. The geopolitical and economic significance of the South China Sea making it a critical area for regional cooperation in the development of the blue economy between the bordering countries.

Among the many benefits from the blue economy, economic development is the one that hardly ignore, particularly in terms of contribution to gross domestic product (GDP) (Martínez-Vázquez et al., 2023; Sarwar, 2022; Qi, 2021; Alharthi & Hanif, 2020). United Nation suggests that each year, marine and coastal resources and industries contribute about US$3 trillion to the global economy, which makes up roughly 5% of the world's total GDP. On country level, the national gross ocean product (GOP) in China reached approximately US$1.26 trillion, accounting for 9% of the nation's GDP in 2019 (World Economic Forum, 2023). On top of that, the ocean economy contributes approximately 3.0% to Bangladesh's GDP, amounting to about US$6.2 billion (World Bank, 2018). The importance of the blue economy to economic growth is self-evident results in spontaneous further study of the mechanism between the two.

Generally, the activities in blue economy can be categorized into two: resource based and service based. Resource based activities referring to the utilization of ocean's physical and biological resources in a sustainable manner, driving growth through industries like fisheries, aquaculture, renewable energy, and marine biotechnology (Eyuboglu & Akmermer, 2023; Pace et al., 2022; Martínez-Vázquez et al., 2021; Alharthi & Hanif, 2020). Among the many resource-based sectors, fisheries and aquaculture are among those contribute the most to GDP (Alsaleh & Wang, 2024; Alsaleh et al., 2023; Das, 2023; Silvestri et al., 2022; Alharthi & Hanif, 2020; Campbell et al., 2020). Alharthi and Hanif (2020) found that fisheries and aquaculture are having high potential to be the engine of growth for South Asian Association for Regional Cooperation (SAARC) countries. On the other hand, Campbell et al. (2020) highlighted the growth potential of aquaculture in the case of United States. The same goes to European Union countries (Alsaleh & Wang, 2024), China (Ahammed et al., 2024), and Africa (Mohanty & Dash, 2020).

Service based activities referring to the preservation, management, and sustainable use of ocean ecosystems and resources, driving economic value through activities like tourism, waste management, and coastal protection (Picken, 2023; Sarwar, 2022; Martínez-Vázquez et al., 2021; Bădîrcea et al., 2021; Bax et al., 2021). Among the service-based sectors, maritime transport and shipping is found to be the top contributor to economic growth particularly in countries like Montenegro (Nikčević & Škurić, 2021), European Union countries (Fratila et al., 2021; Bădîrcea et al., 2021), Pakistan (Butt, 2021), Nigeria (Jacob & Umoh, 2022), and Poland (Mogila et al., 2024). Besides, coastal tourism is also known to be one of the main contributors to economic development (Alsaleh & Wang, 2024; Alsaleh et al., 2023; Kabil et al., 2021; Karani & Failler, 2020). Coastal tourism typically involves a diverse array of activities focused on tourism, leisure, and recreation, taking place within the coastal areas and their adjacent offshore waters (Alsaleh et al., 2023; Wilks, 2023; Karani & Failler, 2020).

According to Wilks (2023), the most desired destination for coastal tourism is Maldives and most of the destinations have their beaches as the top asset. Hence, the preservation and protection of the beaches is the top priority to promote marine tourism (Galdolage et al., 2024; World Bank, 2022).

The importance of blue economy to promote economy development of the countries along the coastal line making it vital to this study. The countries bordering the South China Sea are chosen in this study to evaluate the growth effect of blue economy. Studies on the growth effect of blue economy in the South China Sea region are very rare, with the latest study dating back to Zhao et al., (2020). This study attempts to fill up the gap by applying a more updated dataset ranging from 2000-2022. The data will be analyzed using Autoregressive Distributed Lag (ARDL) method.

3. Model, Data and Methodology

This research explores the influence of blue economy elements on the economic growth of countries surrounding the South China Sea from the period of 2000 to 2022. The study considers aquaculture production and total fisheries production as the blue economy factors, and labour, capital, government consumption expenditure, and trade openness as the control variables. The study countries encompass Brunei Darussalam, China, Indonesia, Cambodia, Malaysia, the Philippines, Singapore, and Vietnam. The data for gross domestic product, aquaculture production, total fisheries production, gross fixed capital formation, and total labour force were obtained from the World Development Indicators (WDI) database. The general government final consumption expenditure and trade openness data were retrieved from the United Nations Conference on Trade and Development (UNCTAD) database. All the study variables are converted into the logarithmic form except the trade openness variable.

Table 1: Source of data and description of variables

Variables	Description	Logarithmic form	Unit of measurement	Source
GDP	Gross domestic product (Economic growth)	LGDP	GDP (constant 2015 US$$)	WDI
AP	Aquaculture production	LAP	Aquaculture production (metric tons)	WDI
TFP	Total fisheries production	LTFP	Total fisheries production (metric tons)	WDI
GFCF	Capital	LGFCF	Gross fixed capital formation (% of GDP)	WDI
LF	Total labour force	LLF	Labor force, total	WDI
GFCE	General government final consumption expenditure	LGFCE	US$ at current prices in millions	UNCTAD
TO	Trade openness		US$ at current prices in millions	UNCTAD

This study develops an econometric model to investigate the long-term and short-term relationships between economic growth and blue economy factors. This study uses aquaculture production and total fisheries production as proxies for blue economy factors. Accordingly, the analysis is divided into two different models. The model's functional form is:

$$GDP=f\,(AP, GFCF, LF, GFCE, TO) \quad (1)$$
$$GDP=f\,(TFP, GFCF, LF, GFCE, TO) \quad (2)$$

The econometric models are specified as follows:

$$GDP_{it} = \alpha_0 + \alpha_1 AP_{it} + \alpha_2 GFCF_{it} + \alpha_3 LF_{it} + \alpha_4 GFCE_{it} + \alpha_5 TO_{it} + \varepsilon_{it} \quad (3)$$
$$GDP_{it} = \beta_0 + \beta_1 TFP_{it} + \beta_2 GFCF_{it} + \beta_3 LF_{it} + \beta_4 GFCE_{it} + \beta_5 TO_{it} + \mu_{it} \quad (4)$$

Transforming the econometric model by taking the natural logarithm of both sides:

$$LGDP_{it} = \alpha_0 + \alpha_1 LAP_{it} + \alpha_2 LGFCF_{it} + \alpha_3 LLF_{it} + \alpha_4 LGFCE_{it} + \alpha_5 TO_{it} + \varepsilon_{it} \quad (5)$$
$$LGDP_{it} = \beta_0 + \beta_1 LTFP_{it} + \beta_2 LGFCF_{it} + \beta_3 LLF_{it} + \beta_4 LGFCE_{it} + \beta_5 TO_{it} + \mu_{it} \quad (6)$$

The use of logarithmic forms for the sampled variables facilitated the achievement of constant variance within the data series. Where i represents the cross-sectional unit, t denotes the time period, and ε and μ refer to error term. α_0 and β_0 represent intercept term, while the coefficients of all the study variables are $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \beta_1, \beta_2, \beta_3, \beta_4$, and β_5.

