ORIGINAL RESEARCH (AR)

DOI: 10.4274/jems.2025.05826

Journal of ETA Maritime Science

Strategic Port Performance Analysis in the Eastern Mediterranean: A Multiple Linear Regression Study of Economic Drivers in İskenderun, Botaş, and Mersin Ports

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Abstract

This study analyzes the current performance and forecasts future demand for the strategic Eastern Mediterranean ports of İskenderun, Botaş, and Mersin, which are vital for Türkiye's international trade and energy logistics. The research aims to identify economic drivers influencing port performance and guide infrastructure and investment strategies. With rising competition between Mersin and İskenderun, the study evaluates how these ports can meet future cargo demands and what growth strategies are appropriate. Data were collected from port authorities and national sources, including gross domestic product, population, exports, and imports. Key performance indicators such as gross tonnage, stevedoring activity, container capacity, and vessel numbers were assessed. Using multiple linear regression, the study projected port performance over ten years with a 2% annual growth in economic indicators. Results show that in İskenderun, population growth has a strong positive effect on gross tonnage (coefficient=5.79, $p<0.01$, $R^2=0.99$), highlighting İskenderun's cost-efficient logistics. Mersin demonstrates notable container capacity growth ($R^2=0.95$); driven also by population growth. In contrast, Botaş shows weaker correlations ($R^2<0.51$), likely due to operational limits. The study recommends improving hinterland infrastructure in İskenderun and expanding capacity in Mersin. Future studies should further investigate Botaş's constraints.

Keywords: Logistic, Eastern Mediterranean, port performance

1. Introduction

Eastern Mediterranean ports are considered strategically important for Türkiye's economy and international trade. Their significance is determined by their economic potential, geographical advantages, and critical positions on global trade routes. As the Eastern Mediterranean region is located at the intersection of major world trade routes, these ports are seen as key contributors to Türkiye's foreign trade volume [1]. The economic importance of Eastern Mediterranean ports is reflected in their role in supporting Türkiye's import and export activities. These ports are used as transit centers for the Southeastern Anatolia and Mediterranean regions, and also for Middle Eastern countries. Consequently, regional trade effectiveness is enhanced, export revenues are increased, and the current account deficit is reduced [2]. Raw materials required by industries, particularly the iron and steel sector are imported and products are exported through these ports. Thus, they are regarded as significant logistics centers [3]. The proximity of these ports to energy resources is also regarded as a factor that increases their strategic value. Located near the Baku-Tbilisi-Ceyhan (BTC) and Kirkuk-Yumurtalık oil pipelines, these facilities are used as critical hubs in energy trade [4]. Since sea routes are preferred for transporting energy products to international markets, these ports are utilized as centers for energy logistics. As a result, income from energy trade is boosted, and energy supply security is ensured [5]. Another important feature of Eastern Mediterranean ports is their proximity to road and railway networks. This proximity allows for fast and economical transportation to inland regions, thereby reducing logistics costs and enhancing Türkiye's competitiveness in international trade. Additionally, closeness to geopolitically sensitive areas such as Cyprus and Syria increase Türkiye's commercial and economic influence in these regions [6].

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Received: 18.06.2025
Last Revision Received: 25.09.2025
Accepted: 12.10.2025
Epub: 12.11.2025

To cite this article: Ö. Akar, "Strategic port performance analysis in the Eastern Mediterranean: a multiple linear regression study of economic drivers in İskenderun, Botaş, and Mersin Ports," *Journal of ETA Maritime Science*, [Epub Ahead of Print]

Ports are essential in regional development as they enhance accessibility, support production and trade, and boost economic and social vitality [7]. Their development contributes to regional economies by generating income, creating jobs, and fostering growth. For example, İzmir, with its 16 ports and 92 million tons of cargo handling capacity, demonstrates how ports influence regional development. However, the ports of İzmir's share in Türkiye's overall cargo handling has decreased over time. Strategic studies suggest revitalizing Turkish State Railways İzmir Port, strengthening Aliağa Port, and specializing Çandarlı Port in wind energy transportation [7].

Port capacity plays a pivotal role in promoting regional economies by ensuring efficient cargo handling, attracting international shipping lines, and encouraging industrial growth. According to Leila and Abdullah [8], southern ports like Jask Port have bolstered regional economies by facilitating uninterrupted oil exports and supporting energy security. Additionally, ports act as catalysts for regional integration by connecting inland production centers to global markets. Efficient port operations reduce transportation costs, improve supply chain efficiency, and increase export competitiveness [8]. Ports also stimulate related industries, including logistics, shipbuilding, and tourism. The economic impact extends beyond direct port activities, with multiplier effects observed in employment generation, urban development, and infrastructure improvements. Bottasso et al. [9] noted that a 10% increase in port throughput in European regions led to a 0.01-0.03% rise in gross domestic product (GDP), underlining the economic significance of expanding port capacities. Moreover, Ferrari et al. [10] emphasized that ports' influence on regional economies is not limited to direct impacts but includes indirect and induced effects, which can lead to significant long-term economic gains.

