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The Importance of Maritime Transport for Economic Growth in the European Union: A Panel Data Analysis

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Abstract: Maritime transport is one of the main activities of the blue economy, which plays an important role in the EU. In this paper, we aim to assess the impact of maritime transport, related investment, and air pollution on economic growth within 20 countries of the European Union, using eight panel data regression models from 2007 to 2018. Our results confirm that maritime transport, air pollutants (NO_x and SO_2) from maritime transport, and investment in maritime port infrastructure are indeed positively correlated with economic growth. In other words, an increase of 10% in these factors has generated an associated increase in economic growth rate of around 1.6%, 0.4%, 0.8%, and 0.7% respectively. Alongside the intensity of economic maritime activities, pollution is positively correlated with economic growth, and thus it is recommended that policymakers and other involved stakeholders act to diminish environmental impacts in this sector using green investment in port infrastructure and ecological ships, in accordance with the current European trends and concerns.

Keywords: blue economy; maritime transport; economic growth; pollution; sustainability; panel data analysis

Citation: Fratila (Adam), A.; Gavril (Moldovan), I.A.; Nita, S.C.; Hrebenciuc, A. The Importance of Maritime Transport for Economic Growth in the European Union: A Panel Data Analysis. *Sustainability* **2021**, *13*, 7961. https://doi.org/10.3390/su13147961

Academic Editors: Tianming Gao, Vasilii Erokhin, Konstantin Zaikov, Andrei Jean Vasile and Jonel Subić

Received: 31 May 2021
Accepted: 14 July 2021
Published: 16 July 2021

1. Introduction

People's lives and economies would not be the same in the absence of the activities carried out in seas and oceans. Therefore, the blue economy is a very important part of the European economy, as it provides food and other resources, supports tourism, facilitates transport, and generates the production and use of renewable energy. Regarding the blue economy of the EU, seven established sectors sum up all the blue activities: marine living and non-living resources, marine renewable energy, port activities, shipbuilding and repair, maritime transport, and coastal tourism. These seven established sectors have a contribution of around 1.5% to the European Union's economy in terms of gross value added, and they employ over 2.2% of the employed persons in the EU [1]. Coastal tourism, maritime transport, and its related sectors are the largest sectors in terms of the value added at factor cost.

Coastal tourism accounts for 45% of the total value added at factor cost of the blue economy, while maritime transport and its related sectors (shipbuilding and repair and ports activities) sum up around 40% of the total value added at factor cost of blue economy activities (Figure 1).

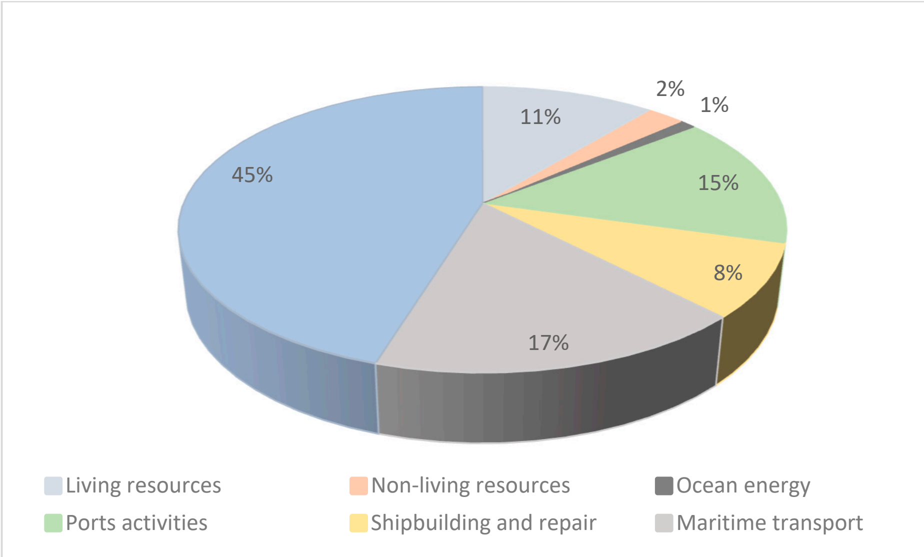

Figure 1. Value added at factor cost (% of total value added of the blue economy, 2019). Source: Eurostat, authors' calculations.

As coastal tourism requires the intensive use of hospitality services, which employ a lot of workers, a large share (64%) of the employees of the blue economy work in the sector of coastal tourism, while the maritime transport and its related sectors (shipbuilding and repair and ports activities) account for 24% of the employees of the blue economy (Figure 2).

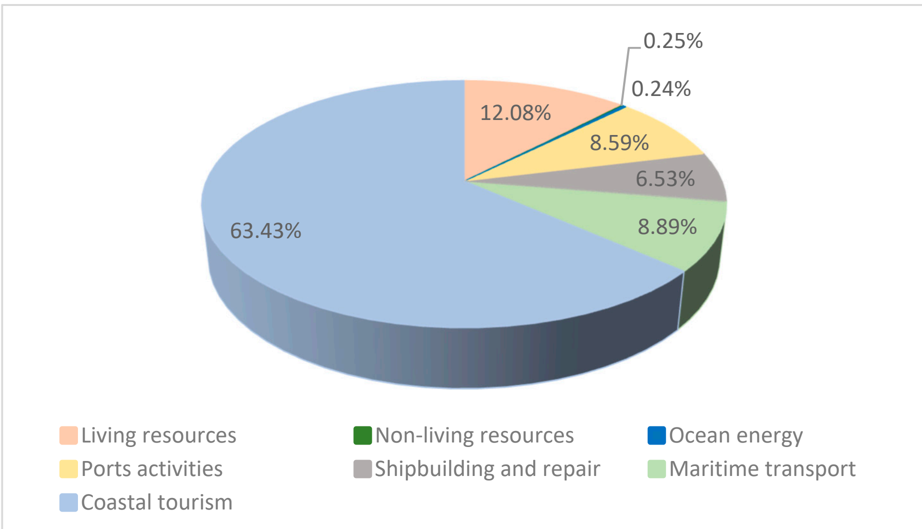

Figure 2. Persons employed by sector (% of total employment in the blue economy, 2019). Source: Eurostat, authors' calculations.

Twenty-two of the EU member states practice maritime transport. Thus, European shipping possesses a large share of the world's fleet (over 40%), accounting for some of the world's biggest maritime clusters. According to the Eurostat data, the total gross weight of goods transported through EU short sea shipping amounted to 1.8 billion tons, consolidating the recovery registered after the economic crisis of 2009. In recent years, ship sizes have been increasing, leading to the intensification of the activities for shipbuilding and repair and port activities. These new larger ships have a reduced impact on the environment, following the European Green Deal. Member states' contributions to the European blue economy are heterogeneous, depending on the geographical position, sectoral structure, and specificities of the economy. As expected, the blue economy has larger shares within the national economies of insular countries or member states with wide sea openings, such as Greece, Croatia, Malta, Cyprus, or Portugal. However, when it comes to the contributions of member states to the EU blue economy, particularly in terms of gross value added, the structure/type of blue activity provided commands the main influence. For instance, economies with significant gas and oil industries, which imply a large share of gross investments and low employment intensity, are likely to provide a larger contribution to the gross value added of the blue economy at the EU level. Yet, countries specialised in coastal tourism, which is labour intensive, have a larger contribution to the EU blue economy in the area of employment when compared to gross value added or to gross investment [1].

Maritime transport is of great importance for the global economy, as it accounts for around 80% of worldwide trade [2], highly affecting economic development. Both maritime transport and its related activities have a great overall impact on the economy, influencing a lot of industries, directly or indirectly. While maritime transport is considered the lynchpin of global trade [3], a lot of other industries rely heavily on it, as an array of resources are transported to manufacturing centres.

As aforementioned, maritime transport and its related activities (shipbuilding, repairs, and ports activities) account for around 40% in terms of value added and 24% in terms of employment within the blue economy. Maritime transport implies a wide range of activities and, together with port activities and logistic nodes, has a great impact on the development of the maritime sectors and trade, which in turn fosters economic growth and job creation.