This study examines the relationship between aquaculture production, total fisheries production, gross fixed capital formation, labor force, government final consumption expenditure, trade openness, and economic growth of countries surrounding the South China Sea. Since the selected countries under investigation are highly interconnected, the issue of "cross-sectional dependence" becomes a significant concern. Given the potential for issues that arise in one country to rapidly disseminate to others, the cross-sectional dependence (CSD) test will be conducted promptly. Next, stationary tests (Levin, Lin & Chu, Im, Pesaran and Shin W-stat, ADF and PP- Fisher Chi-square, CIPS and CADF) will be performed subsequent to the verification of cross-sectional dependence issues. Thirdly, given the panel data structure of the study, the panel cointegration test was employed. Finally, the panel autoregressive distributed lag (ARDL) approach was employed to estimate the coefficients of the variables in the short-run and long–run for the panel data.

The econometric investigation begins by confirming the existence of cross-sectional dependence within the panel data. The CSD test was used because the selected countries in the study are closely connected in different factors, such as their trade ties, geographic location, and shared cultural and political features. Considering this context, there is an interconnected series of dependencies among the countries. Therefore, this study employed Breusch-Pagan LM and Pesaran scaled LM tests, developed by Breusch and Pagan (1980), and Pesaran cross-sectional dependence test, suggested by Pesaran (2004), to account for the potential interdependencies among the selected countries. The Pesaran Cross-Sectional Dependence test statistic is represented by the mathematical expression shown below.

$$CD = \sqrt{\frac{2}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\sqrt{T_{ij}\hat{p}_{ij}}\right) \quad (7)$$

The dataset is characterized by the variable N, which denotes the sample size, and the variable T, which represents the time period. The relationship between the residuals of countries i and j is represented by the variable $\hat{p}_{ij}$.

This study employed both first-generation and second-generation unit root test methods to assess the presence of stationarity in the panel data. We utilized the first-generation unit root tests of Levin, Lin, and Chu (LLC), as proposed by Levin et al. (2002), and Im, Pesaran, and Shin (IPS), as presented by Im et al. (2003), as well as Fisher-ADF and Fisher-PP unit root tests, developed by Maddala and Wu (1999), and Choi (2001). In contrast, Pesaran proposed the CIPS and CADF tests, which are second-generation unit root tests designed to account for cross-sectional dependence and heterogeneity in slope parameters. The mathematical expressions for the Levin, Lin, and Chu test statistics are provided below.

$$\Delta y_{it} = \beta_i y_{it-1} + \sum_{j=1}^{pi} di_j \Delta y_{it-1} + X'_{it}\vartheta + \mu_{it} \tag{8}$$

In this regression model, the parameter vector is represented by ϑ, while the column vector of the independent variable is denoted as Xit'.

Im et al. (2003) developed the IPS unit root test, which utilizes the mean of the individual unit root test statistics, and they also extended the LLC test. The mathematical expression for the IPS unit root test is presented below.

$$\Delta y_{i,t} = \beta_i + \gamma_{i,t-1} + \sum_{j=1}^{k} \theta_k \Delta y_{i,t-j} + \mu_{i,t} \tag{9}$$

The mathematical formulation of the CADF unit root test statistic is described in equation (9).

$$\Delta X_{it} = \beta_i + \gamma X_{i,t-1} + \delta_i \bar{X}_{t-1} + \rho_i \Delta \bar{X}_t + \epsilon_{it} \tag{10}$$

Incorporating the lagged value (t-1) into the equation yields the following formulation:

$$\Delta X_{it} = \beta_i + \gamma_i x_{i,t-1} + \delta_i \bar{X}_{t-1} + \sum_{j=0}^{p} \rho_i \Delta \bar{X}_{t-j} + \sum_{j=0}^{p} \partial_{ij} \Delta X_{i,t-j} + \mathcal{E}_{it} \tag{11}$$

In this context, X_{t-1} denotes the lagged value of the cross-sectional average, while $\Delta X_{i,t-j}$ represents the initial difference of the cross-sectional averages for each individual data point.

The cross-sectional dependence in the panel is denoted by the parameters P, i, and t, which represent the panel, individual, and time dimensions, respectively, along with the time and lag order. Furthermore, the CIPS statistic is derived by calculating the mean of the CADF statistics across the individual cross-sectional units. The equation is expressed as follows:

$$CIPS = N^{-1} \sum_{i=1}^{N} t_j(N,T) = \frac{\sum_{i=1}^{N} CADF_i}{N} \tag{12}$$

Where the $t_j(N,T)$ associated with the CADF regression model are investigated.

This study employs various cointegration analysis methods to explore the cointegrating relationships among the variables. Given the potential for panel heterogeneity, the Pedroni panel cointegration test is employed to assess the existence of cointegration. Pedroni (1999) analysis encompassed two distinct evaluation approaches. The first test employs a within-dimension approach and utilizes four statistical measures: panel v-statistics, panel rho-statistics, panel PP-statistics, and panel ADF-statistics. The second test utilizes a betweendimension approach and employs three statistical measures: group mean statistics, group mean PP statistics, and group mean ADF statistics. The null hypothesis of no cointegration is rejected if the p-values for all test statistics are less than the specified significance level. The general regression residuals for the proposed cointegration regression are expressed as follows:

$$y_{i,t} = \rho_i + \delta_i t + \gamma_{1i} x_{1i,t} + \gamma_{2i} x_{2i,t} + \cdots + \gamma_{Mi} x_{Mi,t} + e_{i,t} \tag{13}$$

for, t = 1,….T; i = 1,…, N; m=1,…, M

The null hypothesis for the no cointegration test states that there is no long-term equilibrium relationship among the variables: H_0: $f_i = 0$ (absence of cointegration).

