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ECONOMIC FACTORS AFFECTING MARITIME CONTAINER TRANSPORTATION: AN ANALYSIS FOR EUROPEAN UNION (EU) COUNTRIES

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ABSTRACT

Maritime container transportation, as one of the most critical elements of international trade, plays a fundamental role in the formation of trade volumes, supporting economic growth, and expanding logistics networks. This study aims to identify the main economic factors affecting maritime container transportation and analyze the relationships between these variables. Within this scope, a panel data analysis was conducted using data from European Union (EU) countries for the period 2000-2022. Empirical findings show that economic growth has a significant and positive impact on maritime container transportation, while inflation has a negative effect on the sector. The effect of exchange rates was found to be positive but relatively limited. Based on the findings, it is recommended that policymakers develop strategies to support sustainable economic growth by increasing investments in infrastructure and innovation in the maritime sector. In addition, the implementation of sound monetary policies aimed at keeping inflation at low and stable levels is critical for increasing the efficiency of maritime transport systems and maintaining international competitiveness. Policies aimed at exchange rate stability are expected to support the sector's stable growth by reducing cost uncertainties in international trade. It is anticipated that these comprehensive approaches will play a significant role in ensuring the sustainable growth of the maritime container transport sector.

Keywords: *International Trade, Maritime Container Transportation, Economic Growth, European Union, Panel Data Analysis*

JEL Classification: *B23, F43, L91*

DENİZYOLU KONTEYNER TAŞIMACILIĞINI ETKİLEYEN EKONOMİK FAKTÖRLER: AVRUPA BİRLİĞİ (AB) ÜLKELERİ İÇİN BİR ANALİZ

ÖZET

Denizyolu konteyner taşımacılığı, uluslararası ticaretin en kritik unsurlarından biri olarak, ticaret hacimlerinin oluşumunda, ekonomik büyümenin desteklenmesinde ve lojistik ağların genişletilmesinde temel bir rol üstlenmektedir. Bu çalışmada, denizyolu konteyner taşımacılığını etkileyen başlıca ekonomik faktörlerin belirlenmesi ve söz konusu değişkenler arasındaki ilişkilerin analiz edilmesi amaçlanmaktadır. Bu kapsamda, Avrupa Birliği (AB) ülkelerine ait 2000-2022 dönemine ilişkin veriler kullanılarak panel veri analizi gerçekleştirilmiştir. Ampirik bulgular, ekonomik büyümenin denizyolu konteyner taşımacılığı üzerinde anlamlı ve pozitif bir etki yarattığını, enflasyonun ise sektörü olumsuz yönde etkilediğini göstermektedir. Döviz kurlarının etkisinin ise pozitif olmakla birlikte nispeten daha sınırlı olduğu

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tespit edilmiştir. Elde edilen bulgular doğrultusunda, politika yapıcılara denizcilik sektöründe altyapı ve inovasyona yönelik yatırımları artırarak sürdürülebilir ekonomik büyümeyi destekleyen stratejiler geliştirmeleri önerilmektedir. Bunun yanı sıra, enflasyonun düşük ve istikrarlı seviyelerde tutulmasına yönelik sağlam para politikalarının uygulanması, denizyolu taşımacılığı sistemlerinin verimliliğinin artırılması ve uluslararası rekabet gücünün korunması açısından kritik öneme sahiptir. Döviz kuru istikrarını hedefleyen politikaların ise, uluslararası ticarette maliyet belirsizliklerini azaltarak sektörün istikrarlı büyümesine destek olacağı öngörülmektedir. Bu bütüncül yaklaşımların denizyolu konteyner taşımacılığında sektörel büyümeyi sürdürülebilir kılmada önemli bir rol üstlenmesi beklenmektedir.

Anahtar Kelimeler: *Uluslararası Ticaret, Denizyolu Konteyner Taşımacılığı, Ekonomik Büyüme, Avrupa Birliği, Panel Veri Analizi*

JEL Sınıflandırması: *B23, F43, L91*

1. Introduction

The volume of world trade has been increasing with the removal of barriers to trade and the liberalization of markets. This has accelerated the development of logistics services worldwide and led to significant transformations in transportation systems. Especially in recent years, there has been a significant increase in the use of containers in transportation systems. The worldwide rise of container transportation is thought to be the result of the interaction of microeconomic, macroeconomic and policy-oriented factors (Vasiliauskas & Barysiene, 2008, p. 311). These interactions have made container shipping a critical logistics solution in global supply chains. The shipping industry is closely linked to globalization and contributes to the expansion of global trade by providing faster, more reliable and economical transportation services (Cho, 2014, p. 194). The introduction of standardized containers in the 1960s led to a technological transformation in maritime transport logistics, leading to the expansion of linehaul services based on container ships and terminals (Vojdani et al., 2013, p. 468). These developments have made maritime transportation more systematic and integrated.