Besides affecting economic growth and development, maritime transport has a great influence on sustainable development, as it is considered an environmentally friendly mode of transport [2]. Although maritime activities do harm the environment, this impact is lower compared, for example, to road transport, and therefore shipping seems subject to less intensive regulation [4]. While maritime transport is the most efficient way of transport in terms of carbon emissions, notice that within the EU, maritime transport accounts for over three-quarters of external trade and one-third of internal trade. However, in the context of the current concerns and policies regarding reducing pollution within the EU, embodied in the Green Deal, action would be necessary to reduce pollution of the sector.

Within this paper, we aim to analyse the impact of maritime transport, related investment, and air pollution on economic growth in the EU. We used eight panel data regression models from 2007 to 2018, for 20 EU countries practicing maritime transport. Although a lot of research papers emphasize the importance of maritime transport for international trade, economic success, and global development patterns, the richness of professional literature for the EU in this context is less than one may first anticipate. Usually, studies for the EU on this theme include microeconomic analyses, while our study assesses the macroeconomic influence of maritime transport, which is of great importance within the European Economy. One would think that common sense says that increasing pollution from increasing maritime infrastructure would generate increasing GDP per capita no matter what region, country, or continent is subject to this research, but we consider that every country, region, or continent is different and has its particularities. Plus, someone may think that, when talking about the EU, decreasing pollution would generate higher GDP per capita as there are constant policies oriented toward sustainable growth within the European Union. In these conditions, it would be interesting for policymakers to see where the EU stands during the transition to a green economy.

The remainder of the paper is extended as follows. Section 2 briefly reviews the related literature. Section 3 describes the data used in this research. Section 4 describes the panel regression models. Section 5 presents the empirical results and discussions. Section 6 concludes the study.

2. Literature Review

Generally, well-developed transport infrastructure ensures returns through certain macroeconomic drivers of productivity, such as "expansion of business activity, innovations, investments, labour market, competition, domestic and international trade global mobile activity, regional economic development, population wellbeing, environment safety, and health" [5]. Maritime transport is an important component of the transportation system, and it accounts for a large part of world trade. Moreover, it is considered that participating in the global maritime trade is a very important factor for attracting global capital [6].

Given its great importance, maritime transport is highly discussed within the literature and, in the past decades, many papers regarding all kinds of topics related to maritime transport have been published. While major academic concerns related to maritime transport regard the micromanagement of ports and liner shipping, over the past decades, the overall research trends shifted towards efficient and sustainable maritime transport, from regulations and policy management, that had formerly been of interest [3].

Therefore, a lot of research papers analyse the impact of maritime transport on economic growth and development and emphasize the importance of maritime transport for international trade, economic success, and global development patterns.

For instance, Akbulaev and Bayramli [7] study the relationship between maritime transport development and the dynamics of economic growth for several countries on the Caspian Sea (Russia, Azerbaijan, Turkmenistan, Kazakhstan, and Iran) and find that the development of maritime transport through better management promotes sustainable economic development. Gherghina et al. [8] evaluated the impact of different transport infrastructure systems (including maritime transport) on economic growth. They used panel data regressions with fixed effects for EU countries from 1990 to 2016. The authors obtained a positive link between maritime transport, related investments, and economic growth and a negative link between air pollutants and economic growth. Khan et al. [9] obtained, also, a positive link between container port traffic and income per capita, using a panel of 40 heterogeneous countries. Likewise, Saidi et al. [10] concluded that transport infrastructure positively influences economic growth, by using the generalized method of moments.

Niavis et al. [11] estimate the importance of maritime transport for the economy, society, and environment of the Adriatic–Ionian region through value estimation methodologies to develop an integrated assessment tool for a comparative evaluation of maritime transport against other drivers of the region. The authors find that maritime transport is the second most important factor of change in the Adriatic–Ionian region, after coastal tourism. Likewise, Özer et al. [12] analyse the impact of maritime transport and rail container transport on economic growth in Turkey, between 1991 and 2016, using the Autoregressive Distributed Lag-based bounds testing approach. They find no significant relationship between rail transport and economic growth, but a positive and statistically significant relationship between maritime container transport and economic growth, both in the short run and long run. Another paper that analyses the impact of maritime transport in France by an input–output approach shows that maritime transport has a strong effect on output, as the multiplier obtained in the empirical research is 2.16 for the year 2016, above the values in other papers within the literature regarding maritime transport [13]. Moreover, using an augmented Solow model, Park and Seo [14] found that container port activities can positively influence regional economic growth.

Lane and Pretes [6] examine the impact of five major factors in maritime dependency on economic development and they find a significant relationship between maritime dependency and gross domestic product per capita. The authors define maritime dependency as" the ability of a country to participate in maritime trade as determined by their geographic access to international waters and trade dependency".

A few studies aim to simultaneously find the correlation between different ways of transport and economic growth [8,15,16]. For instance, Park et al. [15] compare the impact of maritime, air, and land transport on economic growth in OECD and non-OECD countries by using a hybrid production approach that combines economic growth with the supply of and demand for transportation. The researchers obtained that maritime transport has a stronger impact on economic growth than air and land transport, which sometimes have no influence or even affect economic growth negatively, especially in developing countries.

Other studies focus on the influence of investments in port infrastructure on economic growth. Ports are essential for the support of economic activities in the surrounding areas, as they act as a critical association between sea and land transport [17]. The benefits of seaports analysed in the literature include [18] reducing transport costs [19,20], increasing private investment, encouraging trade [21], fostering employment [22,23], improving logistics [24], and other port-related activities [23,25]. Mudronja et al. [18] analysed the impact of seaports on the growth of regional economies within the endogenous growth theory using a sample of 107 EU port regions from 2005 to 2015. The authors obtained that seaports have a significant impact on the economic growth of the EU port regions. Meersman and Nazemzadeh [26] quantified the impact of transport infrastructure investments on the Belgian economy using an economic growth model. The authors obtained that investment in port infrastructure by the government contributes to economic growth. Song and Geenhuizen [27] examined the effects of port infrastructure investment in China on the growth of the regional economies by applying panel data analysis from 1999 to 2010. Their results indicate positive effects of port infrastructure investment in all regions. These results are also confirmed by Shan et al. [28], who studied the impact of seaports on the economy of an associated port city in China, using data from 41 major port cities between 2003 and 2010. Hong, Chu, and Wang [29] conducted a study on 31 Chinese provinces and concluded that water transport infrastructure investment positively influences economic growth only after the investment scale goes above a threshold point. Song and Mi [30] investigated the relationship between port investments and economic growth. In their study, they found bidirectional causality between port investment and economic growth over the short run, and a unidirectional causality running from port investment to economic growth in the long run.

A lot of research papers focus on maritime transport pollution. This kind of pollution is highly discussed in literature, academia, and international institutional circles, focusing on both impact assessment and the measures to effectively reduce pollution from maritime transport. Among the different ways of transport (aviation, road, navigation and railway), maritime transport is considered to be the most environmentally friendly.

For instance, Bagoulla and Guillotreau [13] evaluate the impact of several types of air pollutants and greenhouse gas emissions (SO_2, NOx, CO_2, $PM_{2.5}$, PM_{10}) resulting from shipping transport and find that SO_2 and NOx are the most polluting air pollutants, as they obtain the larger multipliers of all industries for these two types of air pollutants. The authors state that assessing the gas emissions caused by maritime transport is very important in the context of the implementation of more stringent regulations regarding the SO_2 emissions of the shipping sector, by imposing the SO_2 Emission Control Areas limits. Ben Jebli and Belloumi [31] concluded in a study on the Tunisian transportation network that over the short run, a bidirectional causality occurred between CO_2 emissions and maritime transport, whilst a unidirectional causality occurred running from real GDP, combustible renewables, waste consumption, and rail transport to CO_2 emissions. In the long run, GDP drives a reduction in CO_2 emissions, whereas combustible renewables and waste consumption and maritime and rail transport exhibit positive effects on emissions. Taghvaee et al. [32] examined the relationships among maritime transport, environmental pollution, and economic growth by using a dynamic log-linear model in Iran. The authors obtained a positive relationship between maritime transport, environmental pollution, and economic growth, confirming the Pollution Haven Hypothesis.

In addition, Goleblowski [33] states that water transport is the most energy-efficient form of transportation. However, maritime transport might increase its contributions to the impact on the environment in future years [34], so efforts should be made to reduce emissions from maritime transport, alongside other efforts for mitigating all kinds of negative impacts on the environment.