The Kao cointegration test uses a similar approach to the Pedroni cointegration test, but it assumes homogeneity across panels.

$$X_{it} = \alpha_i * Y_{it\beta} + \omega_{it} \tag{14}$$

where the individual units are indexed by i = 1, ..., N and the time periods are indexed by t = 1, ..., T; αi represents the individual constant term for each unit. β signifies the slope coefficient, and ωi represents the stationary distribution. X_{it} and Y_{it} are integrated processes of order I(1) for all i. Kao (1999) proposes two panel cointegration test (standard Dickey-Fuller and Augmented Dickey-Fuller) methodologies. The two panel cointegration tests formulated by Kao (1999) can be derived from:

$$\bar{\omega}_{it} = \rho \bar{\omega}_{it} + V_{it} \tag{15}$$

and

$$\bar{\omega}_{it} = \rho \bar{\omega}_{it-1} + \sum_{j-1}^{\rho} \Phi_j \Delta\, \bar{\omega}_{it-j} + V_{it} \tag{16}$$

Where the parameter $\bar{\omega}_{it-1}$ is calculated using the equation (16). The null hypothesis states that $H_0: \rho = 1$ (no cointegration), whereas the alternative hypothesis asserts that $H_1: \rho < 1$.

For the Johansen cointegration test, Johansen (1988) introduces two different statistical approaches to evaluate the presence of cointegration vectors in non-stationary time series data. These include the likelihood ratio trace statistic and the maximum eigenvalue statistic. The trace statistic and maximum eigenvalue statistic are presented in the corresponding equations.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln{(1 - \hat{\lambda}_i)} \tag{17}$$

and

$$\lambda_{max}(r, r+1) = -T \ln{(1 - \hat{\lambda}_{r+1})} \tag{18}$$

The sample size is represented by T, the number of study variables is denoted as n, and the i-th largest canonical correlation is described as the relationship between the residuals from the three-dimensional processes and the residual from the three-dimensional differentiated processes. The trace test examines the null hypothesis of at most r cointegrating vectors against the alternative hypothesis of full rank r=n cointegrating vectors. In contrast, the maximum eigenvalue statistic tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of r+1 cointegrating vectors.

Maddala and Wu (1999) employ Johansen's (1988) cointegration test and adopt Fisher's (1932) recommendation to combine individual tests, proposing an alternative to the two previous methods for assessing cointegration in the entire panel by aggregating individual cross-sectional cointegration tests.

Assuming that the p-value from an individual cointegration test for a given cross-section is represented by π_i, then under the null hypothesis for the entire panel,

$$-2\sum_{i=1}^{N} log_e(\pi_i) \quad (19)$$

is distributed as χ^2_{2N}.

The EViews statistical software reports the χ^2-value based on the p-values calculated using the MacKinnon-Haug-Michelis methodology for Johansen's cointegration trace and maximum eigenvalue tests.

The study employs the panel autoregressive distributed lag (ARDL) model formulated by Pesaran and Smith (1995) and Pesaran et al. (1999). This technique offers advantages compared to traditional approaches for estimating short-term and long-term effects. This model allows estimating short-term and long-term dynamics simultaneously and suitable for studies with small and large sample sizes (Shin et al., 2014). Furthermore, the panel ARDL approach provides consistent and more robust estimates compared to alternative techniques (Pesaran et al., 2001). Additionally, it can handle variables with differing orders of integration, such as I(0) and I(1), but not higher orders of integration, I(2) (Katircioglu, 2009) and permits the use of different lags structures for each variable (Pesaran et al., 2001). Compared to other dynamic models such as fixed effects and GMM (General Methods of Moments) estimators, panel ARDL can produce more consistent estimates (Gocer and Ongan, 2020). According to the panel ARDL analysis, the long-run model is presented in equation (20).

$$\Delta LGDP_{it} = \alpha_1 + \sum_{k=1}^{p} \beta_{ij} LGDP_{it-j} + \sum_{k=0}^{q} \delta_{ij} \Upsilon_{it-j} + \varepsilon_{it} \quad (20)$$

In the equation (20), i, t, and j denote the cross-sectional unit, time frame, and optimal lags, respectively. The exogenous variables are denoted by Υ_{it}. Additionally, p and q represent the optimal lag structures, while the stochastic error term is denoted by ε_{it}. The short-run model estimates for the study variables are shown in the equation (21) and shown as below:

$$\Delta LGDP_{it} = \theta_1 + \sum_{k=1}^{p} M_{ij} \Delta LGDP_{it-j} + \sum_{k=0}^{q} Z_{ij} \Delta\Upsilon_{it-j} + \Phi_{ij} ECT_{t-i} + \varepsilon_{it} \quad (21)$$

The error correction term (ECT) in the equation (21) determines the speed of adjustment towards the long-run equilibrium following short-run disturbances, thereby enabling a long-run analysis of the relationships between the selected variables. The error correction term, ECT_{t-i}, represents the speed at which the system adjusts towards the long-run equilibrium after a disturbance, as represented by the coefficient Φ_{ij}. Importantly, the coefficients of the lagged error correction term ECT_{t-1} are required to be negative and statistically significant (Menegaki, 2019).

4. Results and Discussions

As shown in Table 2, the results of the Cross-Sectional Dependence (CSD) test demonstrate a significant existence of cross-sectional dependence among the variables under investigation. The CD test statistics for all study variables are highly significant at the 1% level, indicating a lack of cross-sectional independence among these variables across the observational units. The substantial level of statistical significance indicates that variations or disruptions in one component are likely to influence other components within the panel. In other words, the results suggest that a shock experienced by one of the sampled nations could have a ripple effect on the other nations. This finding may be further amplified by other related factors, including globalization, sociocultural dynamics, and the sustainable development purposes of the economies. Given that cross-sectional dependence is a critical factor that must be accounted for in the analysis, as it has implications for the reliability and interpretation of the findings. Hence, it is essential to utilize second-generation panel data methods that address this dependence in order to guarantee precise and reliable conclusions.

Table 2: Cross-sectional dependence test results

Variables	Breusch-Pagan LM	Pesaran scaled LM	Pesaran CD
	CD-statistics	CD-statistics	CD-statistics
LGDP	479.6821***	60.3586***	19.6011***
LAP	353.7192***	43.5261***	16.3951***
LTFP	323.7507***	39.5213***	10.9913***
LGFCF	149.2464***	16.2022***	3.7354***
LLF	578.4963***	73.5632***	23.9967***
LGFCE	589.6736***	75.0568***	24.2652***
TO	197.5103***	22.6518***	3.2969***

*Note: *** represents significance at the 1% level.*

Table 3 summarizes the results from first-generation (Levin, Lin & Chu, Im, Pesaran and Shin W-stat, ADF and PP- Fisher Chi-square) and second-generation (CIPS and CADF) panel unit root tests, which were conducted to evaluate the stationarity of the dataset. The results demonstrate that the LLF variable exhibits stationarity at level form based on the CIPS and CADF tests, implying that it is integrated of order zero or I(0). This suggests that the variable does not display a unit root and remains stable over time without the need for differencing. Conversely, the variables LGDP, LAP, LTFP, LGFCF, LGFCE and TO do not exhibit initial stationarity at their levels form. However, all study variables were found to be integrated of order one or I(1), as they exhibit stationarity when the first difference is taken. The findings suggest that these variables necessitate a first-order differencing to achieve stationarity, implying they adhere to a random walk pattern but stabilize subsequent to the differencing procedure. The panel unit root analyses demonstrate that the dataset does not exhibit any unit root problems, as all variables are either stationary in levels or become stationary after first-differencing.

