“Sustainability issues in maritime transport and main challenges of the shipping industry”

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SUSTAINABILITY ISSUES IN MARITIME TRANSPORT AND MAIN CHALLENGES OF THE SHIPPING INDUSTRY

Abstract

Considering the rapid development of oceanic logistics, the maritime traffic is one of the worst offenders for air and water pollution. This paper primarily aims to explore the key concepts and terms applied to denote the sustainability issues in maritime transport and main challenges for the shipping industry. The present study investigates the existing sustainability frameworks on the relationship between sustainability and maritime industry. Also the author proposes to use modelling approaches to measure the relationship between oil prices, exchange rate, services export and ocean transport value added. The empirical findings indicate that growth rate of the crude oil prices has negative impact on ocean transport value added growth, and it can be traced that the oil industry has a strong influence on value creation in maritime clusters and their competitiveness, especially on the shipping sector. The analysis also sheds light on the impacts of relationship between environmental pollution and maritime cluster activity (through the validation of the EKC hypothesis in Norway). The current paper reveals that there is an inverted U-shaped relationship between economic growth and CO2 emissions. The empirical evidences show that the links between CO2 emissions and ocean transport value added are more significant than with energy consumption indicator. It can be assumed that, due to the energy efficiency policy and technological leadership in the shipping industry, the environmental impact of energy use (renewable energy) has improved.

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INTRODUCTION

The maritime cluster in Norway has an advanced position in the oceanic world, moreover, it is the second largest export industry after the oil industry in the country. There is no other such developed and complete maritime cluster as the Norwegian. Here the industry employs almost 100,000 women and men and generates the value of almost 15 billion euros per year.

In a global context, the Norwegian model is completely unique, in the way that competitors, customers and suppliers work closely, and thereby constantly creates the basis for new technologies and powerful innovations. Today, the maritime cluster is probably the most knowledge-intensive and innovative sector of the country, and broadly speaking it accounts for about ten percent of the total value created in the Norwegian economy.

Nevertheless, in recent years Norwegian shipping industry has faced some increasingly growing problems. There three main branches of the Norwegian maritime sector:

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1) petroleum industry (oil companies, businesses supplying goods to customers, and services for the upstream oil and gas industry);

2) maritime industry (shipyards, shipbuilding, businesses supplying equipment, and maritime design and service providers);

3) seafood industry (fishing, aquaculture and subsequent processing sector).

Tight linkages and close industrial relations have provoked the following situation: a sharp drop in oil prices from 2014 to 2016 led to a decline in the oil industry, and as a result led to a decline in investment in the production of marine equipment and shipbuilding.

Moreover, over the past 30 years, there has been paid great attention to the impact of the maritime industry on environmental degradation, which has attracted significant attention both from the scholarly world and international organizations. Norway's active participation in the implementation of the principles of sustainable development creates the conditions for preventing future crises. For example, in 2016 there was developed a strategy called "Maritime Opportunities – Blue Growth and for Green Future". The main aim is to boost the competitiveness of Norwegian companies within this sustainability directions plan.

Despite efforts to reduce the negative impact of maritime industry, degradation of the oceanic environment continues to grow. In order to determine the most feasible solution, this simultaneously requires the mobilization of academic communities, the industry, business communities and the financial sector, as well as the support of governmental initiatives.

Therefore, this study focuses on sustainability issues within maritime transport as a main challenges of the shipping industry.

The present study is structured as follows: a literature review on the relationship between sustainability and maritime industry is presented in section 1. Section 2 investigates the main challenges of the maritime industry in Norway. Section 3 explains data and methodology, proposes modelling approaches to measure the relationship between oil prices, exchange rate, services export and ocean transport value added, and explains the link between environmental pollution and maritime cluster activity. The results of the proposed models are provided in section 4. Section 5 gives an extended discussion of findings. Finally, this study ends with conclusions and future research directions in final section.

4. LITERATURE REVIEW

The link between sustainability and maritime economic growth, and related challenges has been widely discussed in the literature.

For instance, sustainability issues in the maritime industry have become an important component of maritime logistics and supply chain management.

In their study Lee et al. (2019) state that among three pillars of the sustainability, the social element is getting to be the main point of policy focus, since all ports areas have been influenced by ships' emissions, which cause lung cancer and heart-related illnesses.

Generally speaking, air pollution challenges related to maritime emissions have been discussed as on the global (Jalkanen et al., 2012), as on local levels (Zis et al., 2014).

In the existing literature, Cheng et al. (2013) consider the sustainability changes in terms of ports, supply chain and shipping. Maragkogianni and Papaefthimiou (2015) argue that the port activity should get a special attention, as the technical use in harbor logistics services includes huge amounts of emissions into the air. According to the existing study of Lee et al. (2019), the cruise sector is more to blame for the atmosphere pollution rather than cargo shipping: all major harbor cities, which are characterized by rapid growth of cruise industry (e.g., Singapore, Shanghai, etc.), have highly polluted air. Li et al. (2018) state that the congested container transport network can have a negative influence on ports, environment and people in those areas.

In this regard, the Nature and Biodiversity Conservation Union (NABU) calculated the amount of emissions into the atmosphere caused by the cruise industry in main ports of Germany. The conclusion derived from this study as follows: "fuel oil can contain 3,500 times more sulphur than diesel that is used by road vehicles" (Fung et al., 2014). Findings from Nicolae et al. (2014) also contributed to this line of research – for assessing of the impact on environment in port administration politics, they proposed to consider a computing algorithm on the basis of some ships' parameters: tonnage, propelling systems, engine type, etc.

Li et al. (2018) point out that air pollution in the maritime cluster is a result of fossil fuel combustion by ships and oil-consuming equipment as well. On the other hand, there is also the second (indirect) source of $CO2$ and other GHG emissions as many different types of equipment use electricity converted from coal as power.

There is a bulk of literature on the investigation of measures needed to reduce emissions from all types of vessels. These incorporate greening of ports (Li et al., 2018), zero carbon shipping (Urban et al., 2018), utilization of alternative maritime fuel, such as LNG (Wu et al., 2018), setting standards and laws of green shipping (Shi et al., 2017), and penalties for non-compliance in the shipping sector (Lähteenmäki-Uutela et al., 2019).

Hence, the maritime industry, including ports, shipping and logistics, is faced with different types of regulations and rules to protect environment and reduce the impact of GHG emissions (Shin et al., 2018). Moreover, researchers all over the world started their mutual collaboration to give effective recommendations on setting standards and laws of green shipping (Shi et al., 2017). Also, it has been taken into consideration that measures, which should be implemented to reduce emissions of all ships, firstly should be located in the port areas. Nicolae et al. (2017) argue that "naval/port authorities should promote administrative measures to facilitate monitoring of ship emissions and identification of substandard, highly polluting ships".

Another illustration of the present issue is shown in a study of Urban et al. (2018). They argue about the importance of the innovations in shipping of two main shipping nations, such as Greece and Norway. According to their study, the source of all positive and negative changes should be considered on different levels such as macro level (international), mezzo level (national), and micro level (firms).

Despite that in a literature review the issue of sustainability and maritime economic growth is widely discussed, there are limited studies on the use of various concepts and models to measure the relationship between environmental pollution and maritime cluster activity.