In the debate regarding sustainability among industry, government, and international organizations [35] around the world, many efforts concern mitigating the negative effects of pollution on waters, both rivers [36] and seas.

Regarding the efforts towards reducing maritime pollution, it must be mentioned that the International Maritime Organization (IMO) designed in 2018 is a strategy that set its main aims as reducing greenhouse gas emissions from international shipping by 50% until 2050 and the CO_2 emissions intensity by 40% until 2030, as compared to the 2008 levels. This will call for a combination of operational measures, efficient investments in less polluting technologies, and more competitive market-based measures [37]. The targets set by the IMO are considered rather ambitious [38].

In the context of growing stringency in environmental regulations regarding the maritime sector, a shift to cleaner fuels is considered a very good way of achieving less pollution. However, technical and financial factors can undermine a complete transition to clean fuels within the maritime transport sector [39].

Some other authors argue that levies would be the best ways to induce technological change over the long run and logistical measures could work over the short run, among the changes that need to be executed in order to meet pollution reduction targets [2]. Such measures would have the advantage of determining technological change regarding both ships and port infrastructure that would lead to a more economic/energy-efficient and less polluting sector. However, such changes would require a great number of investments needed over the medium term, while the benefits would amount over the long term. Therefore, taxes, fees, or regulations regarding maritime transport would be internalized within the transport costs [4], affecting decisions and all the related activities in the field. It is considered that ports have considerable potential for enhancing environmental change toward reducing pollution, through promoting lower complexity of the tool implementation by a stronger collaboration within global value chains, and by promoting alliances with cargo-owners and regulators to enhance emission visibility [40]. However, some authors concluded that network design measures can be effective in reducing pollution from maritime transport. Serra et al. [34] conducted a study on an innovative two-hub freight network for shipping services in the Mediterranean Sea compared to the existing connections within that region, and concluded that the redesign of the networks used in shipping transport would help to diminish air pollutants and the greenhouse gas emissions and would promote the emergence of more sustainable transport networks within the Mediterranean Sea.

3. Data Description

We used annual data starting from 2007 until 2018. We selected this time interval after excluding the years for which data are unavailable, in order to obtain a clear and homogenous cross-sectional database. At the time of writing this research, 2018 was the latest available data for maritime transport. The research sample consists of 20 EU countries with maritime transport activities: Belgium, Bulgaria, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Netherlands, Poland, Portugal, Slovenia, Finland, and Sweden. Malta and Romania are excluded from the research, as they have several data gaps. Likewise, we excluded the UK from our sample, as it is no longer a member state of the EU. Brexit impacts on maritime transport activities of the EU and a lot of maritime routes that formerly included the UK are being redesigned to exclude them [41].

The data sources are Eurostat [42], OECD [43], and the World Bank [44] databases. The data consist of gross domestic product per capita (as a proxy for economic growth), maritime transport infrastructure, air pollutants from maritime transport, investment in maritime port infrastructure, and country-level controls. We chose these indicators as they are documented in the literature to be the most relevant for the aim of our research [8,18,27,45].

Regarding the air pollutants resulting from maritime transport, we selected the emissions of SO_2 and NOx, as they are documented in the literature [13] to have the greatest impact of all the air pollutants and greenhouse gas emissions implied by this specific sector. We know that since 2015, International Maritime Organization and thereafter the European Parliament stipulated that all ships in SECA (Sulphur Emission Control Areas, set in 2005 and 2012) should use low-sulphur marine fuel not exceeding 0.1% [13,46] and this kind of regulation has a great impact on the data regarding the emissions of SO_2. We consider that this kind of regulation is captured intrinsically within the data as the member states have to comply. Table 1 shows a list of used variables.

Table 1. The list and explanation of the variables.

Variables	**Description**	**Formulation**	**Source**
GDPpc	Gross domestic product per capita	Expressed in purchasing power standards (PPS) in EUR	Eurostat
MT	Gross weight of goods handled in all ports	1000 tons	Eurostat
MI	Investments in maritime port infrastructure	Expressed in constant euro	OECD
NOx	Emissions of NOx from maritime transport	Tons	Eurostat
SO_2	Emissions of SO_2 from maritime transport	Tons	Eurostat
Services_trade	Services trade openness	Expressed as sum of exports and imports of services measured as share of GDP	Eurostat
Unemployment	Unemployment rate	Expressed as % of unemployment in active population	Eurostat
HICP	Harmonised index of consumer prices	Average index (2015 = 100)	Eurostat
GINI	GINI coefficient of equivalised disposable income	Scale from 0 to 100	Eurostat
Gov_e	Government effectiveness	Expressed as aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately −2.5 to 2.5	World Bank

As expected, the developed economies within the EU register higher levels of maritime transport or related activities, such as investment in maritime port infrastructure. Country specificities and the characteristics of the economy play an important role regarding maritime transport activities and their efficiency. For instance, the Netherlands is the member state of the EU that accounts for the greatest annual average value for the gross weight of goods handled in all ports between 2007 and 2018 (Figure 3), but accounts for a much lower level of NOx emissions from maritime transport compared to other countries (Figure 4), which means it is more environmentally friendly, probably due to using larger and less-polluting ships.

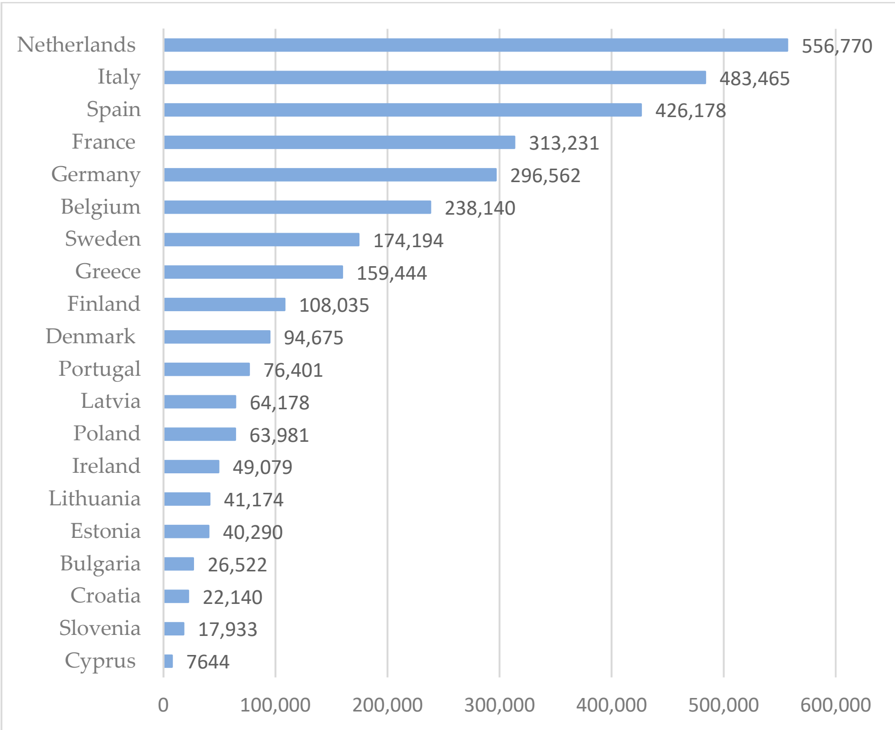

Figure 3. Gross weight of goods handled in all ports (tons, average annual value, 2007–2018). Source: Eurostat, authors' calculations.