Many activities are carried out at sea, covering economic, military, cultural and industrial fields. Among these activities, maritime transportation and port management stand out due to the critical role they play in both national and international trade. The main reason for these preferences is that maritime transportation is less costly than other modes of transportation and has the capacity to carry more cargo at the same time (Aygül & Baştuğ, 2020, p. 26). The fact that materials transported by sea include both final products and production inputs increases the positive effects of this mode of transportation on economic growth (Yurdakul, 2023, p. 23). After a downturn in 2020 due to the pandemic, global maritime trade recovered by 3.2% in 2021, reaching 11 billion tons. Although this volume is slightly below pre-COVID-19 levels, it shows the sector's recovery strength (UNCTAD, 2022). The post-pandemic recovery has once again proven that maritime transport is the cornerstone of international trade and plays a critical role in the recovery of the world economy. Containers are relatively uniform boxes with standardized dimensions that do not require opening their contents at each transfer point. These features speed up and facilitate transportation processes (Vasiliauskas & Barysiene, 2008, p. 311). Especially maritime transportation stands out as the most common and preferred mode of container transportation (Dorduncu, 2021, p. 194). However, containers are also used effectively in land, air and rail transportation. The convenience offered by standardization has made

transportation processes more efficient and flexible. The ease of use of standard containers in transportation processes supports the integration of global supply chains. Containerization allows cargo to be transported by different modes of transport without the need to rearrange the cargo from origin to destination (Lee & Song, 2017, p. 442). This provides time and cost optimization in logistics operations and contributes to more efficient intercontinental trade processes.

This study aims to investigate the key economic determinants of maritime container transportation within European Union (EU) countries over the period 2000–2022. Given the critical role of maritime container transport in facilitating international trade, fostering economic integration, and sustaining supply chain resilience, a deeper understanding of the macroeconomic drivers shaping this sector has become increasingly imperative. Despite the growing body of research on maritime logistics, existing studies predominantly emphasize global trends or country-specific analyses, often overlooking the regional dynamics within major trading blocs. To fill this gap, the present study contributes to the literature by providing a comprehensive panel data analysis focusing on the EU, an economic entity characterized by intense maritime activity and extensive intra-regional trade. Specifically, the research examines the effects of economic growth, inflation, and the real effective exchange rate on maritime container flows, employing robust estimation techniques through Stata 16. In order to build a contextual background for the empirical analysis, the next section discusses the strategic role of maritime container transportation in international trade and examines the current situation in EU countries. Subsequently, the paper proceeds with a detailed literature review, an explanation of the data and methodology employed, the presentation of empirical findings, and a discussion of the policy implications derived from the results. Through this structured approach, the study aims to provide actionable insights for sector stakeholders and policymakers seeking to enhance the resilience and efficiency of maritime transport in the face of macroeconomic fluctuations.

2. Maritime Container Transportation in Trade and the Situation in EU Countries

Businesses competing in the global market have to develop international strategies to cope with the challenges in these markets. Transportation, which is a sub-branch of the logistics system, is considered one of the most important elements in logistics costs. In this context, an efficient and cost-effective transportation system to gain competitiveness in international markets supports economies of scale in production and contributes to lower product prices (Cerit, 2000, p. 50). These economic benefits have made maritime transportation, which forms the basis of global trade, a strategic logistics solution. A reliable and efficient transport network facilitates the liberalization and standardization of trade and the integration of intercontinental production processes. Container ports, which are key points of international trade, are considered as structures that make export and import processes efficient. In this context, increasing port operating efficiency stands out as a critical strategy to improve the competitive advantages of countries (Hsu et al., 2024, p. 1170).

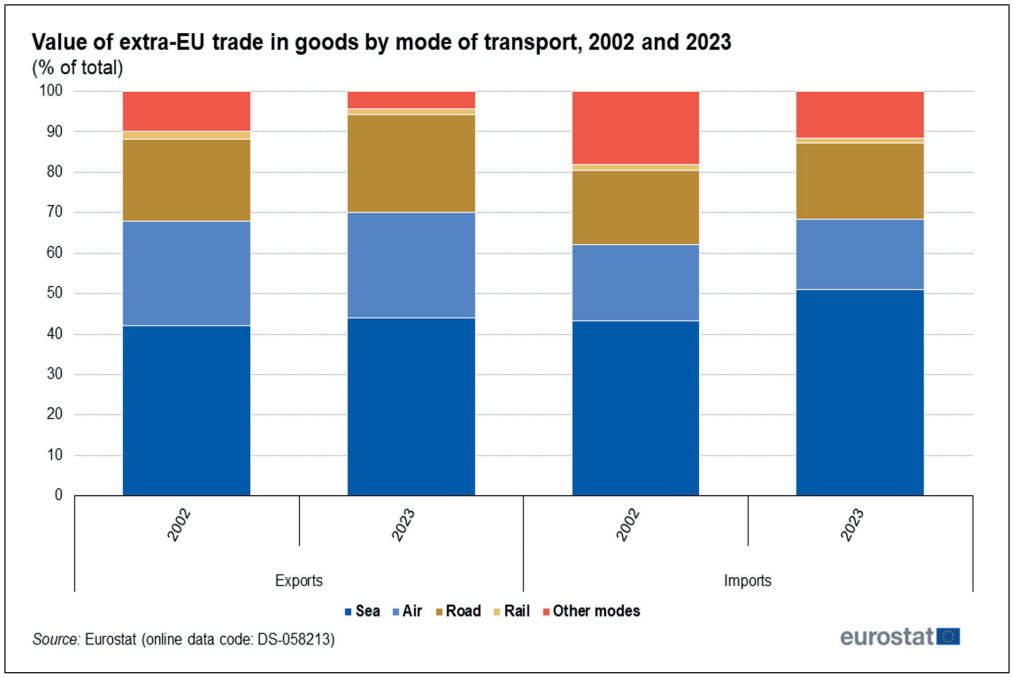
As a result of globalization, ports have become not only physical locations where cargo is handled, but also an integral part of a value-oriented logistics chain system (Song et al., 2005, p. 15). Ports stand out as important infrastructures that drive maritime trade between trading partners, support economic activities, and provide traders with the necessary connections to