Table 3: Panel unit root test results

Variables	Level	First difference
Levin, Lin & Chu Test		
LGDP	2.17790	-8.08331***
LAP	-1.01478	-4.93359***
LTFP	-1.01338	-4.58788***
LGFCF	0.80554	-8.13409***
LLF	0.11263	-5.26649***
LGFCE	1.26953	-6.34894***
TO	1.27118	-6.11171***
Im, Pesaran and Shin W-stat Test		
LGDP	1.92136	-6.31644***
LAP	0.58096	-4.03879***
LTFP	0.21665	-6.28433***
LGFCF	0.75486	-7.31795***
LLF	2.16620	-6.04187***
LGFCE	2.83975	-4.70468***
TO	0.43442	-6.01871***
ADF - Fisher Chi-square Test		
LGDP	12.2119	63.6573***
LAP	16.0129	43.4344***
LTFP	12.5438	65.2614***
LGFCF	15.3499	74.0359***
LLF	8.77922	64.7136***
LGFCE	5.77157	49.9814***
TO	20.5368	65.4438***
PP - Fisher Chi-square Test		
LGDP	6.81294	88.9415***
LAP	9.08891	50.2920***
LTFP	12.9825	70.3218***
LGFCF	14.0253	75.6790***
LLF	6.17521	64.6681***
LGFCE	5.75005	46.4556***
TO	6.47620	72.3886***
CIPS Test		
LGDP	-1.704	-3.324***
LAP	-1.324	-2.861***
LTFP	-1.823	-3.506***
LGFCF	-1.771	-3.777***
LLF	-2.469***	-3.229***
LGFCE	-1.777	-3.975***
TO	-0.860	-3.404***
CADF Test		
LGDP	-1.666	-2.494**
LAP	-1.431	-2.273*
LTFP	-1.612	-2.360**
LGFCF	-2.093	-2.837***
LLF	-2.583***	-2.685***
LGFCE	-1.437	-2.937***
TO	-1.217	-2.493**

*Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.*

This study continues to analyse whether the variables in a panel dataset have stable long-run relationships using several cointegration methods, namely the Pedroni Residual Cointegration test, the KAO test, and the Johansen Fisher Panel Cointegration test in Table 4 and Table 5, respectively. The Pedroni analysis examines both pooled within-dimension tests and group mean tests across dimensions, each with its own intercept. Based on Model 1 in Table 4, the results of the Pedroni panel co-integration test indicate that the null hypothesis, which posits the absence of co-integration, is rejected by six out of the eleven test outcomes. Moreover, there is significant evidence to reject the null hypothesis of no cointegration for the KAO test and Johansen Fisher Panel Cointegration test. In general, these findings suggest that there is evidence of cointegration among the variables in the panel dataset in Model 1. Likewise, Model 2 in Table 5 also obtained similar results as Model 1, which was rejected by five out of the eleven test results in the Pedroni panel co-integration test. Furthermore, the KAO test and Johansen Fisher Panel Cointegration test provide strong evidence to reject the hypothesis of no cointegration in the Model 2. Overall, the findings from Pedroni, Kao, and Johansen cointegration analyses suggest a long-term equilibrium relationship between blue economy (aquaculture production and total fisheries production), gross fixed capital formation, labour force, government final consumption expenditure and trade openness with economic growth in both Model 1 and 2.

Table 4: Panel co-integration test results (Model 1: LGDP LAP LGFCF LLF LGFCE TO)

Tests	Statistic	Prob.	W. statistic	Prob.
Pedroni Residual Co-integration Test				
Panel v-Statistic	0.826338	0.2043	0.415533	0.3389
Panel rho-Statistic	0.639541	0.7388	1.149231	0.8748
Panel PP-Statistic	-2.387574***	0.0085	-1.309853*	0.0951
Panel ADF-Statistic	-3.326519***	0.0004	-2.309410**	0.0105
Group rho-Statistic	2.134128	0.9836		
Group PP-Statistic	-1.358341*	0.0872		
Group ADF-Statistic	-2.775206***	0.0028		
KAO Test				
ADF	-3.361200	0.0004***		
Johansen Fisher Panel Co-integration				
Hypothesized No. of CE(s)	Fisher stat. (from trace test)	Prob.	Fisher Stat. (from max-eigen test)	Prob.
None	398.8***	0.0000	212.9***	0.0000
At most 1	256.3***	0.0000	147.0***	0.0000
At most 2	150.1***	0.0000	82.90***	0.0000
At most 3	86.83***	0.0000	57.90***	0.0000
At most 4	46.84***	0.0001	31.31**	0.0123
At most 5	43.76***	0.0002	43.76***	0.0002

*Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.*

Table 5: Panel co-integration test results (Model 2: LGDP LTFP LGFCF LLF LGFCE TO)

Tests	Statistic	Prob.	W. statistic	Prob.
Pedroni Residual Co-integration Test				
Panel v-Statistic	0.722823	0.2349	-0.765912	0.7781
Panel rho-Statistic	1.029816	0.8485	1.705116	0.9559
Panel PP-Statistic	-2.135603**	0.0164	-0.533179	0.2970
Panel ADF-Statistic	-3.184205***	0.0007	-1.743051**	0.0407
Group rho-Statistic	2.661877	0.9961		
Group PP-Statistic	-1.499190*	0.0669		

Group ADF-Statistic	-2.595556***	0.0047		
KAO Test				
ADF	-3.197226***	0.0007		
Johansen Fisher Panel Co-integration				
Hypothesized No. of CE(s)	Fisher stat. (from trace test)	Prob.	Fisher Stat. (from max-eigen test)	Prob.
None	380.1***	0.0000	200.3***	0.0000
At most 1	237.4***	0.0000	137.4***	0.0000
At most 2	129.9***	0.0000	78.71***	0.0000
At most 3	67.35***	0.0000	34.50***	0.0046
At most 4	50.17***	0.0000	37.53***	0.0018
At most 5	41.92***	0.0004	41.92***	0.0004

*Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.*

After fulfilling the aforementioned econometric requirements and verifying the presence of a long-term association amongst the chosen variables. The panel ARDL model was employed to investigate the direction and magnitude of the blue economy factors and economic factors on the economic growth across the selected countries in the South China Sea. Table 6 and 7 display the results of the short-run and long-run panel ARDL outcomes for Model 1 and Model 2, respectively. The results of the panel ARDL analysis indicate that the blue economy components such as aquaculture production (LAP) and total fisheries production (LTFP) are positively correlated with economic growth (LGDP) in the long-run, but insignificant correlation with economic growth in the short-run for the Model 1 and Model 2. Specifically, the results reveal that a 1% increase in LAP and LTFP will increase LGDP by 0.0409% and 0.4946% in the long-run, respectively. This positive and statistically significant relationship highlights the impact of the blue economy in promoting economic growth in the log-run. This finding is supported by Alharthi and Hanif (2020), in which blue economy factors exhibit a statistically significant positive association with economic growth in South Asian Association for Regional Cooperation (SAARC) nations from 1995-2018, thereby contributing to the realization of Goal 14 of the United Nations' Sustainable Development Goals.

The findings of this study suggest that the effective management and exploitation of aquatic resources may contribute to the promotion of economic growth and alleviate the challenges of food scarcity by enhancing the availability of seafood in developing South Asian nations. Liza et al. (2025) also found that components of Bangladesh's blue economy, such as aquaculture and total fisheries production, have positively and significantly contributed to the country's economic growth in the long-run. The study suggests that enacting sustainable ocean governance policies is essential for advancing the blue economy's capacity to foster employment and economic growth. Moreover, the blue economy components, such as marine trade, have been identified as significant drivers of sustainable economic growth in Gulf countries (Sarwar, 2022). Additionally, Fratila et al. (2021) indicate that maritime transport represents a vital component of the blue economy and it holds an important position within the European Union. The empirical findings demonstrate that maritime transport, air emissions from maritime transportation, and investment in maritime port infrastructure are positively associated with economic growth across 20 European Union countries during the period from 2007 to 2018. Martínez-Vázquez et al. (2021) demonstrate the interconnected nature of diverse components within the blue economy and their relationship with per capita income levels. They suggest that sustainable development of maritime and marine sectors is supported by the blue growth approach, as the oceans and seas serve as engines powering the global economy and offer substantial potential for further growth and innovation.

The empirical results also revealed that GFCF has a positive and statistically significant relationship with GDP in the long-run, but not significant relationship with GDP in the short-run. Specifically, the results show that a 1% increase in LGFCF will increase LGDP by 0.4699% and 0.34% in the long-run for both Model 1 and 2. This empirical evidence indicates that gross fixed capital formation has a positive and statistically significant long-term relationship with economic growth. This finding is consistent with Topcu et al. (2020), in which gross fixed capital formation exhibits a positive and statistically significant relationship with economic growth in high-income economies. Azam et al. (2023) indicate a positive and statistically significant relationship between gross capital formation and economic growth in the panel dataset of 30 developing countries from 1990 to 2017. Poku et al. (2022) demonstrate that gross fixed capital formation exhibits a statistically significant positive association with economic growth in Ghana, using data from 1970 to 2016, in both the short-term and long-term horizons.

The empirical results indicates that while labour force and trade openness do not exhibit a statistically significant relationship with economic growth in the short-term, they demonstrate a statistically significant positive association in the long-term. Explicitly, a 1% increase in LLF will increase LGDP by 1.9483% and 2.1944% in the long-run for Model 1 and 2, respectively. Accordingly, a US$1 million rises in TO is projected to boost long-term LGDP by 40.42% and 37.86% for Model 1 and 2, respectively. These findings are in line with Fetahi-Vehapi et al. (2015), where they suggest that trade openness exerted a positive and statistically significant influence on economic growth in South East European countries over the period 1996 to 2012. Keho (2017) indicates that increased trade openness exerts a positive influence on economic growth in Cote d'Ivoire, both in the short-term and long-term, over the period from 1965 to 2014. The results also suggest a positive and robust complementary relationship between trade openness and capital formation in driving economic growth.

Lastly, the findings further demonstrated a positive and statistically significant long-term relationship between government final consumption expenditure and economic growth for Model 1. However, Model 2 indicated a negative and statistically significant long-term relationship between government final consumption expenditure and economic growth. Moreover, there have not significant relationship between government final consumption expenditure and economic growth in the short-run for both Model 1 and 2. Specifically, a 1% rise in LGFCE will result in a 0.0724% long-term increase in LGDP for Model 1. Conversely, for Model 2, a 1% rise in LGFCE will lead to a 0.1278% long-term decrease in LGDP. This result is aligned with Poku et al. (2022), where the government expenditure exhibits a positive association with economic growth in Ghana, based on data spanning the period from 1970 to 2016. Mostafa (2021) suggest that government expenditure positively influences economic growth in Egypt during the period from 1952 to 2020. Nhemhafuki (2023) demonstrates that government expenditure, as an independent variable, is positively associated with economic growth, even when accounting for the effects of population and trade openness. This finding is based on the examination of annual cross-sectional time series data from 117 countries spanning the period 2001 to 2021. Rashdan et al. (2024) indicate a statistically significant negative relationship between government expenditure and economic growth, observed in both the long-term and short-term contexts.

Table 6: Panel ARDL long and short-run results (Model 1: LGDP LAP LGFCF LLF LGFCE TO)

Variables	Coefficient	Std. Error	t-Statistic	P-value
Long-run estimation				
LAP	0.040900***	0.013027	3.139532	0.0022
LGFCF	0.469920***	0.047978	9.794403	0.0000
LLF	1.948308***	0.113339	17.19009	0.0000
LGFCE	0.072400***	0.026821	2.699396	0.0080
TO	0.404162***	0.036712	11.00896	0.0000
Short-run estimation				
COINTEQ01	-0.255324**	0.102909	-2.481062	0.0145
D(LGDP(-1))	0.047670	0.099126	0.480898	0.6315
D(LAP)	-0.022936	0.045640	-0.502548	0.6162
D(LGFCF)	-0.059083	0.032253	-1.831860	0.1696
D(LLF)	-0.087538	0.375833	-0.232918	0.8162
D(LGFCE)	0.018690	0.037285	0.501277	0.6171
D(TO)	-0.075544	0.037229	-2.029171	0.1448
C	-2.535511**	1.015378	-2.497110	0.0139

*Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.*

Table 7: Panel ARDL long and short-run results (Model 2: LGDP LTFP LGFCF LLF LGFCE TO)