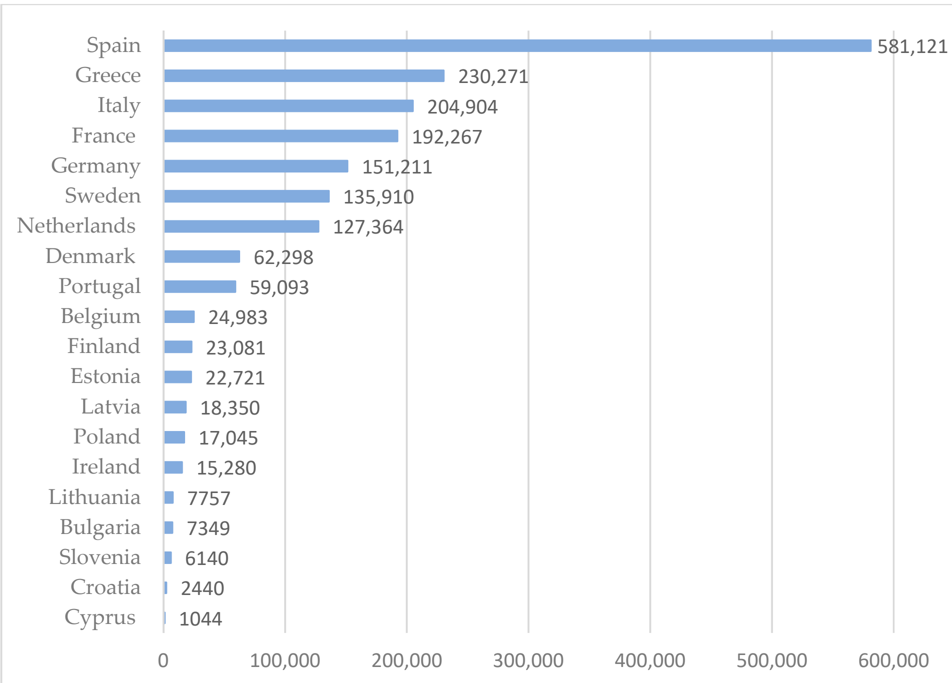

Figure 4. Emissions of NOx from maritime transport (average values). Source: Eurostat, authors' calculations.

Spain registers the highest level of NOx emissions from maritime transport in the EU, over two times larger than Greece, Italy, and France, which are the next greatest pollutants, according to Eurostat data (Figure 4).

Between 2007 and 2018, Spain reported the highest average value of investments in maritime transport of the EU member states, followed by Italy, Germany, and France (Figure 5). However, it is worth mentioning that the data for Cyprus, Latvia, Lithuania, and the Netherlands are not available.

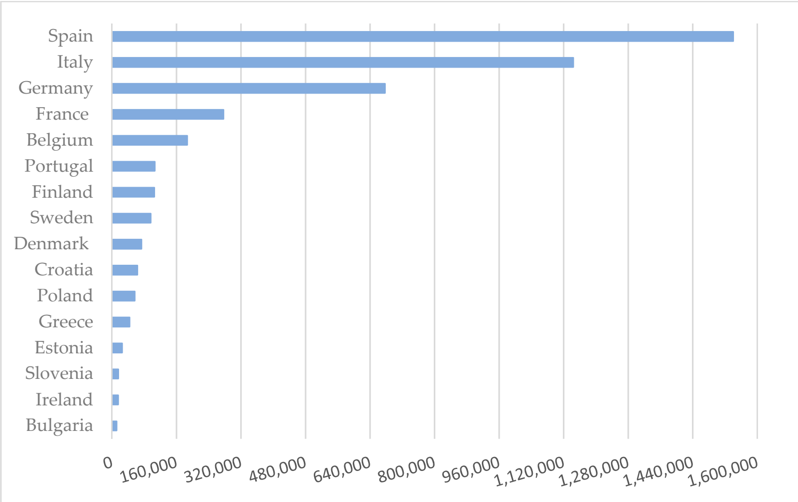

Figure 5. Investments in maritime port infrastructure (average values in thousands of euros). Source: Eurostat, authors' calculations.

Regarding the developing economies of the EU, they account for much lower intensity of maritime transport, which leads, of course, to much lower NO_x emissions from maritime transport. However, when computing the number of tons of NO_x per the number of tons of goods transported, Greece seems to be the most inefficient in terms of maritime pollution, followed by developed countries such as Spain, Sweden Portugal, and Denmark (Figure 6).

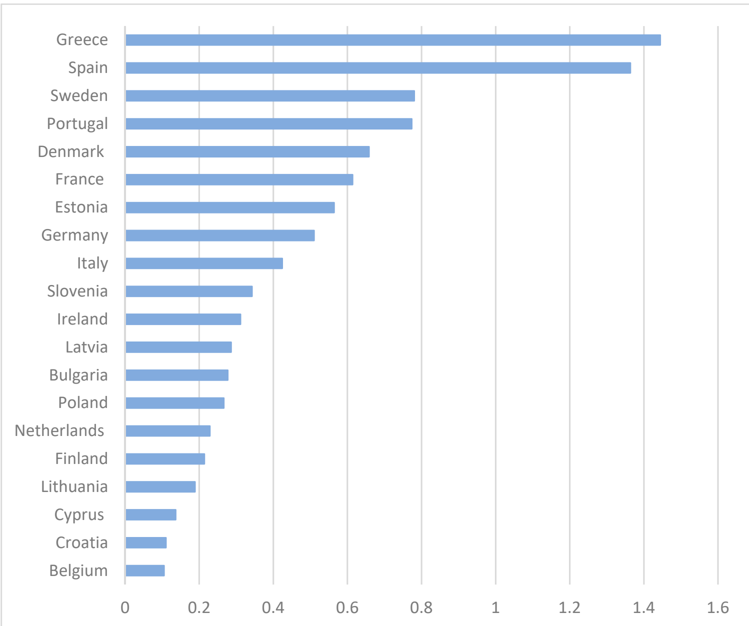

Figure 6. Environmental efficiency of maritime transport (number of tons of NOx per number of tons of goods transported). Source: Eurostat, authors' calculations.

Likewise, the investments in maritime port infrastructure are much lower in developing countries compared to the developed member states of the EU (Figure 5).

Table 2 shows the statistical indicators of the variables used in the panel regression models. The standard deviation shows greater variations in GDP per capita because there are significant differences in the development of selected EU member states. The "MT" variable records larger variations, indicating that there are large differences in the levels of the gross weight of goods handled in ports in the selected countries. Such a phenomenon was anticipated because some of the EU member states' geographical position is more favourable for maritime transport. The minimum value of the MT variable belongs to Cyprus in 2012, while the maximum value belongs to the Netherlands in 2018.

Table 2. Descriptive statistics of variables.

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
GDPpc	240	25,431.66	8054.66	9963.9	57,648.3
MT	240	163,002	164,618.22	6236	604,542
MI (in thousands of euros)	174	293,941	503,140	2714	2,670,698
NOx	240	94,531.28	135,582.29	571	657,054
SO_2	240	29,878.06	52,103.1	10	208,068
Services_trade	240	30.88	21.4	9.4	123.29
Unemployment	240	9.8	4.79	3.4	27.5
HICP	240	97	5.39	77.25	108.05
GINI	237	30.5	3.79	22.7	40.2
Gov_e	240	1.16	0.56	−0.05	2.35

The standard deviation shows greater variations with air pollutants from maritime transport and investment in maritime port infrastructure. This makes sense as air pollutants from maritime transport should be correlated with maritime transport. In the case of the "NOx" variable, the minimum value belongs to Cyprus in 2016, while the maximum value belongs to Spain in 2008. The minimum value of the SO_2 variable belongs to Croatia in 2015 and the maximum value belongs to Spain in 2007. Regarding investment in maritime port infrastructure ("MI" variable), Bulgaria registered the minimum value in 2013 and Spain registered the maximum value in 2008.

4. Panel Regression Models

In this paper, we investigated the effects of maritime transport, specific air pollutants, and related investments on economic growth in 20 EU countries. We ran 8 panel regression models during 2007–2018. We chose these countries as they are all the countries from EU-27 that practice maritime transport. We used the panel technique to increase the number of observations. In other words, by using the panel technique, the number of observations increased, so the problems related to data stationarity are diminished and several tools for mitigating the common problems of the models are available [47].

Within panel data analysis, the observations have two dimensions: a cross-sectional dimension and a time-series dimension. Consequently, panel data represent large samples, which make them appropriate for estimations and their analysis has several advantages [48]. First, the econometric estimates are more efficient—in particular, the parameters have a more accurate inference, as the panel data contain a larger number of degrees of freedom and larger sample variability. Second, the capacity of a panel data analysis to capture many phenomena and behaviours is greater than that provided by time series or cross-sections. Panel data analyses also have the advantage of ensuring accurate predictions regarding individual results by pooling the data and not by using the data on a certain individual. In addition, they represent an appropriate way for investigating homogeneity and heterogeneity, providing individual background for assessing aggregate data and phenomena. They also allow for simplifying the analysis, as the problem of data stationarity diminishes due to the central limit theorem for cross-sectional units, which argues for the asymptotical normality of the limiting distributions of the estimators [49]. In addition, panel data show flexibility in order to determine different and deductible variations of the estimators and allow for the observation of measurement errors. The main disadvantage of panel data is the variables being likely to be dependent on one another, and modelling this dependence might create different models.