deliver their products to their destinations (Othman et al., 2020, p. 114). However, due to the geographical and climatic characteristics of the sea, operations management techniques are less applied in maritime transportation compared to other transportation sectors (Lee & Song, 2017, p. 442). This makes it possible for the sector to benefit from economic scales in long-distance trade with the advantages of larger cargo ships and lower costs. Therefore, it is crucial for ports to provide integration between land and maritime transportation serving logistics, production, knowledge transfer and international trade. As key points of national and international trade networks, ports facilitate the flow of economic welfare and increase the competitiveness of countries in global trade (Baştuğ & Esmer, 2022, p. 35). The strategic location and service quality of ports have become a critical reason of choice for international container transportation companies. Avoiding high costs arising from unnecessary transhipment and relocation operations enables the creation of optimum container transportation systems (Pamucar & Görçün, 2022, p. 1). The clustering of logistics firms around major ports has contributed to strengthening the economic and logistics infrastructure of global cities (Slack & Gouvernal, 2016, p. 406). As containers move through a network of transportation nodes and links, connections between nodes are provided by road, rail and waterways; this process requires the integrated use of infrastructures (Lee & Whang, 2005, p. 295; Lun et al., 2008, p. 21). This integration increases the importance of value-added logistics services and multimodal transportation systems offered by ports.

On the other hand, sustainability and decarbonization discussions, which are gaining importance worldwide, are becoming increasingly important in the maritime transport sector. UNCTAD's 2023 Maritime Transport Report calls for a just transition to decarbonize the sector. While it is stated that emissions have increased by 20% due to old fleets dependent on fossil fuels, it is emphasized that digital transformation and large investments are required for full decarbonization. The report states that the cost of inaction will be higher in the long run. However, the resilience of maritime transport is emphasized, with projected growth of 2.4% in 2023 and over 2% in 2024-2028 (UNCTAD, 2023). This shows that environmental transformation in the sector needs to support business growth. At this point, the efficient use of ports is an important factor that strengthens the integration of national and international supply chains and contributes to environmental transformation.

The demand for container transportation is directly influenced by trade patterns, financial conditions and dynamics in the world economy. Maritime container shipping is of strategic importance for facilitating trade between EU countries and the rest of the world. The European Union (EU) is an important actor in world trade with its institutional structure and economic impact. Founded in 1951 with six countries, the EU today consists of 27 member states and imported goods worth approximately €1.1 trillion and exported goods worth €956 billion through maritime trade in 2021 (Statista, 2023). This data reveals the dependence of EU countries on maritime trade and the economic importance of this mode of transportation. Maritime transportation plays a key role in both the EU's domestic trade and its effectiveness in the global economy. The ratios of trade by modes of transportation in EU countries for the years 2002 and 2023 are as shown in Figure 1.