1. TREND ANALYSIS OF THE NORWEGIAN MARITIME INDUSTRY

Norway is one of nations which has a complete maritime cluster, and in time of shipbuilding slump in the European area, the cluster is still going strong. The maritime sector is deeply connected with lots of substantial related industries, which are also presented in Norway, e.g., the offshore industry, and fishing and aquaculture. It should be noted that Norway holds several well-known global maritime knowledge hubs: Møre has been a pioneer in marine research and innovation (The Norwegian Shipping Industry, 2019), also, the biggest well-known banks and ship insurance companies are placed in Norway.

In 2018 the Norwegian fleet was ranked as number five in the list of world ship owning nations. Japan, Greece and China are the three largest nations by far and the USA is on fourth place.

If to separate the cargo carrying element, the Norwegian fleet value has strengthened with 21 percent from 2017 to 2018. Forecasts moreover estimate further growth. This demonstrates that the situation in these segments is not at all bad.

It is worth mentioning that the Norwegian maritime fleet has different classifications: a) cargo

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ships (or freighter ships) and non-cargo ships; b) merchant vessels or trading vessels (that transport cargo or carries passengers for hire), pleasure craft ships (used for personal recreation) and naval ships; c) ships flying under the Norwegian flag (can be registered in the Norwegian Ordinary Ship Register (NOR) or in the Norwegian International Ship Register (NIS)) and Norwegian-controlled ships sailing under a foreign flag.

Also, the Norwegian fleet can be divided into three main categories (Table 1):

1) the deep sea fleet (car carriers, tankers, dry bulk, LNG, chemical, container and general cargo ships, etc.). There are more than 600 ships under the control by Norwegian Shipowners' Association (NSA);

2) the short sea segments. It plays a key role in transportation of all types of freight and passengers along the coast of the country and from European ports. There are approximately 130 short sea ships under the control by members of NSA;

3) the maritime offshore vessels. Members of NSA control 593 vessels and 55 mobile offshore units (drilling rigs, etc.).

Table 1. Norwegian-controlled foreign-going fleet composition as of January 1, 2019, by number of ships

Source: Norwegian Shipowners' Association (2019).

Category	NOR	NIS	Foreign flags	Total number of ships
Offshore service	159	190	244	593
Other dry cargo vessels	9	131	411	551
Chemical tankers	1	109	129	239
Gas tankers	0	49	64	113
Bulk carriers	0	67	40	107
Other oil tankers	0	43	35	78
Shuttle/storage tankers	2	10	57	69
Passenger vessels/ ferries	6	8	10	24
Combined carriers	0	5	8	13
Total	177	612	998	1,787

Source: Compiled by author.

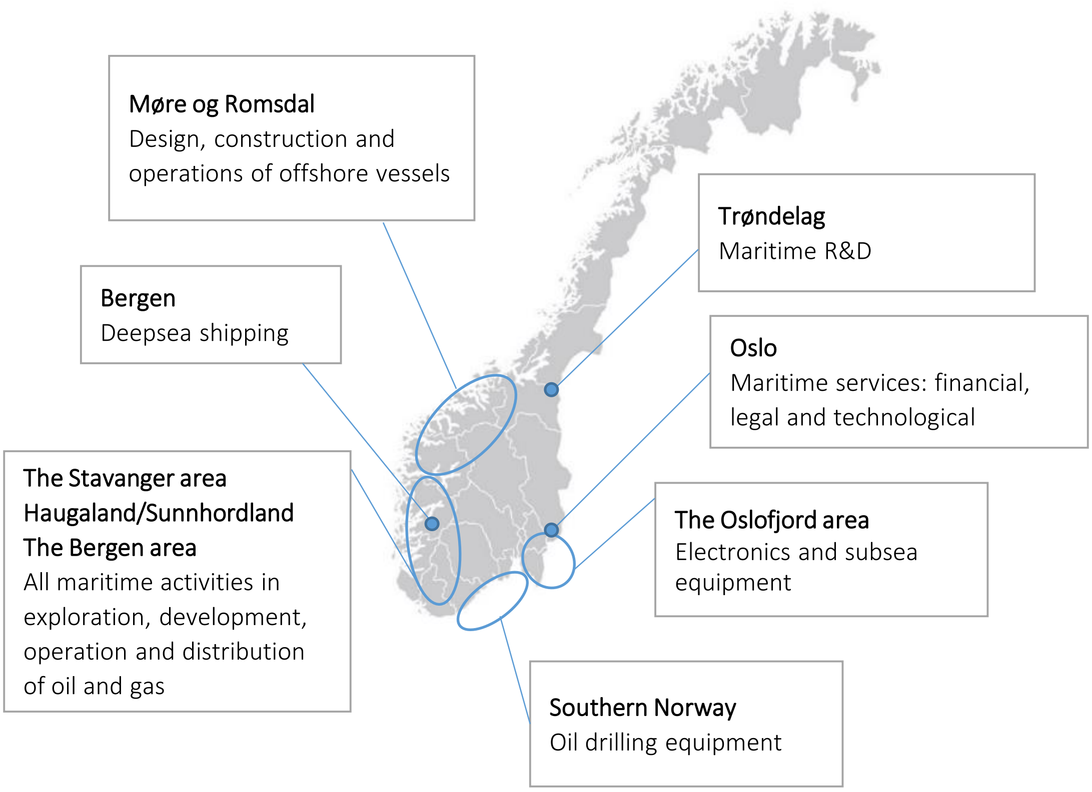

Figure 1. Geographical distribution of the most important maritime regions in Norway

In general, the maritime cluster in Norway can be divided into eight regions (Norwegian Shipowners' Association, 2018):

1) the Oslofjord area;
2) Southern Norway;
3) the Stavanger area – Rogaland south of Boknafjord;
4) Haugaland/Sunnhordland;
5) the Bergen area;
6) Møre og Romsdal;
7) Trøndelag;
8) Northern Norway.

Møre og Romsdal remains the most important area in Norway for shipbuilding activities (Figure 1). Nevertheless, in recent years, the demand for new vessels has declined and the market is still characterized by oversupply.

From June to December 2014, the price of crude oil fell from over USD 110 to USD 50 per barrel, which sent shock-waves through the Norwegian economy (Figure 2). Due to its strong dependency on the oil and gas industry, the Blue Maritime cluster at Møre og Romsdal (Ålesund region) was severely hit by a following downturn in activity. The value added has declined since the peak in 2014 and continued along the same downward-pointing trajectory in 2017 (Norsk Industri/Menon, 2018).

In the shipping industry valued added continued to fall in 2017. The rest of the cluster (yards, equipment and services) managed to stay stable or even increase their value added.

The decline in the shipping sector had a strong effect on the dynamics within the cluster. Its share of the total value added shrank by ten percent in 2017 compared to previous year. However, shipping is still the largest segment in the cluster (Norsk Industri/Menon, 2018).

Meanwhile, the role of other segments is becoming significantly important for the cluster. In 2017 two segments have experienced growth – equipment producers and services (the value added of equipment producers increased by 18 percent and services by 4 percent).

Nevertheless, the ratio of export in sea and coastal water transport services to total export in services have increased during the period (Figure 3). Moreover, in 2018 it reached the point of 41 percent, that proves the statement about the importance of the shipping sector in Norway.