The primary objective of this study is to analyze the current status and forecast future demand for the ports of İskenderun, Botaş, and Mersin, located in the Eastern Mediterranean region. These ports play an increasingly significant role in Türkiye's logistics infrastructure due to their strategic locations and growing trade volumes. Focusing on the Eastern Mediterranean system, we restrict the sample to the three gateway ports—İskenderun, Botaş, and Mersin—because they (i) account for the dominant share of the region's seaborne trade, (ii) provide consistent long-run administrative statistics at a comparable spatial definition, and (iii) exhibit complementary operational profiles (İskenderun: bulk/general cargo; Botaş: energy terminals; Mersin: container and multipurpose), yielding a representative yet heterogeneous test bed relative to smaller or single-purpose harbors. Notably, Mersin and İskenderun ports are emerging as potential alternatives, with increasing competition driven by the rising number and capacity of ports in the region. However, there is a noticeable gap in the literature concerning the analysis of these two ports', potential preferences in handling future demand and how the regional port infrastructure will evolve under various demand scenarios. Addressing this gap, the study employs multiple linear regression analysis to examine the impact of key economic indicators, such as GDP growth, population increase, exports, and imports, on port performance. The research aims to provide insights that will inform port infrastructure planning and investment strategies. Key research questions include: "To what extent might Mersin and İskenderun ports be preferred over each other in meeting future cargo and container demand?" and "What growth strategies should be adopted considering the infrastructure capacities of these ports?".

2. Materials and Methods

The ports under the jurisdiction of the İskenderun, Botaş, and Mersin Port Authorities (Figure 1) are key ports in maritime trade in the Eastern Mediterranean region of Türkiye. These ports are located in areas with intense national and international trade activities and handle various operations, including container transportation, and general cargo operations with different capacities. The ports under the İskenderun Port Authority are located around the İskenderun Bay in Hatay province. The İskenderun Gulf provides a suitable port area for large-capacity vessels due to its deep-water structure and natural sheltered formation. The ports operating in the region specialize in industrial sectors such as iron and steel, energy, and transportation of agricultural products. İskenderun Port has an annual cargo handling capacity of approximately 15 million tons. Additionally, there are small and medium-sized private port facilities in the region. The ports under the Botaş Port Authority are located in the Ceyhan region and hold a critical position in energy transportation. The Botaş Terminal is one of Türkiye's main oil and natural gas export points. This terminal is of strategic importance as the marine export outlet of the BTC Pipeline. Botaş Port has an annual liquid cargo capacity of approximately 50 million tons and is notable for its depth, which allows large tankers to dock. Other ports under the Botaş Port Authority generally serve the transportation needs of the energy and chemical industries. The Mersin Port Authority includes the Mersin International Port, which is Türkiye's largest and busiest container port. Mersin Port stands out with its 2,100-meter-long quay line and a bulk cargo capacity of 15 million tons. Its container handling capacity reaches 2.5 million TEU per year. The port serves as a crucial transit point for transportation between the Middle East, Europe, and Asia. Other ports under the Mersin Port Authority include small-scale marinas, industrial loading facilities, and bulk cargo terminals.

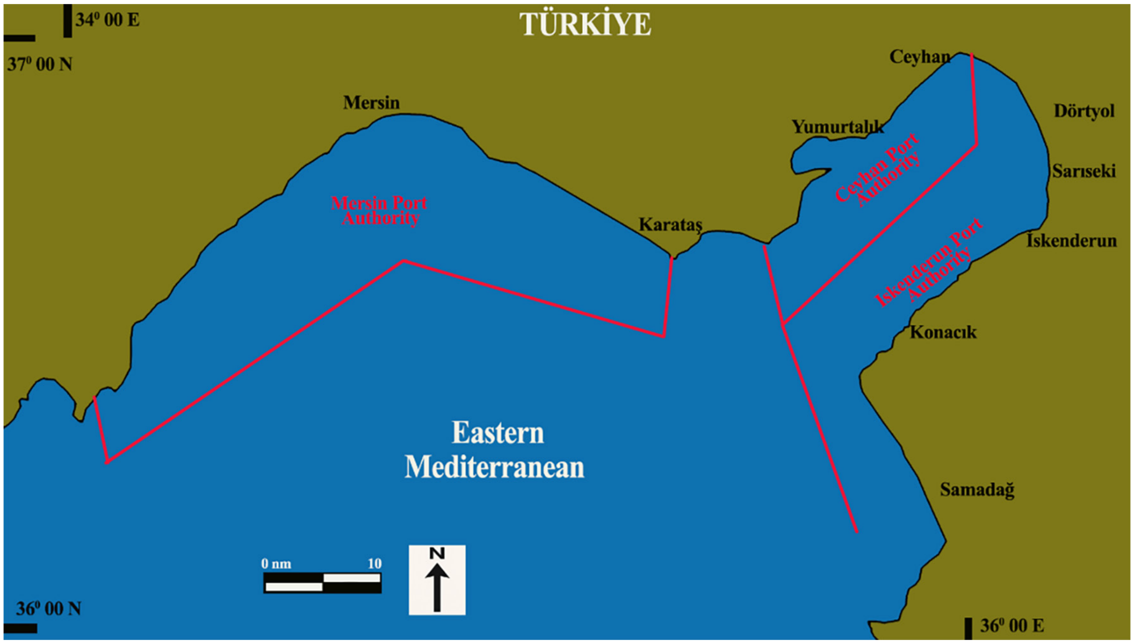

Figure 1. *İskenderun, Ceyhan Botaş, and Mersin port authorities*

2.1. Data Sources and Preprocessing

The analysis uses an annual, calendar-year dataset spanning 2011-2024 for the Eastern Mediterranean ports (İskenderun, Botaş, Mersin). Data sources. GDP and population series were compiled from [SOURCE NAME]. Port performance indicators (gross tonnage, vessel counts, TEU) were obtained from [PORT AUTHORITY/MINISTRY/INDUSTRY ASSOCIATION], harmonized to calendar years. We justify growth assumptions using Türkiye's and port-sector trends over 2011-2024. We compute annual growth rates and CAGRs for GDP and port indicators, and produce three forecast paths: low (L), median/baseline (M), and high (H). For each driver XXX, projections follow Xt+h=Xt(1+gs) h X _ { t + h } = X _ t (1 + g _ s) ^ h X t + h = X t (1 + g s) h with s∈{L,M,H}s\in\{L,M,H\}s∈{L,M,H} derived from the empirical distribution.