Variables	Coefficient	Std. Error	t-Statistic	P-value
Long-run estimation				
LTFP	0.494643***	0.068657	7.204585	0.0000
LGFCF	0.340088***	0.057496	5.914962	0.0000
LLF	2.194391***	0.096454	22.75072	0.0000
LGFCE	-0.127844***	0.027442	-4.658737	0.0000
TO	0.378656***	0.031684	11.95110	0.0000
Short-run estimation				
COINTEQ01	-0.258677**	0.105130	-2.460540	0.0159
D(LTFP)	-0.091296	0.128435	-0.710834	0.4792
D(LTFP(-1))	-0.035488	0.091121	-0.389466	0.6979
D(LGFCF)	-0.042892	0.065713	-0.652709	0.5157
D(LGFCF(-1))	-0.019132	0.029777	-0.642497	0.5223
D(LLF)	0.173038	0.281660	0.614348	0.5407
D(LLF(-1))	-0.497057	0.466874	-1.064649	0.2901
D(LGFCE)	0.092397	0.086301	1.070638	0.2874
D(LGFCE(-1))	0.062894	0.062525	1.005913	0.3174
D(TO)	-0.062634	0.039547	-1.583778	0.1170
D(TO(-1))	0.030700	0.050036	0.613563	0.5412
C	-4.592189**	1.884519	-2.436796	0.0170

*Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.*

5. Conclusions

The significant reliance of many South China Sea nations, particularly developing economies on marine resources for their people's livelihoods makes the blue economy a key strategy for fostering inclusive growth and reducing regional inequalities This study examined the long-run and short-run impacts of key blue economy sectors, namely aquaculture and fisheries production on economic growth in selected South China Sea countries from 2000 to 2022. Employing a panel ARDL model that accounted for control variables like labor, capital, government expenditure, and trade openness, the study offers valuable insights into the developmental role of marine-based industries.

The findings indicate a statistically significant positive relationship between aquaculture and fisheries production, and economic growth in the long-run, while short-term effects are not significant. These findings highlight the lasting importance of the blue economy for sustainable economic development in a region with many economically vulnerable communities heavily dependent on marine resources.

Based on these findings, several policy recommendations are made. Governments should create and implement specific regulations that encourage the sustainable use of marine resources while protecting the environment. Strategic investments should focus on modernizing maritime infrastructure, adopting advanced technologies, and improving skills in coastal areas to boost productivity and resilience. Furthermore, comprehensive monitoring and evaluation systems are needed to track the economic, social, and environmental effects of blue economy initiatives. These systems will support evidence-based policymaking and adaptable governance.

Future research should take a wider, interdisciplinary view that includes the social and environmental aspects of the blue economy. Particular attention should be paid to its potential to reduce poverty, enhance food security and nutrition, protect biodiversity, and build climate resilience. Developing integrated and inclusive assessment tools will be vital for aligning blue economy strategies with the Sustainable Development Goals (SDGs), minimizing potential conflicts, and promoting fair, long-term development across the region.

In conclusion, effective governance of the blue economy, based on sustainability, inclusivity, and resilience, is crucial for realizing its full potential. A balanced and forward-thinking approach can help South China Sea nations achieve lasting economic progress while protecting marine ecosystems and improving the well-being of their coastal and rural populations.

References

Agardy, T., Di Sciara, G. N., & Christie, P. (2010). Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy*, *35*(2), 226–232. https://doi.org/10.1016/j.marpol.2010.10.006.

Ahammed, S., Rana, M. M., Uddin, H., Majumder, S. C., & Shaha, S. (2024). Impact of blue economy factors on the sustainable economic growth of China. *Environment, Development and Sustainability*, 1-28. https://doi.org/10.1007/s10668-023-04411-6.

Alam, A. (2021). Regional Marine Spatial Planning: a tool for greening blue economy in the Bay of Bengal. In *Strategies for sustainability* (pp. 61–80). https://doi.org/10.1007/978-3-030-69325-1_3.

Alatas, B. & Liman, U. (2023, March). Indonesia pushes optimizing blue economy as ASEAN's new growth driver. *Antara Indonesia*. Retrieved from https://en.antaranews.com/news/274407/indonesia-pushes-optimizing-blue-economy-as-aseans-new-growth-driver (Assessed on 26 March 2025).

Alharthi, M., & Hanif, I. (2020). Impact of blue economy factors on economic growth in the SAARC countries. *Maritime Business Review*, *5*(3), 253–269. https://doi.org/10.1108/mabr-01-2020-0006.

Alsaleh, M., & Wang, X. (2025). Aquaculture growth and coastal tourism development in the context sustainable blue economy. *Sustainable Development*, *33*(2), 2030-2046. https://doi.org/10.1002/sd.3224.

Alsaleh, M., Wang, X., Nan, Z., Liu, R., & Sun, Q. (2023). Impact of coastal tourism demand on fisheries industry sustainability: A suggested framework for blue growth. *Natural Resources Forum*. https://doi.org/10.1111/1477-8947.12332.

Amarasinghe, O., Amarasinghe, U. S., Piyasiri, K. H. K., Kumara, P. B. T. P., Liyanage, U. S. P. K., & Kumara, H. (2025). From blue growth to participatory, inclusive and sustainable blue economy in the Bay of Bengal Region. *Sri Lanka Journal of Aquatic Sciences*, *30*(1), 1–24. https://doi.org/10.4038/sljas.v30i1.7619.

Azam, A., Ateeq, M., Shafique, M., Rafiq, M., & Yuan, J. (2023). Primary energy consumption-growth nexus: The role of natural resources, quality of government, and fixed capital formation. *Energy*, *263*, 125570. https://doi.org/10.1016/j.energy.2022.125570.

Bădîrcea, R. M., Manta, A. G., Florea, N. M., Puiu, S., Manta, L. F., & Doran, M. D. (2021). Connecting blue economy and economic growth to climate change: evidence from European Union countries. *Energies*, *14*(15), 4600. https://doi.org/10.3390/en14154600.

Bax, N., Novaglio, C., Maxwell, K. H., Meyers, K., McCann, J., Jennings, S., Frusher, S., Fulton, E. A., Nursey-Bray, M., Fischer, M., Anderson, K., Layton, C., Emad, G. R., Alexander, K. A., Rousseau, Y., Lunn, Z., & Carter, C. G. (2021). Ocean resource use: building the coastal blue economy. *Reviews in Fish Biology and Fisheries*, *32*(1), 189–207. https://doi.org/10.1007/s11160-021-09636-0.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The review of economic studies*, *47*(1), 239-253. https://doi.org/10.2307/2297111.