For the cluster combined, the oil and gas market constitutes 35 percent of the aggregated market. For the shipping companies, the proportion is still high, 81 percent (Figure 4), but for the yards, equipment manufacturers, design companies and other services the proportion is 30 percent or lower (Norsk Industri/Menon, 2018).

Yacht and cruise industry remains the second largest market element. Fishery and aquaculture are significantly important for the maritime cluster as well, at the same time, the growth is still smaller than for the passenger segment (Norsk Industri/Menon, 2018).

Source: The World Bank (2019), SSB (2019).

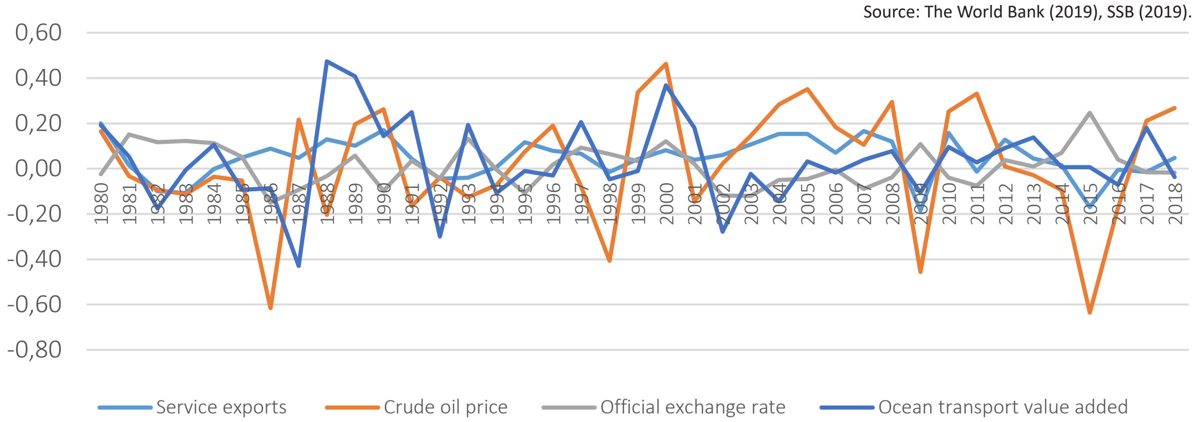

Figure 2. Development in crude oil prices, services export, official exchange rate NOK to USD and ocean transport value added in Norway during the period 1980–2018

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Source: The World Bank (2019), SSB (2019).

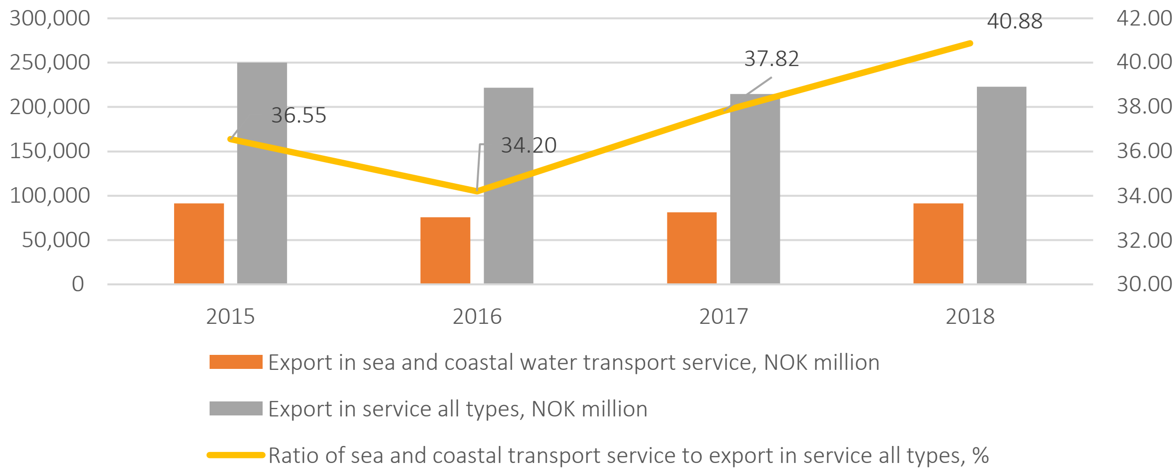

Figure 3. The dynamics of export in sea and coastal water transport services and share of it in total export in services in Norway, 2015–2018

Source: Norsk Industri/Menon (2018).

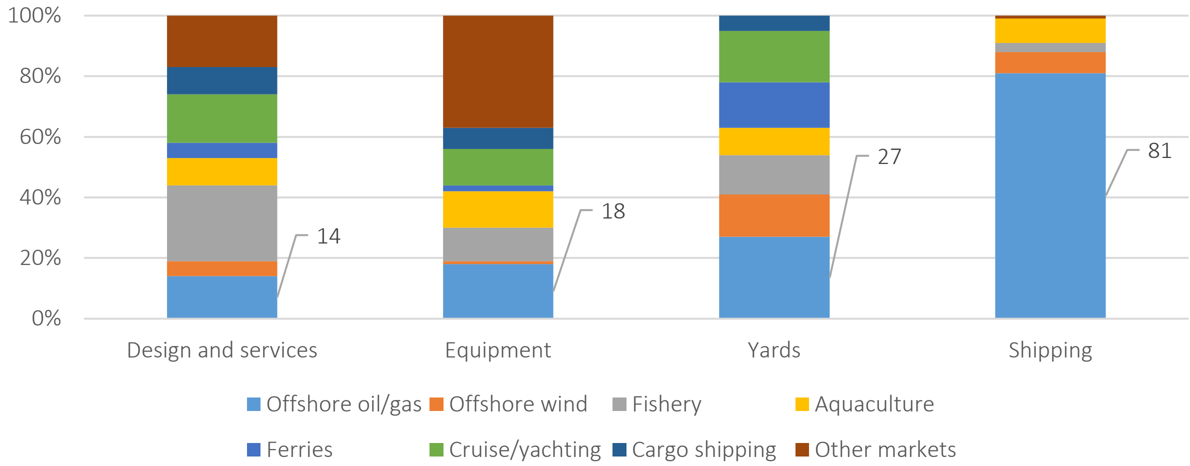

Figure 4. The cluster's turnover broken down on the four segments and split by markets

To conclude, this study will contribute to the existing literature in two ways. Firstly, this paper will examine the impact of oil prices, exchange rates, and service exports on ocean transport value added. Secondly, the study will check the hypothesis about the existence of EKC in Norway.

2. MATERIALS AND METHODS

In order to determine the links between oil prices, exchange rates, service exports and ocean transport value added, as a measure of activity in the shipping sector, this study employs annual time series from 1980 to 2018. The data are collected from the World Bank database (The World Bank, 2019) and Statistics Norway (SSB, 2019).

In this study, the author uses non-linear regression to estimate relationships between variables. The general model is presented as the following:

$$\log VA\_ocean\_transport = \beta_0 + \\ +\beta_1 \log Oil\_price + \beta_2 \log Exch\_rate + \\ +\beta_3 \log Exp\_service + \varepsilon_t, \quad (1)$$

where $\log VA\_ocean\_transport$ is the logarithm of the growth rate of ocean transport value added, $\log Oil\_price$ is the logarithm of the growth rate of crude oil prices, $\log Exch\_rate$ is the logarithm of the growth rate of official exchange rate of NOK against USD, $\log Exp\_service$ is the logarithm of the growth rate of service exports, β_0 is a constant or intercept, $\beta_{1,n}$ is the slope for n-independent variables, ε is the residual vector, t is a year.