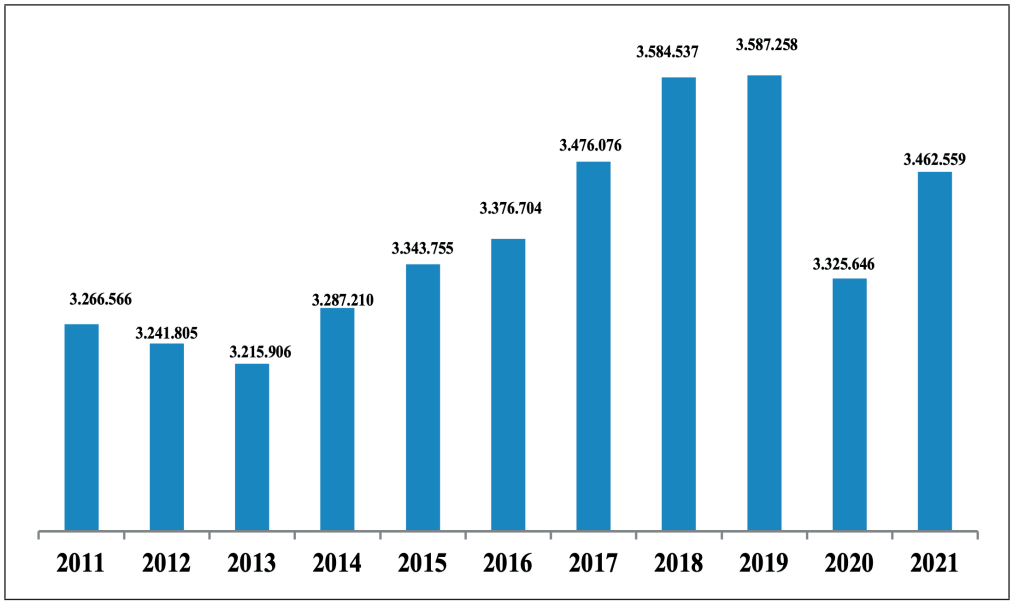
Figure 1: EU Trade by Mode of Transport



Source: Eurostat, 2024.

Figure 1 shows that maritime transport is one of the most preferred modes of transport for EU countries in world trade. In 2023, maritime transport accounted for 43.9% of exports and 51.0% of imports in value terms in the EU's trade with the world, while 74% of trade by volume was carried out by sea. This situation reveals that maritime transportation plays a critical role, especially with its advantages such as low cost, high transportation capacity and flexibility. Air transport accounts for 26.2% of EU exports and 17.4% of EU imports. Road transport accounted for 24.1% of exports and 18.7% of imports, while other modes of transport (e.g. pipelines) accounted for 4.3% of exports and 11.6% of imports. Rail transportation had the lowest share in the total, accounting for 1.5% of exports and 1.3% of imports (Eurostat, 2024). These data show that maritime transport is a critical mode of transport for foreign trade in EU countries due to its cost advantage, high capacity and logistical flexibility. The increasing share of maritime transport in imports stands out as one of the main factors supporting the competitiveness of this mode in global trade. Increasing globalization has greatly increased the volume of trade carried out by maritime transport worldwide. By 2021, the volume of trade by sea worldwide has reached 11 billion metric tons (Statista, 2023). This global trend has also affected the weight of goods transported through EU ports and Figure 2 provides details on this data.

Figure 2: Gross Weight of Products Transported in EU Ports (in 1,000 Metric Tons)



Source: Statista, 2023.

Figure 2 shows that approximately 3.5 billion metric tons of cargo will be transported by sea to the ports of the European Union in 2021. When the figures are evaluated in general, it can be said that there has been an upward trend in maritime cargo transportation over the years, except for 2020. In 2020, the decrease in the amount of cargo transported through EU ports compared to the previous year reflects the negative effects of the COVID-19 pandemic on the global supply chain (Statista, 2023). The restrictions imposed during the COVID-19 pandemic and the inability to respond to increased demand caused delays in cargo handling and congestion at ports. This led to a temporary weakening of maritime transportation chains (Guerrero et al., 2022, p. 113). The effects of the pandemic on supply chains have once again demonstrated the importance of flexible and resilient systems in the logistics sector.

In order to take full advantage of the benefits offered by maritime transportation, modern technologies need to be applied and larger container ships need to be used. However, the use of large container ships creates various complex challenges in port planning and coastal facilities (Vasheghani & Abtahi, 2023, p. 958). This makes it imperative to continuously update port infrastructure and increase operational capacity. Many countries around the world are aiming to create global logistics hubs that connect trading ports. In this context, large-scale investments are being made for the construction of container ports with terminals, berths, storage areas and hinterland connections. Since logistics costs are an important component of total trade costs, a reduction in these costs directly encourages exports and imports, making international trade more competitive (Cho, 2014, pp. 193-194). In this context, it can be said that maritime transportation is directly affected by economic factors and plays a critical role in increasing the cost-effectiveness of trade. Adopting technological developments and increas-

ing infrastructure investments will further strengthen the strategic importance of this mode of transportation in global trade.

3. Literature Review

Understanding the macroeconomic drivers of maritime container transportation has become increasingly important amid evolving trade dynamics, cost fluctuations, and supply chain complexities. Recent studies have shifted from generalized transport evaluations to more nuanced analyses, incorporating diverse variables and country-specific contexts. Table 1 summarizes selected studies examining the relationship between maritime transport and various macroeconomic variables. The literature reviewed has been categorized according to thematic focal points and methodological approaches to highlight the key dimensions and findings relevant to this study.