We compiled an annual series of port performance indicators, including (gross tonnage, stevedoring operations, container capacity, vessel count), together with macroeconomic covariates, including (GDP, population, exports, imports). Units were standardized for interpretability (reported in millions or thousands in the Results). Calendar-year mismatches were harmonized across sources. Cross-checks with administrative reports left no missing values. Outliers were screened using studentized residuals and Cook's distance, flagging observations with D_i above the 4⁄n threshold (D_i: Cook's distance for observation i; n: sample size,). Robustness checks did not warrant removals. Where appropriate, variables were mean-centered to aid interpretation and mitigate multicollinearity.

Notation for diagnostics used in preprocessing:

Raw residual: $e_i=y_i-x_i'\,\hat{\beta}$ (y_i: observed outcome; x_i: regressor row vector; $\hat{\beta}$: OLS estimate).

Leverage: h_{ii} is the i-th diagonal of $H=X\,(X^TX)^{-1}\,X^T$.

Error variance estimate: $s^2=SSE/(n-p)$, with $SSE=\sum e_i^2$ and p the number of parameters including the intercept.

Cook's distance (exact): $D_i=((\hat{\beta}-\hat{\beta}_{(i)})'\,X'X\,(\hat{\beta}-\hat{\beta}_{(i)}))/(p\,s^2)$, where $\hat{\beta}_{(i)}$ is the OLS estimate with observation i deleted.

2.2. Model Specification (Multiple Linear Regression)

For each administrative area r ∈ {İskenderun, Botaş, Mersin} and outcome $Y_{r,t}$ ∈ {gross tonnage, operations, container capacity, vessel count}, we estimate:

$$Y_{r,t}=\beta_{0,r}+\beta_{1,r}\cdot GDP_t+\beta_{2,r}\cdot POP_t+\beta_{3,r}\cdot EXP_t+\beta_{4,r}\cdot IMP_t+\varepsilon_{r,t}$$

with $\varepsilon_{r,t}\sim(0,\sigma_r^2)$.

In matrix form, the OLS estimator is $\hat{\beta}_r$=(XTX)−1XTy.

Definitions: $Y_{r,t}$: dependent variable for region r in year t (reported units). GDP_t, POP_t, EXP_t, IMP_t: macro indicators. $\beta_{k,r}$: marginal effect of covariate k on Y in region r (ceteris paribus). X: design matrix; y: outcome vector; $(\cdot)^T$: transpose. $\varepsilon_{r,t}$: disturbance term; σ_r^2: error variance.

2.3. Theoretical Rationale

Maritime economics predicts co-movement between port throughput and macro demand. GDP and population serve as proxies for aggregate demand and scale; exports and imports serve as proxies for trade intensity and composition. Vessel counts can move inversely with GDP if larger vessels substitute for call frequency (fleet up-gauging).

2.4. Assumptions and Diagnostic Checks

OLS assumptions: linearity, independence, homoskedasticity, and large-sample normality of errors.

Linearity and influence: component-plus-residual plots; leverage h_{ii}; Cook's distance D_i.

Multicollinearity (VIF): $VIF_j=1/(1-R_j^2)$. Flag $VIF_j>10$.

Heteroskedasticity: Breusch–Pagan (auxiliary regression of u_i^2 on regressors, $LM=n \cdot R^2$) and White tests.

If heteroskedasticity is detected, we report heteroskedasticity-consistent (HC3) or, when autocorrelation is present, heteroskedasticity and autocorrelation consistent (HAC) (Newey-West) standard errors.

Autocorrelation: Durbin–Watson statistic $DW=[\sum_{t=2\ldots n} (e_t-e_{t-1})^2]/[\sum_{t=1\ldots n} e_t^2]$. When serial correlation is indicated, point estimates remain OLS; inference uses HAC covariance.

Distributional checks: Q–Q plots; Shapiro–Wilk on residuals. For mild deviations, rely on robust SEs.

Stationarity (if warranted): Augmented Dickey–Fuller (ADF) test $\Delta y_t = \alpha + \rho\, y_{t-1} + \sum \varphi_i\, \Delta y_{t-i} + u_t$. Null hypothesis: $\rho=0$.

Goodness-of-fit and accuracy: $R^2=1-SSE/SST$; Adjusted $R^2=1-((SSE/(n-p))/(SST/(n-1)))$. $RMSE=\sqrt{((1/n) \sum e_i^2)}$, $MAE=(1/n) \sum |e_i|$).

For each coefficient, we report the estimate, standard error, t-statistic, and p-value.