Also, this study adopts and autoregressive distributed lag (ARDL) to estimate the long-run relationships between the indicators. If the value of the dependent variable changes due to a small interval time after changing the values of x factors, then the independent variables must be presented with the corresponding lag $(t-m)$ in the regression equation:

$$\begin{aligned}\log VA\_ocean\_transport &= \beta_0 + \\ &+\beta_1 \log VA\_ocean\_transport_{t-m} + \\ &+\beta_2 \log Oil\_price_{t-m} + \\ &+\beta_3 \log Exch\_rate_{t-m} + \\ &+\beta_4 \log Exp\_service_{t-m} + \varepsilon_t.\end{aligned} \quad (2)$$

Economic growth in the maritime sector has a predictive ability for carbon emission, as the amount of fossil fuels spent increases along with activity. Thus, investigation of the relationship between environmental degradation, economic growth in maritime industry and energy use in Norway is an important task.

In order to test the relationships between air pollution from the international marine bunkers' fuel combustion, economic growth in shipping industry and energy consumption the paper use annual data, covering the years from 1978 to 2015.

The investigation is based on the World Bank database (The World Bank, 2019), International Energy Agency (IEA, 2018), and Statistical Review of World Energy (BP Statistical Review of World Energy, 2018).

Also, it was decided to explore the relationship between $CO2$ emissions and the explanatory variables using a log-linear quadratic regression equation:

$$\begin{aligned}\log CO2_t &= \alpha + \beta_1 \log GDP_t + \\ &\beta_2 \log^2 GDP_t + \beta_3 \log Energy_t + \varepsilon_t,\end{aligned} \quad (3)$$

where $\log CO2_t$ is the logarithm of $CO2$ emissions, $\log VA\_ocean\_transport_t$ and $\log^2 VA\_ocean\_transport_t$ are the logarithms of ocean transport value added and its square, $\log Energy_t$ – is the logarithm of energy consumption.

According to the EKC hypothesis, it is assumed that with an increase in income (*GDP*) per capita (in our case, ocean transport value added) to a certain level, the volume of pollution per capita first increases and then decreases (Xu et al., 2018). If $\beta_1 > 0$ and $\beta_2 < 0$, the EKC hypothesis is valid, thus, there is U-shaped relationship between $CO2$ and dependent variable (Koilo, 2019). The inflection point can be measured as $-\beta_1/2\beta_2$.

It should be noted that the validation of the econometric model is an important and necessary task. To assess adequacy of the presented models in the study, the author used several methods, among them: the Durbin-Watson test (used to verify the existence of the autocorrelation of the residuals in the model (Hisamatsu & Maekawa, 1994)); the Dickey-Fuller test (applied to test some series for stationarity (EViews, 2019)) and the Hanna-Quinn criterion (a measure of model suitability and used in the time series analysis to determine the appropriate order of a model (Salie et al., 2012)). Also in this research author used the Hodrick-Prescott filter as a time series smoothing method in order to highlight the long-term trends in a time series (Kurt, 2006).

3. RESULTS

3.1. Exploring the link between oil prices, exchange rates, service exports and ocean transport value added

This section shows the estimation results of the model. The initial regression analysis and the

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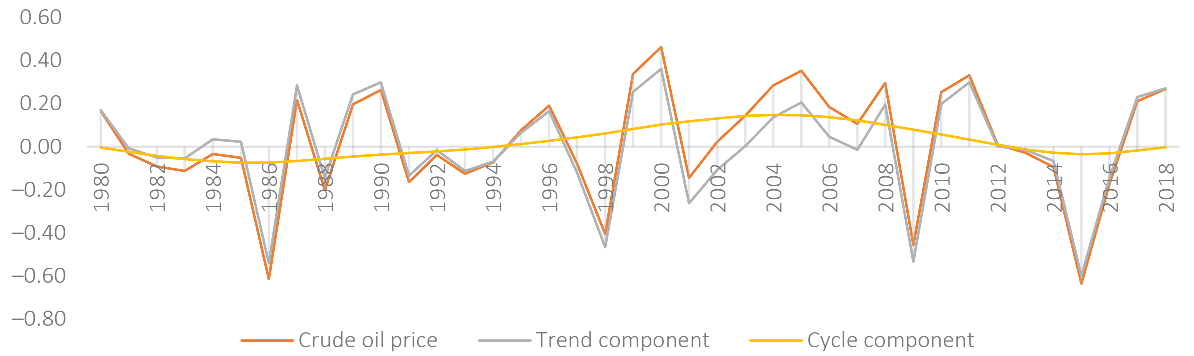

Figure 5. Deviation from trend of the oil price component

validation of the estimates show that the results of the model are not adequate and some variables has no significant effect on resulted indicator. Thus, one uses a Hodrick Prescott-filter to find short-term deviations from long-term equilibriums in data serials. The original results showed that there is a significant deviation from trend of oil prices, hence, in this particular case there is a need to separate the cycle component from trend (Figure 5).

Therefore, further investigation is required to determine the link between oil prices, exchange rates, exports and ocean transport value added on the basis of obtained results from the tests.

Table 2 depicts the regression analysis of the relationship of the estimated indicators.

Table 2. Regression results

Source: Author's calculations.

Variable	Coefficient	*t*-ratio	Std. err.
Dependent variable	–0.05**	–1.70	0.03
log(*Oil_price*)	–0.26	–0.74	0.35
log(*Exch_rate*)	1.46*	4.18	0.35
log(*Exp_service*)	1.57*	4.49	0.35
R-squared	0.63		
ESS	0.51		
RSS	0.75		
F-statistic	7.92		
F-criteria	0.00		

Note: * 1% significance level; ** 10% significance level.

Based on the adjusted R^2 value, one can conclude that the model can explain 63% of the variation in ocean transport value added. It was concluded that the obtained results are reliable – F-criteria is 0.00, this value is less than 0.05.

In order to investigate the adequacy and reliability of the obtained data, and to test for the presence of serial correlation of residuals, the paper use Durbin-Watson (DW) statistics.

The Durbin-Watson test reports a test statistic, with a value from 0 to 4. In this model, $DW_{fact} = 2.38$, which is more than 2, hence, its needed to run the test for negative autocorrelation at significance 0.05. The test statistics (4-*DWfact*) is compared to lower and upper critical values (*DW*1 and *DW*2). In this case, *DW*1 = 1.12, *DW*2 = 1.45, (4-*DWfact*) = 1.62, which is more than *DW*2, thus, the hypothesis about the absence of auto-correlation is accepted.

Next step – the author verified the stationarity of this time series using expanded Dickey-Fuller test (Figure 6).

Since the *p*-value for $VA\_ocean\_transport$ time series is small (–6.47) with a significance level of 0.01, 0.05 and 0.1, this series can be considered stationary (the hypothesis of the presence of a unit root is rejected).