Aijaz, U., & Butt, H. D. (2021). Bolstering sustainable growth through blue economy. *Pakistan Journal of International Affairs*, *4*(1). https://doi.org/10.52337/pjia.v4i1.156.

Campbell, L. M., Fairbanks, L., Murray, G., Stoll, J. S., D'Anna, L., & Bingham, J. (2021). From Blue Economy to Blue Communities: reorienting aquaculture expansion for community wellbeing. *Marine Policy*, *124*, 104361. https://doi.org/10.1016/j.marpol.2020.104361.

Cao, L., Chen, Y., Dong, S., Hanson, A., Huang, B. O., Leadbitter, D., ... & Naylor, R. L. (2017). Opportunity for marine fisheries reform in China. *Proceedings of the National Academy of Sciences*, *114*(3), 435-442. http://dx.doi.org/10.1073/pnas.1616583114.

Chaturvedy, R. R. (2022). Mapping India's blue economy in the Bay of Bengal: opportunities and constraint. *Journal of the Indian Ocean Region*, *18*(2), 99–115. https://doi.org/10.1080/19480881.2022.2118196.

Choi, I. (2001). Unit root tests for panel data. *Journal of international money and Finance*, *20*(2), 249-272. https://doi.org/10.1016/S0261-5606(00)00048-6.

Cisneros-Montemayor, A. M., Moreno-Báez, M., Voyer, M., Allison, E. H., Cheung, W. W., Hessing-Lewis, M., ... & Ota, Y. (2019). Social equity and benefits as the nexus of a transformative Blue Economy: A sectoral review of implications. *Marine Policy*, *109*, 103702. http://dx.doi.org/10.1016/j.marpol.2019.103702.

Damayanti, A. (2017). Regional maritime cooperation in maintaining maritime security and stability: a test case for ASEAN unity and centrality. *Journal of ASEAN Studies*, *5*(2), 119-134. https://doi.org/10.21512/jas.v5i2.1888.

Das, J. (2023). Blue economy, blue growth, social equity and small-scale fisheries: A global and national level review. *Studies in Social Science Research*, *4*(1), 38-82. https://doi.org/10.22158/sssr.v4n1p38.

Evans, L. S., Buchan, P. M., Fortnam, M., Honig, M., & Heaps, L. (2023). Putting coastal communities at the center of a sustainable blue economy: A review of risks, opportunities, and strategies. *Frontiers in Political Science*, *4*. https://doi.org/10.3389/fpos.2022.1032204.

Eyüboğlu, S., & Akmermer, B. (2023). The relationship between economic growth and fisheries production in Türkiye. *Aquaculture Studies*, *24*(2). https://doi.org/10.4194/aquast1017.

Fetahi-Vehapi, M., Sadiku, L., & Petkovski, M. (2015). Empirical analysis of the effects of trade openness on economic growth: An evidence for South East European countries. *Procedia Economics and Finance*, *19*, 17-26. https://doi.org/10.1016/S2212-5671(15)00004-0.

Fisher, R.A. (1932), Statistical Methods for Research Workers, Oliver and Bond, Edinburgh, 4th ed.

Fratila, A., Gavril, I. A., Nita, S. C., & Hrebenciuc, A. (2021). The importance of maritime transport for economic growth in the european union: A panel data analysis. *Sustainability*, *13*(14), 7961. https://doi.org/10.3390/su13147961.

Galdolage, B. S., Ekanayake, E. A., Al-Daoud, K. I., Vasudevan, A., Wenchang, C., Hunitie, M. F. A., & Mohammad, S. I. S. (2024). Sustainable Marine and Coastal Tourism: A Catalyst for Blue Economic Expansion in Sri Lanka. *Journal of Ecohumanism*, *3*(6), 1214-1228. https://doi.org/10.62754/joe.v3i6.4098.

Gamage, R. N. (2016). Blue economy in Southeast Asia: Oceans as the new frontier of economic development. *Maritime Affairs Journal of the National Maritime Foundation of India*, *12*(2), 1–15. https://doi.org/10.1080/09733159.2016.1244361

Germond-Duret, C., Heidkamp, C. P., & Morrissey, J. (2022). (In)justice and the blue economy. *Geographical Journal*, *189*(2), 184–192. https://doi.org/10.1111/geoj.12483

Gocer, I., & Ongan, S. (2020). The relationship between inflation and interest rates in the UK: The nonlinear ARDL approach. *Journal of Central Banking Theory and Practice*, *9*(3), 77-86. https://doi.org/10.2478/jcbtp-2020-0037.

Hai, A. T. N., & Speelman, S. (2020). Economic-environmental trade-offs in marine aquaculture: The case of lobster farming in Vietnam. *Aquaculture*, *516*, 734593. https://dx.doi.org/10.1016/j.aquaculture.2019.734593.

He, H. F (2023, November). South China Sea: openness encouraged to shore up marine economy after disputes threaten to capsize relations. *MyNews*. Retrieved from https://www.scmp.com/economy/china-economy/article/3242984/south-china-sea-openness-encouraged-shore-marine-economy-after-disputes-threaten-capsize-relations?utm_source=rss_feed. (Assessed on 26 March 2025)

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of econometrics*, *115*(1), 53-74. https://doi.org/10.1016/S0304-4076(03)00092-7.

Irshath, A. A., Rajan, A. P., Vimal, S., Prabhakaran, V. S., & Ganesan, R. (2023). Bacterial pathogenesis in various fish diseases: recent advances and specific challenges in vaccine development. *Vaccines*, *11*(2), 470. https://doi.org/10.3390/vaccines11020470.

Jacob, A. O., & Umoh, O. J. (2022). The NIGERIAN blue economy: Economic expansion issues and challenges. *Socio Economy and Policy Studies*, *2*(1), 29-33. https://doi.org/10.26480/seps.01.2022.29.33

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control*, *12*(2-3), 231-254. https://doi.org/10.1016/0165-1889(88)90041-3.

Kabil, M., Priatmoko, S., Magda, R., & Dávid, L. D. (2021). Blue economy and coastal tourism: A comprehensive visualization bibliometric analysis. *Sustainability*, *13*(7), 3650. https://doi.org/10.3390/su13073650.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of econometrics*, *90*(1), 1-44. https://doi.org/10.1016/S0304-4076(98)00023-2.

Karani, P., & Failler, P. (2020). Comparative coastal and marine tourism, climate change, and the blue economy in African Large Marine Ecosystems. *Environmental Development*, *36*, 100572. https://doi.org/10.1016/j.envdev.2020.100572.

Katircioglu, S. T. (2009). Revisiting the tourism-led-growth hypothesis for Turkey using the bounds test and Johansen approach for cointegration. *Tourism management*, *30*(1), 17-20. https://doi.org/10.1016/j.tourman.2008.04.004.