2.5. Testing Stationarity and Persistence in Panel Data

Before estimation, we assess whether the panel series are stationary and how persistent they are. We begin by testing cross-sectional dependence (CD) with Pesaran's Cross-sectional dependence [11], and if dependence is present, we rely on second-generation unit-root tests [12]. Otherwise, we use Levin-Lin-Chu [13], Im-Pesaran-Shin [14], and Fisher-type ADF/Phillips–Perron [15,16] alongside Hadri's stationarity test [17]. Lag lengths in auxiliary regressions are selected by Akaike information criterion/Bayesian information criterion [18,19], and deterministic terms (intercept and, where warranted, linear trend) are included symmetrically. If key variables are I(1), we test for long-run relationships with Pedroni, Kao, and Westerlund panel cointegration tests [20-23]: if cointegration is detected, long-run coefficients are estimated via panel fully modified ordinary least squares/dynamic ordinary least squares or a panel autoregressive distributed lag (pooled mean group) error-correction framework [24-26]. If cointegration is not supported, I(1) variables enter as first differences while I(0) variables remain in levels. To quantify persistence, we report the coefficient on the lagged dependent variable in a dynamic specification, and we use robust inference throughout (HC3 or HAC/Driscoll-Kraay standard errors when heteroskedasticity and/or serial/CD is detected) [27-29].

2.6. Forecasting procedure

We generate ten-year-ahead projections under a moderate scenario with 2% annual growth for each driver.

$X_{k,t+h}=X_{k,t} \cdot (1.02)h$, $k \in \{GDP, POP, EXP, IMP\}$.

Point forecasts (plug-in): $\hat{Y}_{r,t+h}=\beta_{0,r} + \sum \beta_{k,r} X_{k,t+h}$

Prediction uncertainty: $SE(\hat{Y}_{r,t+h})=\sqrt{[\, s_r^2 \cdot (1 + x_{t+h}' (XTX)-1\, x_{t+h})]}$.

95% prediction interval: $\hat{Y} \pm t_{0.975,\ n-p} \cdot SE(\hat{Y})$. With autocorrelation, replace $(XTX)-1\ s_r^2$ by the Newey-West covariance.

3. Results

The results evaluated the impact of key economic factors (GDP), population, exports, and imports on port performance indicators such as gross tonnage, stevedoring operations, container capacity, and vessel count for the İskenderun region. The results demonstrated that the regression coefficients (slopes) represent the expected change in the dependent variable when the independent variable increases by one unit, holding other factors constant. For instance, a coefficient of 5.79 for population in the gross tonnage model indicates that an increase of one million people in the population would lead to an increase of 5.79 million tons in gross tonnage. The standard error associated with each coefficient reflects the precision of the coefficient estimate; lower standard error values indicate higher reliability. For example, the standard error of 0.62 for the population variable in the gross tonnage model suggests higher precision in the coefficient estimate. Scenario bands (L/M/H) produce fan-type intervals around 2035 forecasts. Qualitative rankings across ports maintain their position (Table 1).

The t-value assesses whether the regression coefficient is significantly different from zero. A high absolute t-value suggests that the corresponding variable significantly impacts the dependent variable. In the case of İskenderun, the t-value for the population variable in the gross tonnage model is 9.32, indicating a highly significant relationship. The p-value further validates this significance; a p-value below 0.05 typically denotes statistical significance. The population variable, with a p-value of 0.00, confirms a robust relationship with gross tonnage. Conversely, GDP and import variables displayed p-values of 0.08 and 0.12, respectively, suggesting their effects are not statistically significant at the 5% significance level.

The R-squared (R^2) value measures the proportion of variance in the dependent variable explained by the independent variables. An R^2 value of 0.99 for the gross tonnage model indicates that 99% of the variability in gross tonnage is accounted for by the economic factors considered. For stevedoring operations, the population variable again showed the strongest positive relationship, with a t-value of 6.03 and a p-value of 0.00, while other variables did not demonstrate significant effects. The container capacity model revealed that population remained the most influential factor with a t-value of 7.02 and a p-value of 0.000. Although the import variable had a p-value of 0.07, indicating a weak negative relationship, it did not meet the conventional threshold for statistical significance.

The vessel count model exhibited weaker relationships overall, with an R^2 value of 0.67. In this model, GDP showed a statistically significant negative relationship with vessel count (p-value of 0.04, t-value of -2.39), suggesting that economic growth may lead to the use of larger vessels, thereby reducing the total number of ships. The population variable in this model had a p-value of 0.17, indicating a lack of statistical significance.

Table 2 showed that economic factors had generally weak and statistically insignificant effects on port performance indicators in the Botaş region, such as gross tonnage, stevedoring operations, container capacity, and vessel count. In the gross tonnage model, GDP had a coefficient of -0.02 with a standard error of 0.02, a t-value of -1.04, and a p-value of 0.33, indicating a weak and non-significant relationship, with the R^2 value of 0.45, which shows that only 45% of the variation was explained by the model. The population variable had a coefficient of 0.59, but the high standard error of 1.24 and indicating a p-value of 0.65 indicated no significant effect. In the stevedoring operations model, GDP and population showed similarly low significance, with GDP having a coefficient of -0.03 (t=-1.11, p=0.29) and population having a coefficient of 1.31 (t=0.79, p=0.45), while the R^2 value of 0.50 suggested moderate explanatory power. For container capacity, GDP displayed a coefficient of 0.00 with a t-value of 2.07 and a p-value of 0.07, approaching significance. The R^2 value was 0.51. Other variables such as population (-0.00, p=0.98), exports (0.00, p=0.45), and imports (-0.00, p=0.28) showed no notable effects. The vessel count model had the weakest results, with an R^2 value of just 0.07, GDP showed a negligible impact (-0.00, p=0.91), and other factors like population, exports, and imports also lacked significance with p-values above 0.75. These results, summarized in the related tables, suggest that economic factors do not significantly influence port performance in Botaş and highlight the need for further research into additional variables that may better explain port activities in this region.