Thus, according to the abovementioned results, the regression equation can be presented as the following:

$$VA\_ocean\_transport = -0.05 - -0.26 Oil\_price + 1.46 Exch\_rate + +1.57 Exp\_service. \quad (4)$$

Null Hypothesis: OCEAN_TRANSPOR_VALUE_ADDED has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.473807	0.0000
Test critical values:	1% level	-3.615588	
	5% level	-2.941145	
	10% level	-2.609066	

*MacKinnon (1996) one-sided p-values.

Figure 6. The results of the check on the stationary time series in the EViews program

Empirical findings indicate that service export growth rate has the largest positive effect on ocean transport value added growth. This means that a one percent increase in export growth rate contributes to increase of value added by 1.57 percent. This relationship was significant at one percent level of significance. A similar situation is observed with growth rates of official exchange rates and ocean transport value added. The obtained results show that one percent increase in exchange rate contributes to increase of value added by 1.46 percent.

Figure 7 presents the evelopment in official exchange rate with USD relative to NOK and ocean transport value added during the fourty-year period (1979–2018).

Since mid-2014, the Norwegian krone exchange rate against US dollars has sharply increased. As a result, companies with revenue in US dollars and most expenses in Norwegian kroner had a positive impact on their competitive situation (GCE Blue Maritime, 2018). Hence, the obtained results of the regression model proves the existence of strong relationship between this macroeconomic variables.

However, the regression analysis of the model depicts another tendency for the relationship with crude oil prices: a one percent increase of this indicator decreases ocean transport value added level by 0.26 percent. These analyses prove the statement that oil industry has a strong impact on value creation in the maritime cluster and its

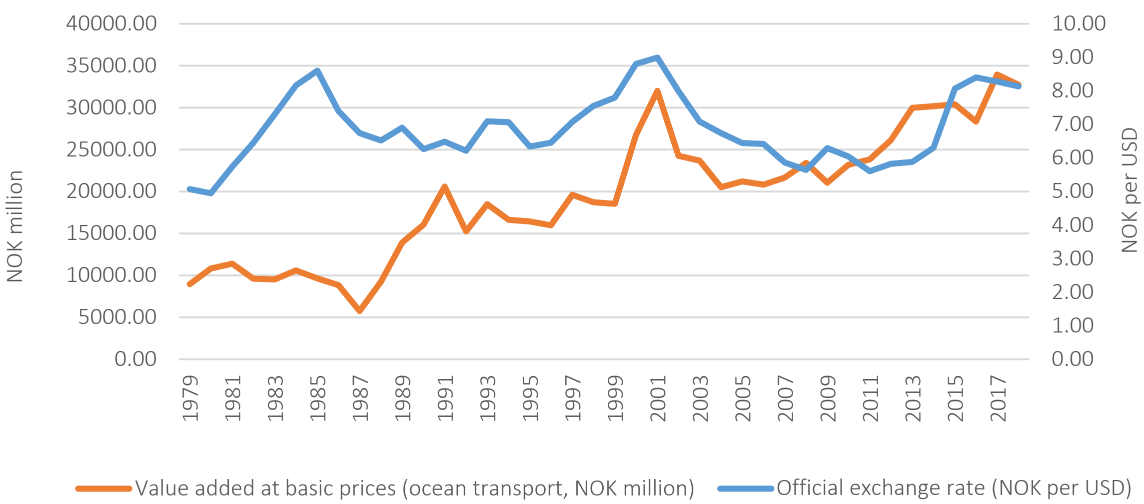

Figure 7. Development in official exchange rate with USD relative to NOK and ocean transport value added during the period 1979–2018

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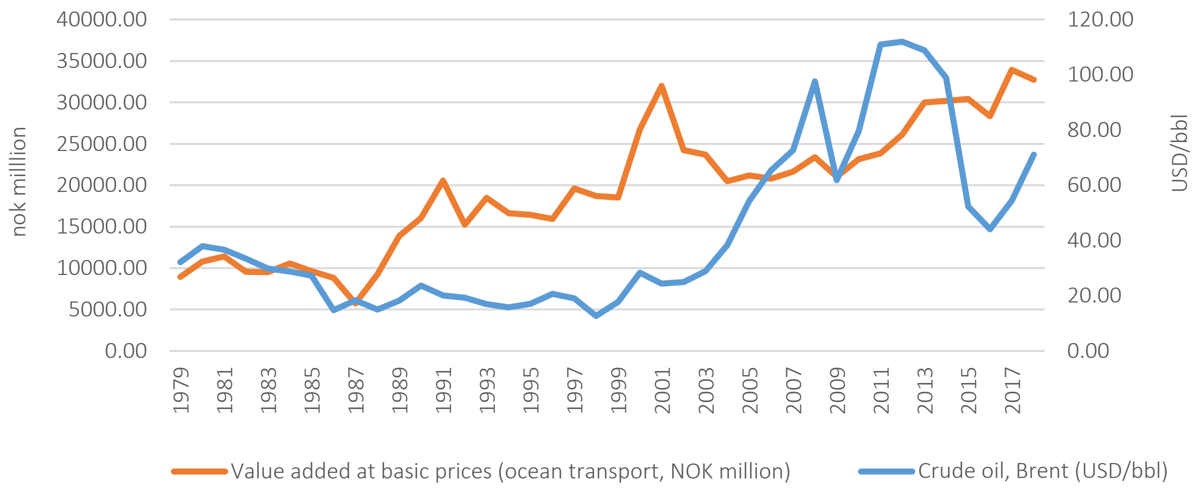

Figure 8. Development in crude oil prices and ocean transport value added during the period 1979–2018

competitiveness, especially on the shipping sector (Figure 8).

The next step of the analysis is based on the above-mentioned multiple regression model. The study adopts an autoregressive distributed lag (ARDL) testing to estimate the long run relationships between the indicators (Figure 9).

Here the multiple *R* (R^2) is 0.79, hence the model can explain 79% of the variation in ocean transport value added. It can be concluded that the ob-

Dependent Variable: OCEAN_TRANSPOR_VALUE_ADDED
Method: ARDL
Date: 07/22/19 Time: 10:33
Sample (adjusted): 1984 2018
Included observations: 35 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Hannan-Quinn criterion (HQ)
Dynamic regressors (4 lags, automatic): CRUDE_OIL_PRICE
OFFICIAL_EXCHANGE_RATE SERVICE_EXPORTS
Fixed regressors: C
Number of models evalulated: 250
Selected Model: ARDL(1, 4, 0, 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
OCEAN_TRANSPOR_VALUE_ADDED(-1)	0.050703	0.136756	0.370754	0.7142
CRUDE_OIL_PRICE	-0.183589	0.092498	-1.984799	0.0592
CRUDE_OIL_PRICE(-1)	0.285275	0.094605	3.015437	0.0062
CRUDE_OIL_PRICE(-2)	-0.323977	0.100501	-3.223609	0.0038
CRUDE_OIL_PRICE(-3)	-0.229633	0.102822	-2.233314	0.0355
CRUDE_OIL_PRICE(-4)	-0.125665	0.090341	-1.390999	0.1775
OFFICIAL_EXCHANGE_RATE	1.172366	0.330243	3.550008	0.0017
SERVICE_EXPORTS	1.671536	0.392332	4.260512	0.0003
SERVICE_EXPORTS(-1)	-0.299217	0.295413	-1.012875	0.3217
SERVICE_EXPORTS(-2)	-0.121194	0.270611	-0.447854	0.6584
SERVICE_EXPORTS(-3)	1.262916	0.285612	4.421790	0.0002
C	-0.084957	0.032747	-2.594395	0.0162

R-squared	0.789435	Mean dependent var	0.035312
Adjusted R-squared	0.688731	S.D. dependent var	0.187096
S.E. of regression	0.104384	Akaike info criterion	-1.415625
Sum squared resid	0.250607	Schwarz criterion	-0.882363
Log likelihood	36.77345	Hannan-Quinn criter.	-1.231543
F-statistic	7.839106	Durbin-Watson stat	2.277264
Prob(F-statistic)	0.000018		

*Note: p-values and any subsequent tests do not account for model selection.