We used the software EViews 11 in order to run the panel regression models.

Before performing an in-depth analysis, it was necessary to consider the characteristics of the time series underlying the empirical study. We checked for the stationarity of data using several tests: Levin, Lin, and Chu test (LLC), Breitung t-stat, Im, Pesaran and Shin W-stat (IPS), ADF—Fisher Chi-Square, and PP—Fisher Chi-Square. All these tests have as a null hypothesis the fact that the series contains a unit root. From an economic point of view, a series is stationary if a shock on the series is temporary, meaning it is absorbed in time. Stationary models are therefore based on the assumption that a process remains in equilibrium over time, around an average value. In order to select the optimal number of lags, the Schwarz (SIC) criterion was used.

The correlation between variables was verified before testing the models, using the correlation matrix. This shows all the correlations between pairs of variables and has the advantage of clearly summarising the main characteristics of a large dataset. Moreover, it can help identify certain patterns within the dataset.

Based on the results obtained, we considered the selected variables in 8 distinct regression models. In these conditions, we solved the issue of multicollinearity.

Before estimating the models, it was necessary to choose an optimal method of estimating the effects because the panel, although eliminating some problems, faces problems related to heterogeneity between data. These issues can be solved by the correct specification of the effects. For this purpose, the Redundant Fixed Effects Test Likelihood Ratio was used. The results obtained are that the estimation method is compatible with fixed effects models, but to solve ex ante heteroskedasticity and cross-sectional dependence, Period SUR should be applied as a weighting method. This method cannot be applied in the case of fixed effects models. That is why we had to make a trade-off and to choose the method with smaller problems. As a result, we chose to apply the panel least square method with no effects and with Period SUR (Seemingly Unrelated Regressions) as a weighting method. Even if we face a limitation of the models (the challenge of heterogeneity is not addressed), the problems would have been bigger in the case of applying fixed effects. Period SUR corrects for heteroskedasticity and general correlation of observations within a cross-section. The SUR method, which was first used by Arnold Zellner in 1962 [50], simplifies the general linear model, where some of the coefficients in the matrix are set to be zero or some of the regressors are different in each equation. Within the SUR model, equations are joint within a certain structure and this aggregation is also explained by the covariance matrix for the associated disturbances. Therefore, this aggregation leads to some additional information as compared to the information available with the individual equations.

In order to investigate the effect of maritime transport, specific air pollutants, and related investments on the economic growth, we employed the following panel regression models:

Model 1:

$$\mathrm{lnGDPpc}_t = a_1\,\mathrm{lnMT}_{t-2} + b_1\,\mathrm{Services\_trade}_t + b_2\,\mathrm{Unemployment}_{t-1} + b_3\,\mathrm{HICP}_{t-1} + b_4\,\mathrm{lnGINI}_{t-1} + b_5\,\mathrm{lnGov\_e}_t + c_0 + u_t$$

where

t = 2007, 2008 ... 2018
a_1 = coefficient of lnMT
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

Model 2:

$$lnGDPpc_t = a_2\ lnSO_{2t} + b_1\ Services\_trade_t + b_2\ Unemployment_{t-1} + b_3\ HICP_{t-1} + b_4\ lnGINI_{t-1} + b_5\ lnGov\_e_t + c_0 + u_t$$

where
t = 2007, 2008 ... 2018
a_2 = coefficient of ln SO_2
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

Model 3:

$$lnGDPpc_t = a_3\ lnNOx_t + b_1\ Services\_trade_t + b_2\ Unemployment_{t-1} + b_3\ HICP_{t-1} + b_4\ lnGINI_{t-1} + b_5\ lnGov\_e_t + c_0 + u_t$$

where
t = 2007, 2008 ... 2018
a_3 = coefficient of lnNOx
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

Model 4:

$$lnGDPpc_t = a_4\ lnMI_{t-2} + b_1\ Services\_trade_t + b_2\ Unemployment_{t-1} + b_3\ HICP_{t-1} + b_4\ lnGINI_{t-1} + b_5\ lnGov\_e_t + c_0 + u_t$$

where
t = 2007, 2008 ... 2018
a_4= coefficient of lnMI
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

Model 5:

$$lnGDPpc_t = a_1\ lnMT_{t-2} + a_2\ lnSO_{2t} + b_1\ Services\_trade_t + b_2\ Unemployment_{t-1} + b_3\ HICP_{t-1} + b_4\ lnGINI_{t-1} + b_5\ lnGov\_e_t + c_0 + u_t$$

where
t = 2007, 2008 ... 2018
a_1 = coefficient of lnMT
a_2 = coefficient of lnSO_2
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

Model 6:

$$lnGDPpc_t = a_2\ lnSO_{2t} + a_3\ lnNOx_{t-2} + b_1\ Services\_trade_t + b_2\ Unemployment_{t-1} + b_3\ HICP_{t-1} + b_4\ lnGINI_{t-1} + b_5\ lnGov\_e_t + c_0 + u_t$$

where
t = 2007, 2008 ... 2018
a_2 = coefficient of lnSO_2
a_3 = coefficient of lnNOx
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

Model 7:

$$lnGDPpc_t = a_2\ lnSO_{2,t-2} + a_4\ lnMI_t + b_1\ Services\_trade_t + b_2\ Unemployment_{t-1} + b_3\ HICP_{t-1} + b_4\ lnGINI_{t-1} + b_5\ lnGov\_e_t + c_0 + u_t$$

where

$t = 2007, 2008 \ldots 2018$
a_2 = coefficient of $\ln SO_2$
a_4= coefficient of lnMI
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

Model 8:

$$\ln GDPpc_t = a_3 \ln NOx_{t-2} + a_4 \ln MI_t + b_1\, Services\_trade_t + b_2\, Unemployment_{t-1} + b_3\, HICP_{t-1} + b_4 \ln GINI_{t-1} + b_5 \ln Gov\_e_t + c_0 + u_t$$

where

$t = 2007, 2008 \ldots 2018$
a_3 = coefficient of lnNOx
a_4= coefficient of lnMI
b_1, b_2, b_3, b_4, b_5 = coefficients of country-level control variables
c_0 = constant
u_t = error term

We applied logarithmic transformation in the models to ensure that the estimates coefficients are robust to the measurement units of the variables. It is a routine procedure not only in maritime economics literature, but also in the economics literature in general [18,27,28]. In order to estimate the coefficients from all 8 models, we applied the panel least square method with no effects and with Period SUR as a weighting method. A more detailed methodology can be seen in Baltagi [51].

After the estimation of the models' results, the following tests were performed in order to verify the maximum likelihood of the estimators:

- Model validity: Fischer test was used (probability < 5%).
- Significance of estimators: checking of their associated probability (probability < 5%).
- The existence of non-zero standard errors, but not much different from zero.
- Absence of residuals' autocorrelation: Durbin–Watson test has the advantage of being based on the estimated residuals, which are generally determined within the regression analysis [52]. The null hypothesis is considered valid or not according to the positioning of the value of the Durbin–Watson statistic within a certain interval determined by some limits that have been tabulated by the two authors.
- Normal residuals' distribution: Jarque–Bera test (probability >5%) is an asymptotic, or large-sample test, based on the OLS residuals [52]. The null hypothesis refers to the residuals being normally distributed, so, asymptotically, the JB statistic follows the chi-square distribution with 2 degrees of freedom. For the acceptance of the null hypothesis, the value of the computed statistic should be close to 0 and the p-value should be high.
- Absence of dependence between cross sections (probability >5%): Breusch Pagan LM and Pesaran scaled LM. The cross-sectional dependence may result from common shocks and some unobserved components that affect the error, the spatial dependence, and idiosyncratic pairwise dependence regarding the disturbances without a pattern of common components or special dependence [53]. The Breusch Pagan LM test is suitable for testing cross-sectional dependence in panels. Under the null hypothesis, the test statistic is asymptotically chi-square distributed with $n(n-1)/2$ degrees of freedom [54]. Given the fact that the Breusch Pagan LM test is not appropriate for large samples, the standardised version of the LM test was introduced [49]. We use both tests for assessing the existence of the dependence between cross-sections.
- Linearity of the model: R-squared (coefficient of determination).
- Absence of multicollinearity: correlation matrix.