The Mersin region demonstrated diverse relationships between economic factors and port performance indicators, including gross tonnage, stevedoring operations, container capacity, and vessel count. In the gross tonnage model, GDP showed a coefficient of -0.01 with a standard error of 0.02, resulting in a t-value of -0.58 and a p-value of 0.58, which indicates no significant relationship. However, the population variable stood out with a positive coefficient of 3.45, a t-value of 3.15, and a p-value of 0.01, reflecting a statistically significant positive influence, while exports and

Table 1. *Regression analysis results for İskenderun port authority area*

Dependent variables	Factors	Slope (Coefficient)	SE (Slope)	t-value	p-value	R^2
Gross tonnage	GDP (Billion USD)	-0.02	0.01	-1.99	0.08	0.99
	Population (Million)	5.79	0.62	9.32	0.00	
	Exports (Billion USD)	0.04	0.10	0.41	0.69	
	Imports (Billion USD)	-0.09	0.05	-1.69	0.12	
Operations	GDP (Billion USD)	-0.02	0.01	-1.72	0.12	0.98
	Population (Million)	3.83	0.64	6.03	0.00	
	Exports (Billion USD)	0.08	0.10	0.80	0.44	
	Imports (Billion USD)	-0.03	0.05	-0.60	0.56	
Container capacity (TEU)	GDP (Billion USD)	-0.00	0.00	-0.04	0.97	0.98
	Population (Million)	0.07	0.01	7.02	0.00	
	Exports (Billion USD)	0.00	0.00	1.08	0.31	
	Imports (Billion USD)	-0.00	0.00	-2.06	0.07	
Vessel count	GDP (Billion USD)	-0.00	0.00	-2.39	0.04	0.67
	Population (Million)	0.10	0.07	1.50	0.17	
	Exports (Billion USD)	-0.01	0.01	-0.61	0.56	
	Imports (Billion USD)	0.01	0.01	0.94	0.37	

Standard errors in parentheses; HAC (Newey-West). Autocorrelation: Durbin-Watson reported; Breusch-Godfrey (lags 1-4)/Ljung-Box used for confirmation. Multicollinearity: all VIF <10. *** p<0.01, ** p<0.05, * p<0.10.

imports had minimal impact, as indicated by high p-values of 0.93 and 0.35, respectively. The R-squared value of 0.87 for this model suggests that 87% of the variance in gross tonnage can be explained by the independent variables. For stevedoring operations, GDP had a coefficient of 0.01 and a p-value of 0.31, showing limited significance, while population demonstrated a moderate effect with a coefficient of 0.65 and a p-value of 0.10. Exports (0.07, p=0.22) and

Table 2. *Regression analysis results for Botaş port authority area*

Dependent variables	Factors	Slope (Coefficient)	SE (Slope)	t-value	p-value	R^2
Gross tonnage	GDP (Billion USD)	-0.02	0.02	-1.04	0.33	0.45
	Population (Million)	0.59	1.24	0.47	0.65	
	Exports (Billion USD)	-0.15	0.19	-0.79	0.45	
	Imports (Billion USD)	0.06	0.11	0.52	0.61	
Operations	GDP (Billion USD)	-0.03	0.03	-1.11	0.29	0.5
	Population (Million)	1.31	1.65	0.79	0.45	
	Exports (Billion USD)	-0.23	0.26	-0.88	0.40	
	Imports (Billion USD)	0.07	0.14	0.47	0.65	
Container capacity (TEU)	GDP (Billion USD)	0.00	0.00	2.07	0.07	0.51
	Population (Million)	-0.00	0.00	-0.02	0.98	
	Exports (Billion USD)	0.00	0.00	0.79	0.45	
	Imports (Billion USD)	-0.00	0.00	-1.16	0.28	
Vessel count	GDP (Billion USD)	-0.00	0.00	-0.11	0.91	0.07
	Population (Million)	-0.01	0.04	-0.14	0.89	
	Exports (Billion USD)	-0.00	0.01	-0.22	0.83	
	Imports (Billion USD)	0.00	0.00	0.33	0.75	

Fixed-effects unless noted. Standard errors clustered by port; if cross-sectional dependence is detected, Driscoll-Kraay SEs are reported. Serial correlation: Wooldridge AR(1) test. Cross-section dependence: Pesaran CD. Multicollinearity: all VIF<10. *** p<0.01, ** p<0.05, * p<0.10.