Figure 9. Autoregressive distributed lag (ARDL) testing results in the EViews program

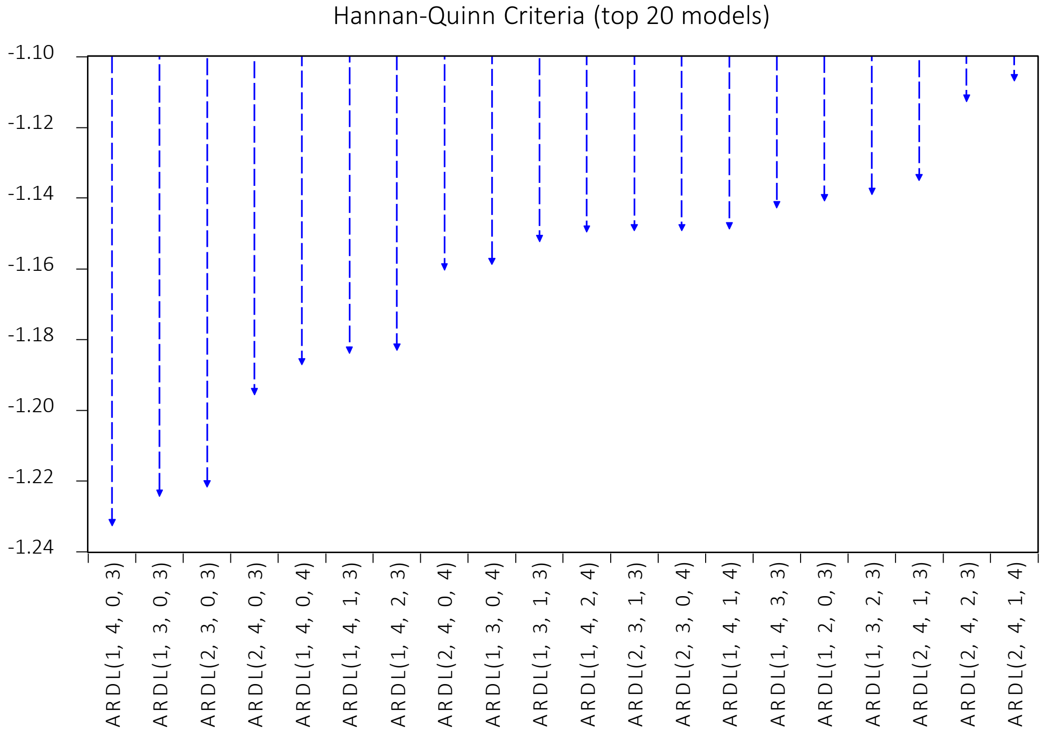

Figure 10. Selection of the optimal model ARDL according to Hanna-Quinn criterion

tained results are reliable since the *F*-value is close to 0.00, this value is less than 0.05. Moreover, the *F*-statistic is 7.84, and it exceeds the value of the *F*-criteria, this makes possible to argue about the adequacy of the obtained values of the model.

Also, in this model automatic selection (the Hanna-Quinn criterion) was used with a maximum of 4 lags of both the dependent variable and the repressors. Out of the 250 models evaluated, the procedure has selected an ARDL (1,4,0,3) model – a one period lag of the dependent variable $\log(VA\_ocean\_transport)$, 4 lags of $\log(Oil\_price)$, and 3 lags of $\log(Exp\_service)$.

Thus, the obtained ARDL equation can be presented as the following:

$$\begin{aligned} &VA\_ocean\_transport = -0.08 + \\ &+0.05VA\_ocean\_transport_{t-1} - \\ &-0.13Oil\_price_{t-4} + \\ &+1.17Exch\_rate_t - 1.26Exp\_service_{t-3}. \end{aligned} \quad (5)$$

The analysis of the coefficients of ARDL model shows: the growth rate of the ocean transport value added in the current period is the result of the growth of the same criterion in the previous year, hence an increase of this indicator by one percent will lead to the growth of it by 0.05 percent in the current period. An increase of one percent of oil prices with a lag in four years leads to a decrease in ocean transport value added in the current period by 0.13 percent. Additionally, one finds an impact of exports on services: an increase of this indicator with a lag of three periods is accompanied with a fall of ocean transport value added in the current period by in 1.26%.

To view the relative superiority of the selected model against alternatives, there also can be used a criteria graph to view the Hanna-Quinn criterion of the top twenty models (Figure 10).

To sum up, the empirical results show that official exchange rate of the NOK to the USD and service exports growth rates have positive effects on ocean transport value added growth, when there is another tendency for the relationship with crude oil prices, i.e. negative correlation with economic growth in the shipping industry.

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3.2. Regression results on relationships between carbon emissions from international marine bunkers and ocean transport value added in Norway

Globally, all transport in the world consumes 20-25% of all fossil fuel burned per year, the share of aviation in this consumption is 13%, and motor transport is 80%. Since 1990, the emissions of freight transport have increased significantly, while the total amount of harmful emissions into the atmosphere has decreased by 28 percent (International Energy Agency, 2019).

According to Figure 11, the transport sector in Norway is the most vulnerable and emits 39 percent of total $CO2$ emissions. The highest level is observed in Sweden (53%), while in the Netherlands it's only 19%.

Despite the fact that shipping is the most environmentally friendly way of transporting goods in the world, moreover, more efficient than road or air transport, the World Shipping Council (WSC) and its members are committed in improving fuel efficiency and reducing $CO2$ emissions across the fleet.

Figure 12 shows a summary of $CO2$ emissions by transportation subsectors in Norway. It proves that road transport emitted 76 percent of total emissions in 2015, while water transport – just four percent. Nevertheless, the maritime industry seeks to further improve fuel efficiency and its carbon footprints.

It should be noted that the modern maritime transport industry has the opportunity to reduce the consumption of resources. To this end, the IMO has developed Ship Energy Efficiency Management Plan and Energy Efficiency Design Index (EEDI). According to these recommendations, shipowners and maritime transport organizations should focus on a number of key points, namely: efficient fuel consumption, design of propulsion system, maintenance and operation of machinery and equipment, management of the ship and fleet, optimization of cargo operations, energy saving and personnel training (World Shipping Council, 2019).

To this end, the study suggests that energy use and economic growth in maritime clusters could be important sources of variation in $CO2$. Recent actions of world organizations towards sustainable development might improve efficiency across the fleet. Hence, the relationship between environmental degradation ($CO2$ emissions from marine

Source: International Energy Agency (2018).