5. Empirical Results and Discussions

In the first phase, we tested the stationarity of the data. Table 3 summarises the outcome of the panel unit root tests. As we can see, some of the variables are integrated at I(1) and some at I(0). In other words, a part of the variables was not stationary in level, but in the first difference.

Table 3. Panel unit root tests output.

Variable	Level—Individual Intercept and Trend				
	LLC	Breitung	IPS	ADF	PP
lnGDPpc	−19.1780 ***	2.32959	−8.55462 ***	106.955 ***	57.2319 *
lnMT	−14.3030 ***	0.16832	−5.63158 ***	101.536 ***	95.4038 ***
lnMI	−4.88361 ***	2.50397	−0.66579	38.9663	38.0995
lnNOx	−6.29546 ***	1.99138	−3.32316 ***	87.9797 ***	77.1056 ***
lnSO_2	−7.80266 ***	0.38992	−2.02398 **	66.4199 ***	36.9825
Services_trade	−14.5281 ***	−0.10619	−6.52585 ***	114.749 ***	87.5906 ***
Unemployment	−13.1816 ***	3.65470	−2.39590 ***	67.7357 ***	25.6041
HICP	−8.01232 ***	−2.38944 ***	−2.00334 **	62.6765 **	54.4576 *
lnGINI	−7.04141 ***	2.31291	−1.85141 **	75.9441 ***	81.4968 ***
lnGov_e	−5.62726 ***	−1.05582	−1.02065	50.4070	46.7934
Variable	**First Difference—Individual Intercept and Trend**				
	LLC	**Breitung**	**IPS**	**ADF**	**PP**
lnGDPpc	−28.2747 ***	−4.96016 ***	−11.1369 ***	209.571 ***	253.799 ***
lnMT	−22.1740 ***	−5.26555 ***	−7.64395 ***	158.476 ***	200.929 ***
lnMI	−8.09441 ***	0.36848	−1.20382 *	54.5193 ***	68.9395 ***
lnNOx	−13.2303 ***	−2.51307 ***	−4.94830 ***	122.873 ***	152.557 ***
lnSO_2	−12.5274 ***	−2.97424 ***	−4.55593 ***	112.065 ***	143.600 ***
Services_trade	−13.8096 ***	−5.15360 ***	−5.62210 ***	115.935 ***	140.172 ***
Unemployment	−11.8828 ***	−1.99291 **	−4.45867 ***	110.206 ***	144.391 ***
lnGINI	−15.5880 ***	−1.85241 **	−6.12254 ***	125.505 ***	177.835 ***
lnGov_e	−14.5148 ***	−3.48785 ***	−5.45307 ***	117.998 ***	206.494 ***

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Lag lengths are determined via Schwarz Info Criterion.

Then the correlation between variables was verified before testing the models. Table 4 shows the correlation coefficients of the variables.

Table 4. Correlation coefficients.

	lnGDPpc	lnMT	lnMI	lnNOx	lnSO_2	Services_trade	Unemployment	HICP	lnGINI	lnGov_e
lnGDPpc	1									
lnMT	0.5064	1								
lnMI	0.3664	0.8286	1							
lnNOx	0.3776	0.8780	0.6857	1						
lnSO_2	0.2263	0.7849	0.7191	0.8131	1					
Services_trade	0.3258	−0.3463	−0.4668	−0.3567	−0.3932	1				
Unemployment	−0.2862	0.1418	0.0501	0.2568	0.0711	−0.0381	1			
HICP	0.1681	0.0143	−0.1917	0.0199	−0.1606	0.1551	0.2599	1		
lnGINI	−0.5377	0.0825	0.0642	0.2352	−0.1147	0.4429	0.4429	0.0601	1	
lnGov_e	0.7649	0.2023	0.2271	0.1359	0.2327	−0.3142	−0.3142	−0.0502	−0.6314	1

A positive or a negative correlation that is greater than 0.8 serves as a threshold for a correlation presence [18,55]. The review of the correlation coefficients shows there are strong linear associations between several variables. In these conditions, we solved the issue of multicollinearity by considering the selected variables in distinct regression models.

The effects of maritime transport, specific air pollutants, and related investments on economic growth are presented in Table 5. The empirical results provide support for a positive influence of all variables (except for GINI and unemployment) on economic growth. In line with previous studies [8,9,18,32], the gross weight of goods handled in all ports has a positive impact on GDPpc. Moreover, in line with previous literature, investments in maritime port infrastructure have a positive effect on economic growth [8,27]. Similar to

Taghvaee et al. [32], air pollutants are positively correlated with GDPpc, confirming the Pollution Haven Hypothesis.

Table 5. Results of the panel regression models (1–4).

	Model 1	**Model 2**	**Model 3**	**Model 4**
	lnGDPpc	**lnGDPpc**	**lnGDPpc**	**lnGDPpc**
lnMT	0.1649 *** (0.0124)			
lnMI				0.0706 *** (0.0091)
lnNOx			0.0803 *** (0.0064)	
lnSO_2		0.0451 *** (0.0061)		
Services_trade	0.0062 *** (0.0004)	0.0045 *** (0.0008)	0.0054 *** (0.0005)	0.0068 *** (0.001)
Unemployment	−0.0086 *** (0.0010)	−0.0075 *** (0.0015)	−0.0112 *** (0.0012)	−0.0076 *** (0.0022)
HICP	0.0112 *** (0.0010)	0.0122 *** (0.0013)	0.01 *** (0.0009)	0.0169 *** (0.0021)
lnGINI	−0.4419 *** (0.0664)	−0.7185 *** (0.0955)	−0.5199 *** (0.0701)	−0.5269 *** (0.1379)
lnGov_e	0.1425 *** (0.0128)	0.1709 *** (0.0178)	0.1751 *** (0.0151)	0.1862 *** (0.0249)
Constant	8.5220 *** (0.2838)	10.9048 *** (0.3427)	10.0155 *** (0.2583)	8.8341 *** (0.5458)
R^2	0.8368	0.6999	0.7929	0.7024
Durbin–Watson	1.7861	1.7374	1.7567	1.7143
Jarque–Bera (*p*-value)	0.0646	0.7952	0.05	0.1412
Breusch Pagan LM (*p*-value)	0.7995	0.4873	0.9366	0.2202
Pesaran scaled LM (*p*-value)	0.3963	0.9980	0.1390	0.4513
Observations	198	216	216	153
Number of countries	20	20	20	17

Notes: *** $p < 0.01$. Standard errors are in parentheses.

The first model aims to establish the influence of the gross weight of goods handled in all ports on economic growth and living standards of the population. The results show that an increase of 10% of the gross weight of goods handled in all ports (lagged two years) is positively correlated with a 1.649% increase of the GDPpc, on average. This confirms that maritime transport positively influences economic growth and living standards. The obtained coefficient is statistically significant. This correlation might be explained by the fact that maritime transport fosters trade and also investment, two important components of gross domestic product. Moreover, by fostering trade and investment, it subsequently leads to higher employment in the related sectors, which has a positive influence on the living standard of the population. However, the channels through which maritime transport influences economic growth might be different from one country to another and our results show a general tendency for our cross-sectional sample. For instance, for some developing countries, importing capital goods could diminish the net export, but, on the other hand, this category of goods would foster investment, which will positively influence economic growth on the medium term.