Table 3. *Regression analysis results for Mersin port authority area*

Dependent variables	Factors	Slope (Coefficient)	SE (Slope)	t-value	p-value	R^2
Gross tonnage	GDP (Billion USD)	-0.01	0.02	-0.58	0.58	0.87
	Population (Million)	3.45	1.09	3.15	0.01	
	Exports (Billion USD)	-0.01	0.17	-0.09	0.93	
	Imports (Billion USD)	-0.09	0.09	-0.99	0.35	
Operations	GDP (Billion USD)	0.01	0.01	1.08	0.31	0.91
	Population (Million)	0.65	0.36	1.81	0.10	
	Exports (Billion USD)	0.07	0.06	1.33	0.22	
	Imports (Billion USD)	-0.04	0.03	-1.16	0.28	
Container capacity (TEU)	GDP (Billion USD)	-0.00	0.00	-1.96	0.08	0.95
	Population (Million)	0.04	0.02	2.13	0.06	
	Exports (Billion USD)	0.01	0.00	2.20	0.05	
	Imports (Billion USD)	-0.00	0.00	-1.39	0.20	
Vessel count	GDP (Billion USD)	-0.00	0.00	-0.24	0.81	0.52
	Population (Million)	-0.10	0.07	-1.44	0.18	
	Exports (Billion USD)	0.00	0.01	0.17	0.87	
	Imports (Billion USD)	0.00	0.01	0.27	0.80	

Specifications include log-linear and reduced covariate sets, principal-component summaries, where relevant. Time-series alternatives use Prais-Winsten/GLS with HAC SEs. Dynamic panel checks (if lagged yyy): Arellano-Bond AR(1)/AR(2) and Hansen/Sargan; Windmeijer-corrected SEs. Results are consistent with Tables 1 and 2. *** p<0.01, ** p<0.05, * p<0.10.

imports (-0.04, p=0.28) remained statistically insignificant, though the overall R^2 value of 0.91 indicates a strong explanatory power for the model (Table 3).

Figure 2 shows historical data and future projections for four key port performance indicators in Botaş, İskenderun, Mersin, and Türkiye, until 2035. The top left chart shows the total number of ships handled in thousands.

In Botaş, the ship count stayed in the range of 1,000 to 2,000 from 2010 to 2024, with a further decline expected after 2025. For Türkiye, the total ship count is projected to decrease from around 75 thousand in 2024 to 55 thousand by 2035. This drop may indicate a trend towards using larger ships as the economy grows. The top right chart shows gross tonnage (million tons). Gross tonnage in İskenderun and Mersin increased steadily from 800 million tons in 2010 to 1 billion tons in 2024. Across Türkiye, gross tonnage is expected to reach 1000 million tons by 2024 and rise to 1300 million tons by 2035. This increase reflects the growing trade volume, especially in İskenderun and Mersin. The bottom left chart presents stevedoring operations (million tons). Mersin exhibits the greatest growth, rising from 20 million tons in 2010 to 90 million tons by 2024. Türkiye's total operations are expected to reach 525 million tons in 2024 and grow to 600 million tons by 2035. This trend highlights Mersin's growing handling capacity and Türkiye's expanding trade activities. The bottom right chart shows container capacity (million TEU). Mersin is expected to increase from about 5 million TEU in 2010 to 17 million TEU by 2024. Türkiye's total container capacity is projected to grow from 18 million TEU in 2024 to 25 million TEU by 2035. Botaş exhibits minimal container activity in this period. All projections assume a 2% annual growth in key economic indicators, reflecting moderate economic growth typically seen in emerging markets. These projections provide essential insights for port infrastructure planning and investment strategies.

4. Discussion

The performance analysis of the administrative areas under Botaş, İskenderun, and Mersin Port Authorities shows distinct responses to key economic factors. As observed in Table 1, indicators such as GDP, population, exports, and imports affect each region differently, showing their unique strengths and limitations. The İskenderun Port Authority administrative area shows strong performance linked to population growth. According to Table 2, population growth is the most significant factor influencing port activities (p-value=0.00). The area's natural deep-water coastline and competitive freight service costs enable large vessels to dock easily, lowering operational expenses. This advantage positions İskenderun as a cost-effective regional logistics hub. Botaş Port Authority administrative area exhibits weaker performance correlations. As detailed in Table 3, GDP and population show no statistically significant relationships with port performance (p-value>0.29). Operational constraints caused by petroleum pipelines limit available expansion areas, negatively affecting performance. However, the container capacity model shows a near-significant correlation with GDP (p-value=0.07), suggesting that infrastructure