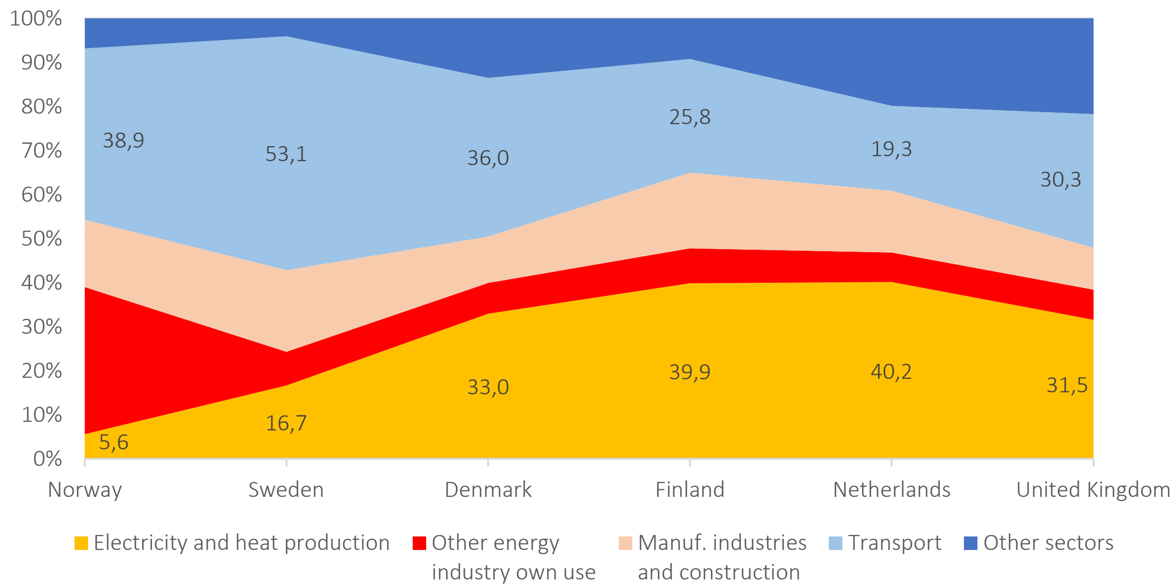

Figure 11. Share of carbon dioxide emissions from fuel combustion by sectors in 2015

Source: International Energy Agency (2018).

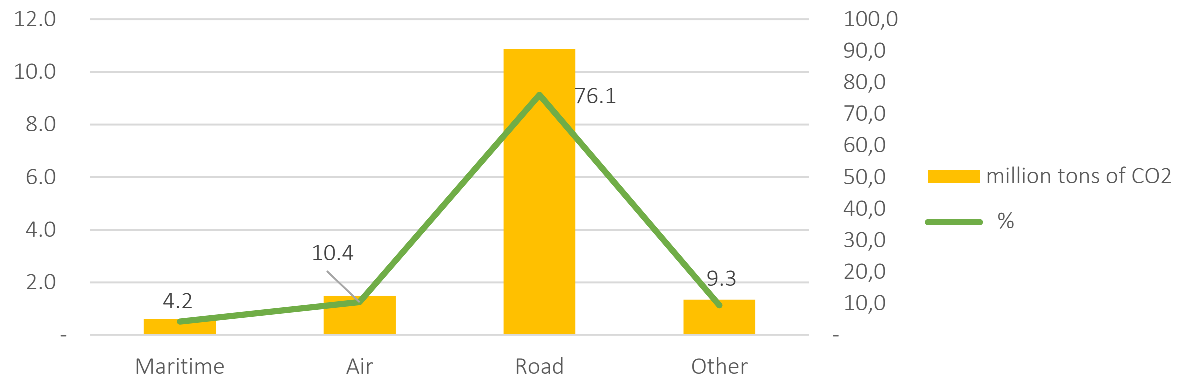

Figure 12. Distribution of *CO2* emissions from the transportation sector in Norway in 2015, by subsector

bunkers), ocean transport value added, and energy use should be investigated. For this reason, the paper checks the EKC hypothesis: can it be argued that Norway has already reached a certain level of economic growth and maturity in the shipping industry, which allows to improve the environmental situation and levels of *CO2* emissions?

The regression results are given in Table 3.

The determination of validity of the regression estimates, based on the significance of R^2 and the F-statistic show that results of the model are adequate and reliable.

Table 3. Regression results

Source: Author's calculations.

Variable	Coefficient	*t*-ratio	Std. err.
Dependent variable	–15.14**	–1.99	7.61
$\log(VA_{ot})$	6.86*	2.37	2.90
$\log(VA_{ot})^2$	–0.83*	–2.36	0.35
log(*Energy*)	1.30	1.27	1.03
R-squared	0.47		
ESS	1.56		
RSS	5.65		
F-statistic	3		
Prob(*F*-statistic)	0.04		

Note: * 5% significance level; ** 10% significance level.

Thus, according to the abovementioned results, the regression equation can be presented as follows:

$$CO2 = -15.14 + 6.86VA\_ocean\_transport - -0.83VA\_ocean\_transport^2 + 1.30Energy.$$

This implies that for each unit increase in ocean transport value added, *CO2* emission increase with 6.86 percent at the departure and this rate is decreasing, when inflection point is reached, and for each percentage increase in energy consumption, level of environmental pollution increases with 1.30 units, respectively.

According to the regression results, the coefficient of the logarithm of value added is positive (6.86) and its squared value is negative (–0.83). Hence, there is an inverted U-shaped relationship between economic growth and *CO2* emissions, and, in this case, the environmental Kuznets curve hypothesis can be accepted.

Hence, the turning point is 4.12, that is 14.266 million. NOK of ocean transport value added. It was suggested that after the inflection point was reached in 1990, *CO2* emissions have a tendency to decline. Thus, these evidences prove the EKC hypothesis in Norway.

Hence, the empirical evidences show that the links between *CO2* emissions and ocean transport value added are stronger, rather with energy consumption. It can be assumed, due to the energy efficiency policy and technological leadership in the shipping industry, that the environmental impact of energy use (renewable energy) has improved.

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Source: Authors' calculations.