The control variables in the model are statistically significant and have the expected positive or negative impact on economic growth. For instance, we found that services trade openness encourages economic growth, although the influence is rather small: if services trade openness increases by 10 percentage points, the GDPpc will increase by 0.062%, on average. The influence could be more intense in some of the developed countries where high tech services with large value added are an important part of the economy. As expected, unemployment and economic growth are negatively correlated: when unemployment (lagged one year) increases by 10 percentage points, the GDPpc will decrease by 0.086%, on average, as fewer workers would produce less. Likewise, the GINI coefficient has a negative influence on economic growth: when the GINI coefficient (lagged one year) increases by 10%, the GDPpc decreases by 4.419%, on average, which means that rising inequalities hamper economic growth. Most often, rising inequalities undermine education opportunities for children and also create a vicious poverty cycle which in turn affects economic growth. On the other hand, we found that government effectiveness positively affects the GDPpc (an increase of 10% in the government effectiveness is associated with an increase of 1.4% of the GDPpc, on average). It is clear that the more effective the government is, the more support it offers for the population and business environment, which in turn positively affects economic growth. Finally, regarding the influence of the HICP on the GDPpc, the positive correlation is normal, as the higher the prices, the higher the GDP.

The influence of specific air pollutants from maritime transport on economic growth can be seen in the second and third models. The results of the research show that air pollutants are positively correlated with economic growth. The estimated coefficients are 0.0415 with SO_2 and 0.0803 with NOx and are statistically significant. The results show that when emissions of SO_2 from maritime transport increase by 10%, the GDPpc increases by 0.415%, on average (in the case of second model), and when emissions of NOx from maritime transport increase by 10%, the GDPpc increases by 0.803%, on average (in the case of the third model). These results are in line with the positive correlation we found between maritime transport and economic growth: alongside with the intensification of maritime transport, the pollution would rise, but economic growth would also be fostered. Therefore, the green transition goals that are at present of great interest for the EU countries are expected to determine, over the long run, the achievement of economic growth alongside declining pollution.

Model 4 assesses the impact of investments in maritime port infrastructure. According to our research, investments in maritime port infrastructure should encourage economic growth. Therefore, the estimated coefficient is 0.0706 and is statistically significant, which indicates that when investments in maritime transport (lagged two years) increase by 10%, the GDPpc increases, on average, by 0.706%. Investments in maritime transport influence both present and future economic growth. Moreover, they determine the intensification of port activities, which in turn favours maritime transport, which has already been proven to have a positive influence on economic growth and the living standards of the population. As in the first model, all the control variables are statistically significant and have the expected positive or negative impact in the other three models.

Tests for the absence of residuals' autocorrelation, normal residuals' distribution, and the absence of dependence between cross-sections are shown in the previous table. According to the Durbin–Watson test from all the four models, the errors are not autocorrelated. In addition, the residuals are normally distributed, according to the Jarque–Bera test. A *p*-value greater than 0.05 confirms the null hypothesis of the test, which claims that the residuals are normally distributed. Breusch Pagan LM and Pesaran scaled LM reveal there is no dependence between cross-sections in none of the four models. Their *p*-value greater than 0.05 confirms the null hypothesis of the tests, which claims the absence of dependence between cross-sections.

Because maritime transport, specific air pollutants, and related investments have a cumulated effect on economic growth, we combine all these factors to see a more aggregated impact. Due to the issue of multicollinearity, we cannot include all these variables in one single model. That is why we propose another four panel regression models. The results are similar to those obtained in the previous models (although, of course, the values of the obtained coefficients are different) and are presented in Table 6.

Table 6. Results of the panel regression models (5–8).

	Model 5	**Model 6**	**Model 7**	**Model 8**
	lnGDPpc	**lnGDPpc**	**lnGDPpc**	**lnGDPpc**
lnMT	0.1591 *** (0.0139)			
lnMI			0.0491 *** (0.0077)	0.0431 *** (0.0056)
lnNOx		0.0826 *** (0.0079)		0.0911 *** (0.0061)
$lnSO_2$	0.0051 (0.0043)	0.0126 *** (0.0045)	0.0418 *** (0.0064)	
Services_trade	0.0065 *** (0.0005)	0.0066 *** (0.0006)	0.0069 *** (0.0003)	0.0073 *** (0.0002)
Unemployment	−0.0086 *** (0.0011)	−0.0113 *** (0.0013)	−0.0064 *** (0.0018)	−0.0125 *** (0.0013)
HICP	0.0116 *** (0.0011)	0.0128 *** (0.0013)	0.0185 *** (0.0017)	0.0164 *** (0.0015)
lnGINI	−0.4952 *** (0.0722)	−0.6551 *** (0.0902)	−0.7486 *** (0.1089)	−0.7961 *** (0.0945)
lnGov_e	0.1341 *** (0.0133)	0.1328 *** 0.0144	0.1565 *** (0.0181)	0.1184 *** (0.0146)
Constant	8.6784 *** (0.3)	10.038 *** (0.3466)	9.4705 *** (0.4281)	9.3876 *** (0.388)
R^2	0.8391	0.7936	0.8041	0.8981
Durbin–Watson	1.8038	1.7625	1.8176	1.9481
Jarque–Bera (*p*-value)	0.056	0.1499	0.7179	0.8153
Breusch Pagan LM (*p*-value)	0.3943	0.9377	0.4587	0.8867
Pesaran scaled LM (*p*-value)	0.8135	0.1370	0.9515	0.2356
Observations	198	198	138	138
Number of countries	20	20	16	16

Notes: *** $p < 0.01$. Standard errors in parentheses.

The impact of the gross weight of goods handled in all ports and the one of the SO_2 emissions from maritime transport on economic growth are examined by the fifth model. We found that when maritime transport (lagged two years) increases by 10%, the GDPpc increases, on average, by 1.591%. This positive influence is confirmed also by Lane and Pretes [6], who found a significant relationship between maritime dependency and gross domestic product per capita. Other authors obtained similar results as ours, using other methodologies. For example, Saidi et al. [10] used a generalised method of moments in some African countries, Özer et al. [12] used the Autoregressive Distributed

Lag based bounds testing approach in Turkey, and Park and Seo [14] used the Solow model in South Korea. In the case of emissions of SO_2 from maritime transport, the estimated coefficient is much lower (0.0051), showing a weaker but positive influence. The control variables in the model are statistically significant and have the expected positive or negative impact on economic growth. For example, government effectiveness should encourage economic growth and we have the confirmation in the results. We found that this indicator is statistically significant at 1% and the results should be interpreted as follows: if government effectiveness increases by 10%, the GDPpc will increase by 1.341%, on average. The influence channels and connections are the same as explained for the previous models.

The impact of specific air pollutants from maritime transport on economic growth can be seen in model 6. As in the previous models, the results of the research show that air pollutants are positively correlated with economic growth. These correlations confirm the fact that a higher intensity of maritime transport produces higher pollution, but also leads to GDP growth, which in turn will determine better living standards. The estimated coefficients are 0.0126 in the case of SO_2 and 0.0826 in the case of NOx and are statistically significant. The results should be interpreted as follows: if emissions of SO_2 oxides from maritime transport increases by 10%, the GDPpc will increase by 0.126%, on average, and if emissions of NOx oxides from maritime transport (lagged two years) increases by 10%, the GDPpc will increase by 0.826%, on average. On the other hand, as maritime transport might increase its contributions to the impact on the environment in future years [34], efforts should be made to reduce emissions from maritime transport, even if it is the most energy-efficient form of transportation [33].

Services trade openness, HICP, and government effectiveness encourage economic growth with the estimated coefficients 0.0066, 0.0128, and 0.1328, respectively. At the same time, unemployment and the GINI coefficient negatively affect economic growth, with statistical significance at 1%. These results are in line with the literature, as fewer workers produce less, and rising inequalities produces a vicious poverty cycle that hampers economic growth.

Model 7 reveals the impact of investments in maritime port infrastructure and emissions of SO_2 oxides from maritime transport. The estimated coefficients are statistically significant at 1%, indicating that if investments in maritime port infrastructure increase by 10%, the GDPpc increases by 0.491%, on average, and if emissions of SO_2 oxides from maritime transport (lagged two years) increase by 10%, the GDPpc increases by 0.418%, on average. The control variables in the model are statistically significant and have the expected positive or negative impact on economic growth. Our results are in line with the literature, as the effect of investments in maritime port infrastructure on the living standards is positive [8,27], even if some authors used regional data in different countries [27–30].

From our point of view, investments in maritime port infrastructure foster port facilities, which determine better handling capacities and have a positive impact on the volume of the goods that can be handled in ports. This also might require the employment of additional labour force, thus resulting in lower unemployment. On the other hand, in the absence of strong measures for green transition, the higher the intensity of maritime transport, the higher the related pollution.