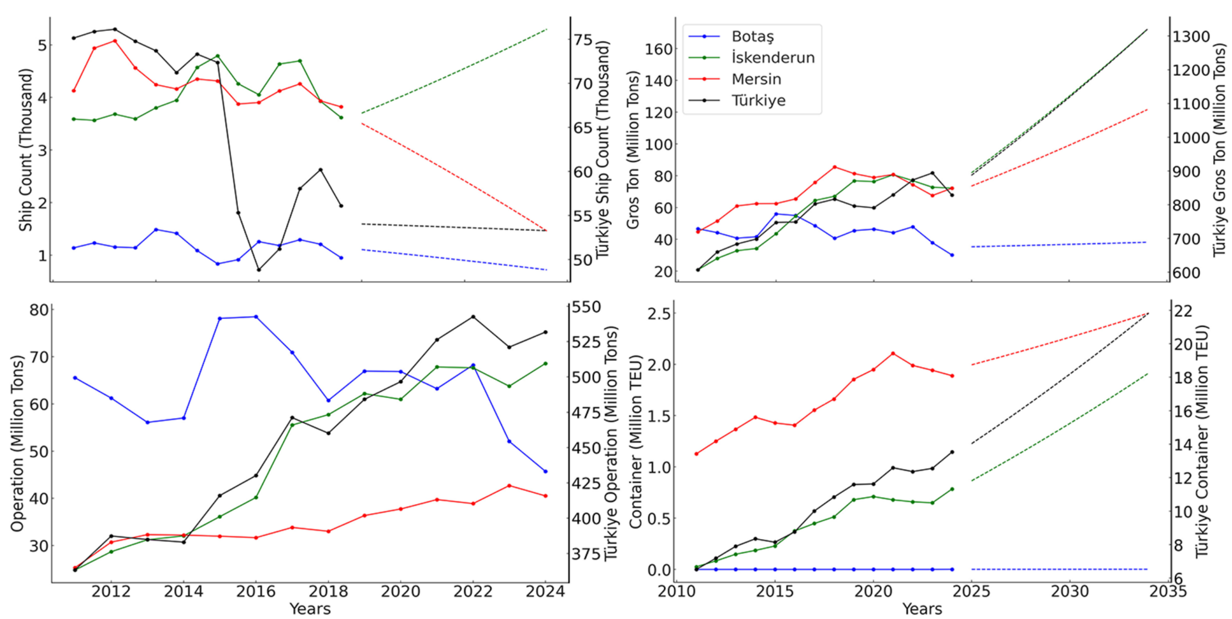

Figure 2. *Projected trends and historical performance indicators for Botaş, İskenderun, Mersin, and Türkiye (2010-2035) (In the top left chart, the total number of ships handled (thousand), the top right chart illustrates gross tonnage (million tons), the bottom left chart shows stevedoring operations (million tons) and the bottom right chart represents container capacity (million TEU)*

improvements could enhance future performance. Mersin Port Authority administrative area presents a more balanced, yet complex structure. Table 3 indicates that population plays a critical role in determining performance (p-value: 0.01). Mersin shows strong performance in container capacity (R^2=0.95), reflecting its importance as a key transit hub in regional trade. However, a decrease in the number of vessels, as shown in Table 3, suggests a shift towards accommodating larger vessels, despite growing trade volumes. Comparatively, İskenderun Port Authority stands out for its rapid growth and cost advantages (Table 1). Mersin Port Authority, with its extensive capacity and strategic location, remains a crucial transit center, however, its slowing growth may leave it vulnerable to competition from İskenderun unless strategic expansions are pursued (Table 3). Botaş Port Authority, while maintaining its strategic role in energy transportation, remains constrained by infrastructure limitations (Table 2). For Mersin, only population is statistically significant in the baseline gross-tonnage model ($p=0.01$). Therefore, claims about strategic leadership in container transport are toned down and interpreted as hypotheses unless supported by the TEU-specific specification (see Table 3).

Figure 2 compares the performance of port authority administrative areas in Türkiye with those in the Eastern Mediterranean, including Botaş, İskenderun, and Mersin. The data highlight how regional contributions shape Türkiye's overall maritime trade and outline future development projections. A declining trend in ship count is observed nationwide, likely due to the use of larger vessels. The Eastern Mediterranean areas of İskenderun and Mersin account for about 10% of total ship traffic, reflecting the region's growing importance in Türkiye's maritime trade. Mersin's strategic role in transit shipping secures its significant share of traffic, while İskenderun's expanding capacity supports its rapid growth. In terms of gross tonnage, Türkiye's total cargo volume is expected to exceed 1,300 million tons by 2035, with Eastern Mediterranean areas contributing approximately 25%. Mersin leads in container shipping capacity, while İskenderun plays a key role in industrial cargo transport. Operations show steady growth, with Eastern Mediterranean areas contributing 20%. Mersin will reach 90 million tons by 2024, representing 17% of the national total. İskenderun's expanding operations are driven by its specialization in steel and energy transport. Container capacity in Türkiye is projected to grow from 18 million TEU in 2024 to 25 million TEU by 2035. Mersin accounts for 15% of this capacity, maintaining its position as a key container hub. İskenderun holds an 8% share, with potential for growth through improved hinterland connections. Botaş remains focused on energy transportation, contributing minimally to container handling.

The performance analysis of ports in the Eastern Mediterranean aligns with key findings in the literature regarding the role of ports in regional development. For example, the study on İzmir Ports revealed that ports contribute significantly to regional development through income generation, job creation, and added value in the long term [7]. Similarly, the analysis of İskenderun, Botaş, and Mersin ports demonstrated that economic indicators such as population growth have strong impacts on port performance, supports the role of ports in boosting economic vitality in surrounding areas [1]. Luo et al. [30] highlighted that port competition and cooperation can have both positive and negative impacts on port competitiveness, depending on geographical location and strategic approaches. This finding is reflected in the case of Mersin and İskenderun ports, where the potential for these ports to act as alternatives to one another plays a critical role in shaping commercial dynamics in the Eastern Mediterranean region [1]. Leila and Abdullah [8] emphasized that ports, such as Jask Port in Iran, are not only economically important but also strategically significant. This observation is mirrored in the case of Botaş Port, whose strategic location for energy transportation highlights the functions of Eastern Mediterranean ports. Studies on the performance of container terminals in Türkiye have highlighted that the terminal area is the most important factor affecting the performance of Mersin Port. The research shows that larger and well-organized terminal areas contribute significantly to the efficiency and competitiveness of port operations. The study also suggests that the terminal's physical size and operational capacity are key elements that determine its ability to handle cargo efficiently and compete with other regional ports [31].

Additionally, Mersin Port's strategic location among Middle Eastern ports plays a critical role in the economic and geopolitical development of both Türkiye and the region. Due to its proximity to major trade routes and regional markets, Mersin Port serves as a key logistics hub, facilitating trade between Europe, the Middle East, and Asia. The port's location enhances Türkiye's commercial influence in the region and supports regional trade and economic activities [32].