Table 1: Literature Review

Author(s)	Country/ Region	Method	Theme	Key Findings
Chi & Cheng (2016)	Australia–Asia	GARCH(1,1) model	Economic growth, exchange rate volatility	Economic growth is a fundamental determinant of maritime transport volumes. Exchange rate volatility affects maritime transportation in the long term, varying across countries. The accuracy of the volatility measurement method is emphasized.
Chi (2018)	Japan–USA	Nonlinear ARDL model	Asymmetric effects	Exchange rate and income changes have asymmetric effects on maritime trade flows across sectors. Nonlinear models reveal these effects more clearly than linear models.
Konstantakis et al. (2019)	Greece	Panel data analysis (1998–2015)	Macroeconomic factors, crises	Greek maritime transport is independent of local macroeconomic conditions and is shaped by global trade and international demand. The study suggests that the methodology can be applied to other Mediterranean countries.
Özer et al. (2021)	Türkiye	ARDL Bounds Test	Container transportation and economic growth	Maritime container transportation has a positive and significant impact on economic growth in both the short and long term. No significant relationship was found with rail transportation.
Arlı et al. (2022)	Türkiye, Greece, Italy, Spain	Panel cointegration and causality analysis	Port container volume and labor force relationship	No long-term relationship was found, but bidirectional causality exists in the short term, highlighting the sector's ability to adapt to economic conditions in the short run.

Table 1 continue

Ding & Choi (2023)	South Korea	DSGE and VARX models	Transportation costs and macroeconomy	Increases in maritime transport costs negatively affect real output and real exchange rates, while positively impacting CPI and nominal variables.
Michail et al. (2022)	Eurozone and beyond	VECM and threshold regression analysis	Transportation costs and inflation	Rising transportation costs significantly increase inflation, particularly outside the Eurozone. Sensitivity to transportation costs intensifies after a certain threshold.
Ferrari et al. (2023)	Global	Multi-regional general equilibrium model	Transportation costs and international trade	Maritime transport costs rose sharply after COVID-19; they are highly sensitive to global supply and demand imbalances.
Carrière-Swallow et al. (2023)	Global	BDI index analysis	Freight costs and prices	Shipping costs have a significant impact on import prices, producer price index (PPI), and inflation.
Çokluk & Şan (2024)	Türkiye	Export container traffic analysis	Export and inflation relationship	High value-added export growth reduces inflation, with effects lasting approximately 10 months. Inflation is also largely driven by its past values.
Szczepańska-Przekota & Przekota (2024)	Poland	VAR model	Cargo volume and macroeconomic indicators	Bidirectional relationships are identified between maritime transport and macroeconomic variables, notably fuel prices, growth, and inflation.
Nwoloziri et al. (2024)	Nigeria	Regression analysis	Foreign exchange reserves and trade	Foreign exchange reserves positively influence export and import volumes, but the effects are statistically limited. Strengthening reserves could support trade growth.

A comprehensive review of the literature demonstrates that macroeconomic variables particularly economic growth, inflation, and exchange rates—play a crucial role in shaping maritime transportation. While many studies confirm a strong link between maritime transport and economic growth, this relationship is not uniform across countries and often depends on structural economic factors and trade openness. Exchange rate volatility and inflation emerge as key sources of asymmetry, influencing transport costs and trade flows differently across sectors and time periods. Moreover, several studies suggest that maritime transport activity, though supportive of economic development, may at times operate independently of domestic business cycles, being more responsive to global demand dynamics. In this context, investigating the macroeconomic determinants of maritime container transportation within a specific regional framework such as the European Union offers valuable insights for the formulation of targeted, data-driven trade and logistics policies.

4. Method, Analysis and Findings

Panel data refers to data sets consisting of multiple observations for each sampling unit (Baltagi & Giles, 1998, p. 291). Such data sets are based on a cross-section or a group of people who are examined periodically over a given time period. Panel data analysis has become an increasingly popular method for longitudinal data analysis in the social and behavioral sciences. It offers an effective way of examining a particular topic periodically over time (Yaffee, 2003, p. 1). The growing popularity of panel data analysis stems from the fact that it allows for more comprehensive results by combining the time dimension with cross-sectional variables.

In this study, a panel data set including 20 EU member states is constructed using data for the period 2000-2022. Although there are 27 member countries of the European Union, seven countries are not included in the analysis due to landlockedness and data limitations. The countries included in the analysis provide an appropriate sample to assess the relationship between maritime container transportation and economic growth, inflation and exchange rate. The countries considered are shown in detail in Table 2.

Table 2: Countries Included in the Analysis

Country Name	Country Name	Country Name	Country Name
Germany	Finland	Spain	Poland
Belgium	France	Sweden	Portugal
Bulgaria	Croatia	Italy	Romania
Denmark	Netherlands	Latvia	Slovenia
Estonia	Ireland	Lithuania	Greece

Panel data models are essentially regression models estimated with panel data. Therefore, the tests, assumptions and other features of regression models are also valid for panel data models. Panel data models have one dependent variable and one or more independent variables. In addition, since the model is a statistical or econometric model, the error term is also included in the model (Alıcı & Akar, 2020, p. 15). Within the scope of this study, the economic factors affecting maritime container transportation are examined with the regression model shown below.

$$CT_{it} = \beta_0 + \beta_1 GDPPC_{it} + \beta_2 INF_{it} + \beta_3 lnER_{it+} \varepsilon_{it}$$

The explanations of the symbols in the above model are as shown below:

i; countries,

t; time,

β_0 ; constant value,

β , β_{12} , and β_3 are the coefficients to be estimated,

ε_{it} ; error term.