The impact of investments in maritime port infrastructure and emissions of NOx oxides from maritime transport on economic growth is examined in the last model. The results of the research show that both factors have a positive effect on GDPpc. The estimated coefficients are 0.0431 with investments in maritime port infrastructure and 0.0911 with NOx and are statistically significant. The results show that when investments in maritime port infrastructure increase by 10%, the GDPpc increases by 0.431%, on average, and if emissions of NOx oxides from maritime transport (lagged two years) increase by 10%, the GDPpc increases by 0.911%, on average. Unemployment and the GINI coefficient are found to negatively affect the economic growth, with statistical significance at 1%; therefore, if unemployment (lagged one year) increases by 10 percentage points, the GDPpc will decrease by 0.125%, on average. If the GINI coefficient (lagged one year) increases by 10%, the GDPpc will decrease by 7.961%, on average. Government effectiveness and HICP are found to positively affect the GDPpc, their estimated coefficients being 0.1184 and 0.0164.

Tests for the absence of residuals' autocorrelation, normal residuals' distribution, and the absence of dependence between cross-sections are shown in Table 6. According to the Durbin–Watson test from all four models, the errors are not autocorrelated. Moreover, the residuals are normally distributed, according to the Jarque–Bera test. A p-value greater than 0.05 confirms the null hypothesis of the test, which claims that the residuals are normally distributed. Breusch Pagan LM and Pesaran scaled LM reveal that there is no dependence between cross-sections in all four models. Their p-value is greater than 0.05 and confirms the null hypothesis of the tests, which claims the absence of dependence between cross-sections.

All in all, regardless of the used models, the results obtained lead us to the conclusion that maritime transport fosters economic growth and the improvement of the living standards of the population through various channels. First, maritime transport contributes to trade development, as it encourages the mobility of goods. Therefore, it leads to better allocation of resources across countries and subsequently to higher production of consumer goods. Second, especially in but not limited to developing countries, maritime transport plays an important role in the imports of capital goods, which foster investment and technological development, leading to a higher economic efficiency and larger volume of production. Moreover, the intensified economic activities determined by larger production and investments (including in maritime ports infrastructure) would require higher employment, which would generally contribute to better living standards, alongside economic growth. However, the intensity of these influences might be different from one country to another, depending on country-specific factors.

Our results also show a positive correlation between pollution resulting from maritime transport and economic growth. Higher pollution is the result of intensified maritime transport, which was proven to have a positive influence on economic growth. As stated before, diminishing pollution from maritime transport by fostering the transition to green transportation facilities would be optimal and is expected to take place over the long term, in the context of the current concerns in this direction at the EU level.

6. Conclusions

The blue economy is a very important part of the European economy, providing many resources and services, and maritime transport and its related activities account for around 40% of this sector. In the current context of economic and technological development, transport systems are expected to become more efficient, safe, and sustainable [56].

Maritime transport is a very important way of transport, supporting global trade, the global value chains, resource allocation, and overall economic growth and development. It affects a wide range of industries, both directly and indirectly, and it is considered to have a lower impact on the environment compared to other ways of transport, such as road transportation.

Under these circumstances, in this paper, we examine the impact of maritime transport, related investment, and pollution (SO_2 and NOx) on economic growth within 20 countries of the European Union, through panel data regression models during 2007–2018. The empirical results provide support for a positive influence of all variables (except for the control variables GINI and unemployment) on economic growth. In line with previous studies [8,9,18,32], we obtained that the gross weight of goods handled in all ports has positive impact on GDPpc. Even if we used a different methodology and different countries—like Saidi et al. [10], who used generalised method of moments in some African countries, or Özer et al. [12], who used the Autoregressive Distributed Lag based bounds testing approach in Turkey, or Park and Seo [14], who used the Solow model in South Korea—we found, like these studies, a positive influence of maritime transport on economic growth.

As Taghvaee et al. [32] concluded, air pollutants are positively correlated with GDPpc, confirming the Pollution Haven Hypothesis. It would be interesting to see how the correlation will move in the future after we obtain new available data due to the fact that starting with January 2020, a standard of 0.5% sulphur rate is now imposed instead of the previous3.5% rate (MARPOL Annex VI) [13]. Plus, as of 2021, the emissions of NOx will be limited in the Baltic Sea by up to 80% [57]. Likewise, also in line with previous literature, investments in maritime port infrastructure have a positive effect on economic growth [8,32], even if some authors used regional data in different countries [27–30].

More specifically, the results of our empirical analysis show that an increase by 10% in maritime transport will generate an increase of around 1.6% in GDPpc; an increase by 10% in emissions of SO_2 from maritime transport generates an increase of around 0.4% in GDPpc; an increase by 10% in NOx emissions from maritime transport generates an increase of around 0.8% of GDPpc; and an increase by 10% in investments in maritime port infrastructure generates an increase of around 0.7% in GDPpc.

Our results are important as they offer a clear numerical influence of maritime transport, maritime air pollution, and maritime investments on economic growth, which could help when assessing the macroeconomic effects of different phenomena or regulations regarding maritime transport on economic growth. Our research could be interesting for policymakers to see where the EU stands during the transition to a green economy and could be a helpful tool when deciding what kind of policies they would need to adopt (a more restrictive or expansionary policy) to reach the final target.

As we stated before, maritime transport is an important part of the European economy, influencing a wide range of industries and activities and employing many people. Therefore, we considered it important to assess the macroeconomic influence of maritime transport.

The main limitation of our research regarded data availability. For instance, the latest data for maritime transport was from 2018, which constrained us from capturing more recent trends and influences. In addition, the data series for Romania and Malta, two member states that practice maritime transport, were largely filled with gaps, so we considered it better to exclude them from the analysis.

In addition, we faced a limitation regarding the models, as the challenge of heterogeneity is not addressed. We chose this alternative, as we had to solve ex ante heteroskedasticity and cross-sectional dependence, which we consider would have generated higher problems.

Despite an aggregated positive correlation between pollution from maritime transport and economic growth (that we obtained in our results), there are probably countries in the panel that have lower emissions of NOx and SO_2 from maritime transport combined with GDPpc increases. This negative link may occur in countries with a large and clean industry sector, in which high labour productivity supports complex techniques [58]. Therefore, future research could use country-level data in order to analyse country specificities and provide useful insights on how to accommodate higher economic growth with a decrease in pollution, possibly complementing policies that are already in practice or supported by the existing literature (for example, the adoption of more environmentally-friendly policies, the internalisation of externalities, or the adoption of regulations against pollution-havens).

All in all, in the context of the current high concerns and determinations regarding the transition to a green economy, there is scope for improving technologies used in port infrastructure and shipbuilding in order to reduce the impact on the environment. Even if port authorities have undertaken considerable efforts by adopting appropriate policy frameworks and investing in new technologies, there is still a long road ahead [59]. This would impose great investments and could be an important factor of future sustainable growth and development, both in the EU and around the world. However, given the large costs involved in such investments, financing could be a great challenge, as they involve the allocation of large amounts of financial resources in the short run, while the benefits would materialise over the long run. Nevertheless, owing to the pandemic and the concerns for recovery and resilience within the EU, member states have the possibility of accessing unprecedented financial resources to implement a wide range of reforms and investments, and the green transition is one of the main purposes of these programs, alongside the digitalisation of the economy.

In this context, and given the overall findings of our research, our view is that a green transition within the maritime transport and its related activities within the EU should be supported by financing and reform incentives rather than by imposing levies, as they would have a negative impact on aggregate supply and prices, with a subsequent poor influence on economic and social development.

Author Contributions: Conceptualisation, A.F. and I.A.G.; methodology, I.A.G. and A.F.; software, A.F.; validation, A.F., I.A.G., S.C.N. and A.H.; formal analysis, A.F. and I.A.G.; investigation, A.F. and I.A.G.; resources, S.C.N. and A.H.; data curation, A.F. and I.A.G.; writing—original draft preparation, A.F. and I.A.G.; writing—review and editing, A.F., I.A.G., S.C.N. and A.H.; visualisation, A.H. and S.C.N.; supervision, A.F. and I.A.G.; project administration, S.C.N. and A.H.; funding acquisition, A.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data can be found on Eurostat, the World Bank database, and the OECD database, for free.

Conflicts of Interest: The authors declare no conflict of interest.

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