Studies on port and city integration suggest that ports can enhance economic sustainability through transport infrastructure and logistics integration [33]. In this context, Mersin Port's role as a key transit point between the Middle East, Europe, and Asia strengthens its position in regional competition by enhancing trade connectivity [1]. Karaoğlu et al. [34] highlighted that despite global disruptions such as the coronavirus disease-2019 pandemic, Mersin Port exhibited remarkable resilience, demonstrated by increased cargo handling capacity, primarily driven by the arrival of larger vessels. This adaptability mirrors the development of Shanghai Port, where port expansion and economic growth are strongly interconnected, contributing significantly to regional economic development [35]. The importance of sustainability in port operations has become increasingly prominent. Studies conducted in Chinese port cities have shown that ports play a crucial role in promoting regional economic development. The throughput capacity of ports significantly influences the regional GDP, as efficient port operations enhance industrial growth, improve supply chain logistics, and foster economic integration. The relationship between port performance and economic indicators was thoroughly analyzed through panel data regression models, revealing that while port throughput positively affects secondary industries, it shows a negative correlation with primary and tertiary industries, emphasizing the need for strategic port-city integration [36]. Similarly, a comparative study on the competitiveness of Rotterdam and Chennai ports revealed that geographical location and infrastructure are the most decisive factors influencing port competitiveness. Rotterdam Port, with its strategic positioning along major sea routes, advanced technological infrastructure, and robust governance, has secured its status as a leading maritime hub. Conversely, Chennai Port struggles with limited infrastructure, suboptimal governance, and poor connectivity, which hinder its competitiveness. The study suggests that strategic investments, infrastructural enhancements, and governance reforms are vital for improving the global competitiveness of Chennai Port [37]. Yorulmaz and Baykan [38] emphasized that the adoption of environmental management systems and sustainable growth strategies in Turkish ports, particularly those in the Eastern Mediterranean, aligns with global best practices, ensuring long-term operational efficiency and economic sustainability.

Economic indicators (GDP, population, exports, and imports) have significant effects on port performance, with these effects varying by region. Studies on Chinese ports show that economic factors like GDP and exports directly affect port capacity usage. Port integration, especially among small and medium-sized ports, boosts economic growth [39]. As a result, the growing capacity and affordable services of the small ports in the İskenderun Port Authority area make it a key player in regional development, while Mersin Port may need to reassess its position amid increasing regional competition.

One of the key drivers behind İskenderun's rising prominence is the natural depth levels of its coastal areas, particularly in Payas and Sarıseki. These depth advantages allow larger vessels to dock without the need for extensive dredging operations, reducing operational costs and turnaround times. Additionally, freight service pricing in these areas remains competitive, further positioning İskenderun as a cost-effective alternative for shipping companies. In contrast, Mersin Port, despite its established infrastructure and handling capacity of 2.5 million TEU annually, shows signs of slowing growth. Although the facility continues to serve as a vital transit hub between the Middle East, Europe, and Asia, the rate of new investments and expansion projects has slowed. This deceleration has coincided with shipping companies increasingly favoring İskenderun for its scalable capacity, cost advantages, and strategic location. The Botaş Port Authority region, which was once considered a potential area for further expansion, now faces operational constraints due to petroleum pipelines. These pipelines have limited the available area for port activities, making large-scale expansion projects impractical. When comparing İskenderun and Mersin, the trend is clear: İskenderun is experiencing accelerated growth in port capacity, attracting more maritime traffic with each passing year. This growth is supported by improved hinterland connections and lower freight service prices. Meanwhile, Mersin's growth rate has plateaued, with its role shifting more toward sustaining existing operations rather than aggressively expanding capacity. The future of regional development in the Eastern Mediterranean will likely see İskenderun taking a leading role. Its faster growth trajectory, favorable geographic and economic conditions, and increasing investments signal a shift in regional maritime dominance. Mersin, while still important, may find its growth opportunities limited unless strategic expansions are implemented.

5. Conclusion

This research analyzed the current performance and projected future demand for the port authority areas of İskenderun, Botaş, and Mersin in the Eastern Mediterranean region. According to the findings, the İskenderun Port Authority area demonstrates strong growth potential, primarily driven by population growth and its naturally deep-water coastline, which provides cost-effective logistics opportunities for large-tonnage vessels. Therefore, improving hinterland connectivity and strengthening logistics infrastructure are identified as priority actions to enhance the competitiveness of the İskenderun area. The Mersin Port Authority area maintains its critical role as a key transit hub in regional trade, thanks to its robust container capacity and strategic location. The study recommends accelerating capacity expansion investments and developing terminal infrastructure capable of accommodating larger vessels in the Mersin area. These strategic initiatives will enable Mersin to sustain its competitive advantage and continue its growth trajectory. In contrast, the Botaş Port Authority area exhibits weak correlations between economic indicators and port performance, primarily due to operational constraints imposed by petroleum pipelines that limit expansion opportunities. However, infrastructure development projects and investments promoting economic diversification have the potential to improve Botaş's performance. Additionally, developing energy logistics-focused strategies will further strengthen Botaş's strategic role in the region. Overall, investment in transportation infrastructure to enhance regional integration, capacity expansion, and strategic collaborations across the Eastern Mediterranean port authority areas will boost their competitiveness in international trade and contribute significantly to Türkiye's long-term economic growth.

Footnotes

Funding: The author did not receive any financial support for the research, authorship and/or publication of this article

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