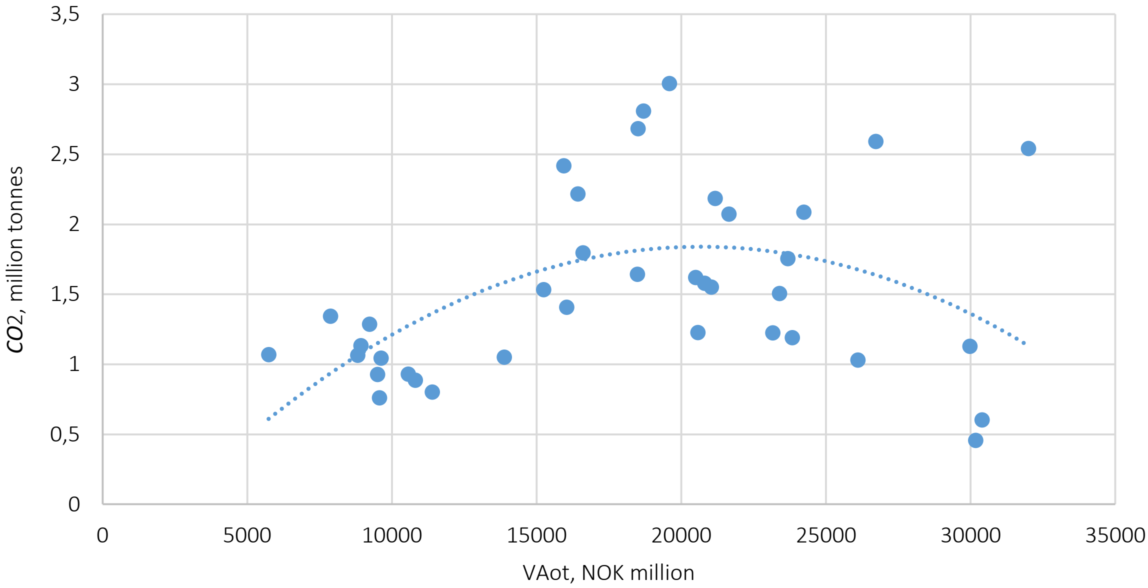

Figure 13. EKC for *CO2* emissions from international marine bunkers and ocean transport value added in Norway

4. DISCUSSION

The development of the Norwegian maritime cluster is deeply connected with the productivity of the oil and the fishing industry. Nowadays shipping companies are faced with the main challenges of the century: on the one hand, how to mitigate the oil price crises and to shift the activities to alternative industries, on the other hand, to get towards the major goal – the west Norwegian fjords should become zero-emission zone by 2026 (SAFETY4SEA, 2018).

Although maritime clusters nowadays are not going through the best times, the industry still shows strong resilience in sustaining their competitive position in the world. This is the result of active investment in new technologies and good export potential all around the world.

In order to stay in the forefront of the maritime industry, Norway should keep its position in technological leadership and continue the capacity for reinventing themselves. Also its important to provide this optimization both in environmental and economic terms in line with sustainability goals.

Nevertheless, Norway still uses large amounts of fossil fuels (Ministry of Petroleum and Energy, 2019). The International Council on Clean Transportation reports that total fuel consumption by the global shipping fleet has increased on 7 million tons (+2.4 percent) during the last three years (ICCT, 2017).

In the previous section the paper explored the link between energy use and *CO2* emissions. One can argue that the increasing level of fuel consumption can lead to deterioration of the natural resources and environment. In fact, ships emitted 932 million tons of *CO2* in 2015. Container ships together with bulk carriers, and oil tankers accounted for 55 percent of *CO2* emissions 2013–2015 (ICCT, 2017).

Meanwhile, Norway supported the IMO agreement, adopted in April 2018, on a comprehensive strategy for the total elimination of *CO2* emissions in the shipping industry. This includes goals to decrease the level of carbon dioxide emissions at least by 40% by 2030 and 70% by 2050. In fact, nowadays more electricity is being used in marine industry in Norway, both in combination with other fuels (hybrid ships) and alone (Ministry of Petroleum and Energy, 2019).

It should be noted, among seventeen sustainable development goals, there are six main of them, Source: Compiled by author based on SAFETY4SEA (2018).

Figure 14. Sustainable development goals related to the maritime industry

which are deeply connected with the shipping industry (Figure 14).

As mentioned before, new technologies use can exacerbate problems for the planet and, at the same time, contribute toward the UN's SDGs. In general, the digital revolution, integration and automation provide transparency and increase the accountability of the shipping industry (SAFETY4SEA, 2018).

To sum up, all segments in maritime clusters are deeply connected with tne technologies use and innovations in a fundamental way. An important question is whether the maritime industry has the right competence, capacity and willingness to continue to exploit these megatrends to reduce costs, increase market shares and gain competitiveness (GCE Blue Maritime, 2018).

CONCLUSION AND FUTURE STUDIES

In this paper, existing sustainability frameworks on the relationship between environmental sustainability and the maritime industry were reviewed and discussed.

It was derived that the Norwegian maritime cluster is the second largest export industry of the country after the oil and gas industry. Nevertheless, in the recent five years, Norwegian shipping industry has been faced with decline in investments in the production of marine equipment and shipbuilding caused by a significant decrease in oil prices from 2014 to 2016. Meanwhile, Norway was always in the top of performers in striving to reach the United Nations SDGs, including the transition from oil and gas dependency to low carbon. Hence, two main issues arise: how to keep the competitive position as the forerunner for sustainable maritime technology, particular in terms of green shipping and driving for a greener future, on the one hand, and remain attractive industry for long term investments in times of recession of the oil prices, on the other hand?

This research proposes modelling approaches to measure the relationship between oil prices, exchange rates, service exports and ocean transports value added, and to explain the link between environmental pollution and maritime cluster activity.

Empirical findings indicate that the growth rate of service exports has the biggest positive effect on

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ocean transport value added growth. This means that a one percent increase in export growth rate leads to increase of value added by 1.57%. A similar situation is observed with the growth rate of exchange rates and ocean transport value added. The estimated results show that a one percent increase in exchange rate leads to increase of value added by 1.46 percent. At the same time, the regression analysis of the model depicts another tendency for the relationship with crude oil prices: a one percent increase of this indicator decreases ocean transport value added level by 0.26 percent. Hence, it can be traced that the oil industry has a strong impact on value creation in the maritime cluster and its competitiveness, especially on the shipping sector

The paper also uses an autoregressive distributed lag (ARDL) to estimate the long run relationships between the indicators. The analysis shows: the growth rate of ocean transport value added in the current period is the result of the growth of the same criterion in the previous year, hence an increase of this indicator by one percent last year will lead to the growth of it by 0.05 percent in the current period. An increase of one percent of oil prices with a lag of four years leads to a decrease in ocean transport value added in the current period by 0.13 percent. In addition, there is an impact of exports of services: an increase of this indicator with a lag of three periods is accompanied with fall of ocean transport value added in the current period by in 1.26%.

The regression results of the estimation the links between the carbon emissions from international marine bunkers and ocean transport value added confirm the validity of the EKC hypothesis in Norway at a turning point 4.12 and it was reached in 1990. Furthermore, it was revealed that after the inflection point, which appears at 14.266 million. NOK, $CO2$ emissions per unit have a tendency to decline with the increasing levels of ocean transport value added.

Global competition is furious and growing in oceanic industries. Therefore, Norwegian maritime companies are dependent on constantly developing products and production methods. The development of maritime clusters in Norway is based on knowledge and technologies. It is strong in innovative research, which helps to build bridges with other leading sectors of the Norwegian economy by using environmentally friendly and energy efficient maritime transport.

Some research limitations still exist in the current paper. For example, author investigated the impact of ocean transport value added on $CO2$ emissions, but the study doesn't reflect the influence in the other direction: how air-pollution exposures the economic growth in the maritime industry. The shipping industry has to face the challenge of meeting strict rules, and the industry should be in line with climate regulations. Therefore, future research can perform surveys and use causality analysis to determine this relationship. Another limitation, due to the lack of indicators and reliable data of port performance, imply that the current study does not consider sustainability framework for individual ports, which would be recommended to apply and make comparisons of the effectiveness of port logistics companies. Hence, it would be meaningful to trace the sustainability performance of ports. However, these limitations of the present study give a new perspective and avenue for future research.

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