The data set of the study, which includes information on the variables used in this study, is as shown in Table 3.

Table 3: Data Set of the Study

Variable Name	Code	How to use	Source
Container Transportation	CT	Container cargo by sea (thousand tons)	OECD
Economic Growth	GDPPC	GDP per capita (USD)	World Bank
Inflation	INF	Inflation, consumer prices (annual %)	World Bank
Exchange Rate	ER	Real effective exchange rate (dollar)	World Bank

Per capita income is one of the most important economic indicators showing the level of development of a country. This indicator refers to the gross domestic product (GDP) of a country divided by the total population. Values are calculated in US dollars to ensure international comparability (Beylik et al., 2022, p. 5). Per capita, income plays a critical role in assessing the welfare level of an economy and the average living standards of individuals. Inflation, on the other hand, is a broad economic measure that represents the rate of increase in prices over a given period. This concept refers to the increase in the cost of living in a country over a given period and shows how much a group of goods or services has become more expensive, usually within a year (Bryan & Cecche, 1994, p. 196; Öner, 2010, p. 44). Inflation rates are a critical indicator that affects many economic activities from consumer behavior to investment decisions. Exchange rate is simply defined as the price of one currency against other currencies (Bilgiç, 2019, p. 26). The real effective exchange rate (REER) is a key indicator used to assess the degree of appreciation or depreciation of national currencies in international commercial transactionsThe real effective exchange rate (REER) is a key indicator used to assess the degree of appreciation or depreciation of national currencies in international commercial transactions. It reflects the evolution of relative prices and costs across countries and is widely used to evaluate the impact on a country's trade balance (Couharde et al., 2018, p. 209; Çuhadar et al., 2019, pp. 79–80). In addition, inflation and exchange rates are inherently interrelated, as changes in price levels can influence currency values and vice versa. However, variance inflation factor (VIF) test results (Table 6) indicate that this correlation does not lead to multicollinearity problems within the model, and therefore does not compromise the validity of the regression estimates. Descriptive statistics of the variables used in the study and correlation findings between variables are presented in detail in Table 4 and Table 5 respectively. The number of observations is not equal across models because some countries lack data for certain years; therefore, the estimation was carried out using the maximum number of available observations. To provide a general overview and ensure comparability across countries, descriptive statistics are presented as overall averages rather than on a country-by-country basis.

Table 4: Descriptive Statistics

Variables	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
CT	441	35121.27	4488.3	115	198283
GDPPC	422	29036.49	18632.41	1621.26	100172
INF	419	2.325982	3.240325	-4.4781	45.6666
ER	403	98.12003	6.213652	69.1222	112.185

When examining the values presented in Table 4, it is observed that container transport (CT) has the highest number of observations, while the real effective exchange rate (REER) has the lowest number of observations. This difference stems from variations in data availability across countries and years; however, the current number of observations is considered sufficient to ensure the robustness of the empirical analysis.

Table 5: Correlation Analysis

CT	1.000			
GDPPC	0.5441***	1.000		
INF	-0.3922***	-0.1312**	1.000	
ER	0.1951 ***	0.1328 **	0.0953 **	1.000

Description: *** p < 0.01, ** p < 0.05, * p < 0.10

When the correlation coefficients in Table 5 are analyzed, container shipping was found to have a statistically significant positive correlation (0.5441***) with economic growth, a statistically significant negative correlation (-0.3922***) with inflation, and a statistically significant positive correlation (0.1951***) with the exchange rate, respectively.

Another test to be examined after correlation is the Variance Inflation Factor (VIF). Used for multicollinearity, VIF measures the relationship of all explanatory variables simultaneously. This test explains how much the variance of a coefficient increases due to linear dependence on other explanatory variables (Pratheepan, 2014, p. 4). The results of the VIF test are as shown in Table 6.

Table 6: VIF Test Results

Variables	VIF Value	1/VIF Value
GDPPC	1.14	0.869761
INF	1.12	0.882648
ER	1.04	0.983984
Average VIF Value	1.10	

VIF value reflects the uncertainty in coefficient estimates. If the VIF value is close to 10, it is concluded that exogenous variables are correlated, while a value close to 1 emphasizes that independent variables are not correlated. A threshold value of 5 is generally used when evaluating this test (Busu & Nedelcu, 2021, p. 6). When Table 6 is analyzed, it is seen that the VIF value is within the acceptable limit.