Keho, Y. (2017). The impact of trade openness on economic growth: The case of Cote d'Ivoire. *Cogent Economics & Finance*, *5*(1), 1332820. https://doi.org/10.1080/23322039.2017.1332820.

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, *108*(1), 1-24. https://doi.org/10.1016/S0304-4076(01)00098-7.

Liza, J. I., Majumder, S. C., & Rahman, M. H. (2025). Scrutinizing the impact of blue economy factors on the economic growth in Bangladesh: An empirical study. *Marine Policy*, *173*, 106542. https://doi.org/10.1016/j.marpol.2024.106542

Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and statistics*, *61*(S1), 631-652. http://dx.doi.org/10.1111/1468-0084.61.s1.13.

Martínez-Vázquez, R. M., Milán-García, J., & De Pablo Valenciano, J. (2021). Challenges of the Blue Economy: evidence and research trends. *Environmental Sciences Europe*, *33*(1). https://doi.org/10.1186/s12302-021-00502-1

Martínez-Vázquez, R. M., Milán-García, J., Manso, J. R. P., & De Pablo Valenciano, J. (2023). Impact of blue economy sectors using causality, correlation and panel data models. *Frontiers in Marine Science*, *10*. https://doi.org/10.3389/fmars.2023.1034054

Menegaki, A. N. (2019). The ARDL method in the energy-growth nexus field; best implementation strategies. *Economies*, *7*(4), 105. https://doi.org/10.3390/economies7040105.

Mogila, Z., Ciolek, D., Toroj, A., & Zaucha, J. (2024). How important is the blue economy for regional development? – The case of Poland. *Marine Policy*, *168*, 106303. https://doi.org/10.1016/j.marpol.2024.106303.

Mohanty, S. K., & Dash, P. (2020). Economic opportunities in blue economy in Africa. In *Springer eBooks* (pp. 89–110). https://doi.org/10.1007/978-981-15-5550-3_6.

Mostafa, M. G. A. A. (2021). The causal link between government expenditure and economic growth in Egypt over the period from 1952 to 2020. *Systematic Reviews in Pharmacy*, *12*(3), 231-243. https://doi:10.31838/srp.2021.3.38.

Narwal, S., Kaur, M., Yadav, D. S., & Bast, F. (2024). Sustainable blue economy: Opportunities and challenges. *Journal of Biosciences*, *49*(1). https://doi.org/10.1007/s12038-023-00375-x.

Nhemhafuki, S. (2023). Government Expenditure and Economic Growth: A Cross-Country Analysis. *Journal of Economics Students*, *1*(1), 43-56. https://doi.org/10.3126/joess.v1i1.65691.

Nikčević, J., & Škurić, M. (2021). A contribution to the sustainable development of maritime transport in the context of blue economy: the case of Montenegro. *Sustainability*, *13*(6), 3079. https://doi.org/10.3390/su13063079

Pace, L. A., Saritas, O., & Deidun, A. (2022). Exploring future research and innovation directions for a sustainable blue economy. *Marine Policy*, *148*, 105433. https://doi.org/10.1016/j.marpol.2022.105433

Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, *61*(S1), 653-670. https://doi.org/10.1111/1468-0084.61.s1.14.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels. Cambridge Working Papers. *Economics*, *1240*(1), 1. http://dx.doi.org/10.2139/ssrn.572504.

Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of econometrics*, *68*(1), 79-113. https://doi.org/10.1016/0304-4076(94)01644-F.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, *16*(3), 289-326. http://dx.doi.org/10.1002/jae.616.

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American statistical Association*, *94*(446), 621-634. https://doi.org/10.1080/01621459.1999.10474156.

Picken, F. (2023). Tourism and the blue economy. *Tourism Geographies*, 1–9. https://doi.org/10.1080/14616688.2023.2291821

Poku, K., Opoku, E., & Agyeiwaa Ennin, P. (2022). The influence of government expenditure on economic growth in Ghana: An Ardl approach. *Cogent Economics & Finance*, *10*(1), 2160036. https://doi.org/10.1080/23322039.2022.2160036.

Qi, X. (2021). Building a bridge between economic complexity and the blue economy. *Ocean & Coastal Management*, *216*, 105987. https://doi.org/10.1016/j.ocecoaman.2021.105987

Rashdan, A., El-Din, A. T. G., & Hefny, S. B. W. (2024). The impact of government final consumption expenditure on Egypt's economic growth. *The Business and Management Review*, 15(2). 269-278. http://dx.doi.org/10.24052/BMR/V15NU02/ART-26.

Sarwar, S. (2022). Impact of energy intensity, green economy and blue economy to achieve sustainable economic growth in GCC countries: Does Saudi Vision 2030 matters to GCC countries. *Renewable Energy*, *191*, 30–46. https://doi.org/10.1016/j.renene.2022.03.122

Silvestri, R., Morrone, D., Del Vecchio, P., & Mele, G. (2022). Blue economy and aquaculture before and during the pandemic era: a systematic literature review. *British Food Journal*, *126*(1), 13–32. https://doi.org/10.1108/bfj-07-2022-0660

Stephenson, R. L., & Hobday, A. J. (2024). Blueprint for Blue Economy implementation. *Marine Policy*, *163*, 106129. https://doi.org/10.1016/j.marpol.2024.106129

Topcu, E., Altinoz, B., & Aslan, A. (2020). Global evidence from the link between economic growth, natural resources, energy consumption, and gross capital formation. *Resources Policy*, *66*, 101622. https://doi.org/10.1016/j.resourpol.2020.101622.

Wilks, J. (2023). A new era for coastal and marine tourism in the blue economy. *Tourism in Marine Environments*, *18*(1), 67–69. https://doi.org/10.3727/154427323x16855174644972

Zhang, H. (2016). Problems and countermeasures on the fishery development in the South China Sea. *International Journal Aquatic Fisheries Science*, *2*(1), 23-026. http://dx.doi.org/10.17352/2455-8400.000015.

Zhao, C., Fang, C., Gong, Y., & Lu, Z. (2020). The economic feasibility of Blue Carbon cooperation in the South China Sea region. *Marine Policy*, *113*, 103788. https://doi.org/10.1016/j.marpol.2019.103788

Zheng, C., Xiao, Z., Zhou, W., Chen, X., Chen, X., Zheng, C., ... & Chen, X. (2018). Marine Resource Characteristics and Current Utilization. *21st Century Maritime Silk Road: A Peaceful Way Forward*, 67-86. http://dx.doi.org/10.1007/978-981-10-7977-1_5.