The use of panel regression analysis offers a robust methodological approach to studying the complex relationships and dynamics between variables. However, it is crucial to carefully select the appropriate model and apply the necessary statistical tests during the analysis process. These tests allow researchers to increase the reliability of their findings and draw more robust inferences. In panel regression analysis, there are generally three main models: fixed effects model, random effects model and pooled least squares model (POLS), also known as

the classical model. A series of tests are required to determine which of these models is more appropriate for the analysis (Adeboye & Agunbiade, 2017; Gardiner et al.; 2009).

First, the Breusch-Pagan test is applied to determine whether the pooled ordinary least squares (POLS) model is appropriate or whether there are significant unit (country) effects in the data. The null hypothesis of the test suggests that the variance across entities is zero (i.e., no panel effect), implying that POLS is appropriate. If the null hypothesis is rejected at the 5% significance level, it indicates the presence of panel effects, and thus, either a random effects or fixed effects model should be used instead of POLS (Güriş, 2018, p. 71; Oğuz & Sökmen, 2019, p. 216). In such cases, the random effects model is estimated, and subsequently, the Hausman test is applied to determine whether fixed or random effects are more appropriate. The null hypothesis of the Hausman test states that the random effects model is consistent and efficient. If the null is rejected at the 5% significance level, the fixed effects model is preferred (Doğan & Kevser, 2020, p. 23). In this context, Breusch-Pagan and Hausman test findings are presented in detail in Table 7.

Table 7: Breusch-Pagan and Hausman Test Results

Test Name	Chi-Square Test Statistic	P Value
Breusch-Pagan	1247.31	0.0000
Hausman	23.34	0.0006

Table 7 shows that as a result of the Breusch-Pagan test, the null hypothesis stating that the variance of unit and time effects is equal to zero is rejected. Because the null hypothesis states that the variance exists. Due to the observed effects, it would not be appropriate to use the pooled least squares model in this study. As the Hausman test statistic shows, there is a probability value less than 0.05. Therefore, the validity of random effects is rejected and the fixed effects model should be used in the research.

When using panel data models, it is important to apply statistical tests to check for the presence of problems such as changing variance, autocorrelation and inter-unit correlation. Since such problems may affect the validity and reliability of the forecasts, appropriate tests are required. In this context, the study examines potential problems by using tests specific to the fixed effects model (Tatoğlu, 2016, pp. 221-227). This approach aims to increase the reliability of the analysis results by ensuring the validity of the model. The results are shown in Table 8.

Table 8: Variance, Autocorrelation and Inter-unit Correlation Test Results

Test Name	Test Statistic	P Value
Modified Wald Test	3243.51	0.0000
Baltagi Wu Local Best Literal Test	0.4753156	0.0000
Pesaran Test	34.158	0.0000

When Table 8 is analyzed, the significant probability value of the modified Wald test indicates that there is a problem of changing variance in the model. This means that the error

terms do not have constant variance and the variance varies across units (Ghilagaber, 2004; Nwangburuka et al., 2023). A Baltagi-Wu test statistic less than 2 indicates the presence of an autocorrelation problem (Alıcı & Akar, 2020, p. 19). Autocorrelation indicates that error terms are dependent between consecutive observations and may negatively affect the accuracy of model forecasts. When the results of the Pesaran test are analyzed, a p-value below 0.05 indicates the presence of cross-sectional dependence in the model, suggesting that the residuals are correlated across units. This indicates that there is correlation between the units and these relationships should be reflected in the model (Kapetanios et al., 2014; Mercan et al., 2015).

The test results show that the fixed effects model suffers from problems of heteroscedasticity, autocorrelation and inter-unit correlation. Since these problems may affect the reliability of the model estimates, it is important to use robust estimation methods such as Driscoll-Kraay in the analysis process. This approach increases the robustness of the model and makes the findings more reliable. The fixed effects estimator developed by Driscoll and Kraay is a robust estimation method that provides more accurate and reliable estimates by eliminating the problems of changing variance, autocorrelation and inter-unit correlation. This method is especially preferred in panel data analyses to increase the validity and robustness of model estimates (Ali et al., 2021; Beylik et al., 2022; Ewane, 2023; Rehman & Ahmad, 2022). Since the model includes these problems, the analysis was conducted with this estimator. On the other hand, although data transformation techniques are often used to address potential issues such as autocorrelation and heteroscedasticity, the original form of the variables was retained to maintain the clarity of interpretation. Additionally, the use of Driscoll-Kraay standard errors helps to control for these econometric problems, ensuring robust and reliable coefficient estimates. The results of the analysis are as shown in Table 9.

Table 9: Driscoll and Kraay Regression Test Results

CT	Coefficients	Driscool/Kraay Standard Error	P Value
GDPPC	1.13004	0.0897553	0.0000
INF	-1.15651	0.1112131	0.0000
ER	0.367542	0.0157542	0.0032
F: 183.75 (0.0000)*			
R^2 : 0.4823			

When Table 9 is analyzed, the F-statistic indicates that there is a statistically significant relationship between the variables. An increase of 1 unit in economic growth per capita (measured in thousand USD) leads to an increase of approximately 1.13 unit (TEUs) in maritime container transportation. Similarly, a 1% increase in the inflation rate results in a decrease of about 1.15 unit. In addition, a one-unit increase in the real effective exchange rate index corresponds to an increase of approximately 0.36 units. The R^2 value indicates that approximately 48% of the variation in maritime container transportation is explained by the independent variables included in the model.

Overall, the results suggest that economic growth means that individuals and businesses in a country can afford to purchase a higher quantity of goods and services. This leads to an

increase in consumption demand, making it necessary to transport more goods to meet these demands. Maritime container transportation is effective in meeting this increased demand as it allows for the transportation of large quantities of goods. Inflation refers to an increase in general price levels. This leads to a decrease in the purchasing power and demand of individuals and an increase in operating costs. Again, since maritime container transportation involves large-scale operations, increases in costs such as fuel, labor and maintenance directly affect transportation fees. Finally, exchange rate increases mean that a country's currency appreciates against other currencies. Exchange rate increases can stimulate trade, especially exports, in a country because exporters benefit from exchange rate increases and become more competitive. Since maritime container transportation usually involves the transportation of large quantities of goods, this transportation is increasing in parallel with the increase in export transactions.

5. Conclusion and Discussion

Maritime container transportation is of great importance in the international trade and logistics industry. The maritime industry has experienced a radical change with the standardized transportation method known as containerization. Containerization has accelerated port operations by facilitating the handling, loading and unloading of cargo, while at the same time reducing transportation costs. Moreover, the ability of containers to move seamlessly between different modes of transportation such as road, rail and maritime supports the integration of transportation networks. Therefore, maritime container transportation stands out as an economical, reliable and competitive option for international and long-distance trade.

Maritime container transportation contributes to economic growth and trade dynamics in various aspects, especially in European Union (EU) countries. Maritime transport is the most frequently used mode of transportation for imports and exports in EU countries. In this study, economic factors affecting maritime container transportation are analyzed using data for the period 2000-2022. A panel data set is constructed and analyzed using a regression model to assess the impact of economic growth, inflation and real effective exchange rate on maritime container transport. The results of the analysis show that economic growth has a strong and positive effect on maritime container transportation. It is found that a one unit increase in economic growth leads to a 1.13 unit increase in maritime container transportation. This finding is consistent with the literature that economic growth supports the logistics sector by increasing trade volume (Chi & Cheng, 2016; Konstantakis et al., 2019; Özer et al., 2021). This suggests that policies that promote economic growth may also have positive effects on the logistics sector. The effect of inflation on maritime container transportation is found to be negative; a one-unit increase in inflation causes a 1.15-unit decrease in transportation. The finding that high inflation negatively affects transportation activities by increasing trade costs is consistent with other studies in the literature (Çokluk and Şan, 2024; Michail et al., 2022). This result emphasizes the necessity of policies aimed at achieving price stability and shows that inflation control is an important tool to increase sustainability in the transportation sector. It is found that a one-unit increase in the exchange rate leads to a 0.36-unit increase in maritime container transportation. It is observed that exchange rate increases encourage exports and increase trade volumes and maritime transportation. This finding is consistent with studies on the sectoral and asymmetric effects of exchange rate changes (Chi, 2018; Chi & Cheng, 2016). The positive impact of exchange rate fluctuations on foreign trade increases the importance of maritime transportation in international trade.

The findings of this study show that economic growth and exchange rate increases have a positive effect on maritime container transportation, while inflation has a negative effect. In countries with high per capita income, the increase in maritime container transportation is largely due to increased purchasing power. This situation increases consumption, production, and trade volumes. On the other hand, high inflation increases consumption and trade costs, weakens logistics activities, and reduces container flows. Exchange rate increases, depending on the context, generally support maritime transport activities by enhancing export competitiveness.

Policymakers should prioritize strategies that promote sustainable economic growth, such as investing in port infrastructure, increasing digitalization, and supporting innovation, while taking measures to maintain price stability. Controlling inflation, reducing logistics costs, and maintaining trade competitiveness are of utmost importance. For industry stakeholders, incorporating macroeconomic indicators into strategic planning can improve demand forecasting, investment decisions, and risk management, thereby enhancing resilience and competitiveness in the global maritime market.

This study is limited to a macroeconomic perspective using panel data from EU countries, and does not incorporate sector-specific variables such as infrastructure capacity, regulatory frameworks, or technological developments. Future research could expand on this work by integrating micro-level data, conducting firm-level case studies, or exploring nonlinear relationships and regional heterogeneities within the EU maritime sector.

Conflict of Interest

The author declares that there are no conflicts of interest related to this study.

Ethics Approval

This study did not require specific ethical approval, as it did not involve procedures necessitating such clearance.

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