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CONTENTS

Forecasting the Cargo Throughput for Haiphong Port in Vietnam

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ABSTRACT

Port throughput forecasting is fundamental in port optimization. A reliable prediction model is essential for the terminal operators to make decisions on planning and renovation of building structure and other port facilities. By monitoring the changes in seasonal patterns and business cycles in months or quarters, the predicted values help port managers in decision making and planning in the context of small and unexpected changes. In this paper, the authors reviewed a various of commonly used forecasting methods applied for the time-series data in the short-term. By applying a set of monthly data of Haiphong port from January 2003 to February 2019 to these models and evaluating forecast accuracy by root mean squared error (RMSE), we found that the Winters exponential smoothing method appears to be the best model for forecasting total cargo throughput with trend and seasonal variations. The empirical results could be used as a reliable scientific source for the port managers and the departments to make short-term plans for upgrading facilities and setting up effective loading and unloading plans, and then contribute to avoiding congestion and reducing unnecessary waste.

Keywords: Forecast, Cargo throughput, Trend and seasonal components

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1. Introduction

With the rapid development in economic globalization, ports are becoming increasingly vital in the operation of international trade activities (Notteboom, 2016), particularly in the 21st century, owing to the significant growth in container shipping. With such a vast volume of cargo transported, the need for a sufficiently accurate cargo throughput forecast is not surprising since it can significantly influence the port development strategy, investments in infrastructure, daily operations management. According to Hyndman and Athanasopoulos (2018), forecasting is the process of making statements about events that actual outcomes have not yet been observed, but forecasting will estimate of the values at certain specific times in the future, which can help people and organizations planning and making decisions. Accurate port throughput prediction can not only avoid repetitive construction, but also improve the port resource utilization efficiency. However, if the prediction of throughput provides poor accuracy, port authorities will make unsuitable decisions, which may lead to significant financial losses (Xie, 2017). Thus, it is essential to implement accurate port throughput forecasting in port transportation system nowadays.

The forecasts for port operations are usually conducted in the long-term, but short-term forecasts are also important. In monitoring the changes in seasonal patterns and business cycles, the fact has been proved that short-term forecasts often yield better results than long-term forecasts (Franses and Dijk, 2005). As the prediction period is shorter, fewer unexpected factors may arise, short-term forecasts would be more accurate than long-term forecasts. Furthermore, forecasts on a short-term basis are necessary for the control and scheduling of a port system, and for the terminal operator in decision making and planning in the context of small and unexpected changes (Peng and Chu, 2009). However, the role of forecast in the seaport system is not paid much attention in Vietnam, mainly comes from weak statistical work. Currently, forecast is mainly conducted by the Government in the long term, e.g. the government introduced a master plan related to the development of seaport systems by 2030. However, regarding each port, the forecast task remains plenty of limitations, especially in the short term. Operational plans are mainly based on past experiences or sentiment, without forecast results and scientific bases, which leads to inaccurate decisions.

The aim of this study is to adopt monthly cargo throughput datasets of Haiphong port to forecast the values until the end of 2020. Future values of time series are assumed to be based solely on past values. Therefore, historical data are analyzed in an attempt to identify a pattern, and a similar historical pattern is assumed to continue in the future. The authors apply monthly data to the several suitable models for forecasting in the short-term, then conclude, among the applied models, which model is capable of generating the most accurate prediction of cargo throughput useful for Haiphong port authority. In this study, the data was collected from the planning and statistics department of Haiphong Port and analyzed with the support of statistical software such as Eviews 10 and Microsoft Excel 2016.

2. Literature review

Forecasting models may be classified according to different factors. In order to ground the problem presented in this paper, the literature review section focus on two classification factors: time horizon and method approach.

Forecast may be dealt with at different time-horizons according to the type of planning problem. Long and medium-term forecasts provide key inputs for port infrastructure planning (terminal capacity, berth utilization, and expansion decisions), in-port services and operational plans. Kuroda and Takebayashi (2005) forecasted long-term demand of container throughput in Indonesia in order to evaluate the investment required to expand the capacity of the Indonesian ports for the following 15 years. Schulze and Prinz (2009) focused on medium-term forecast models (SARIMA and Holt–Winters methods) to forecast the container transshipment in German ports in 3 different economic regions namely Asia, Europe and North America.

Short-term forecasts provide key inputs for monthly operation management decisions. These include port operation scheduling, congestion delay occurrences, maintenance planning, revenue management, among others. Chou, Chu and Liang (2008) built a short-term forecasting model for the number of monthly volumes of import container at ports in Taiwan. In an attempt to optimize cargo handling procedure, Peng and Chu (2009) made forecast for container throughput in three ports of Taiwan by month.

Regarding forecasting methods, several approaches have been considered to predict cargo throughput at ports. Among the most commonly used approaches two are worth highlighting: causal econometric and time series. The econometric approach seeks to identify relationships between demand-related factors (e.g. total cargo throughput) and social, economic, and service-related factors. The time series approach relies on historical data series to generate forecasts making use of the correlation between present and past observations.

Regarding time series approaches, Grubb and Mason (2001) applied the Holt-Winters method by considering monthly time series to demonstrate forecasting performance for long lead times. Another forecasting application was developed by Peng and Chu (2009). They found out the best forecasting model of container throughput from six difference methods, namely: classical decomposition, the trigonometric model, the seasonal dummy variables, the grey forecast, the hybrid grey forecast and SARIMA. The result shows that the classical decomposition has the best performance to predict container throughput in Keelung port and Taichung port. While in the prediction of container throughput in Kaohsiung Port, SARIMA and the classical decomposition perform better than other methods.

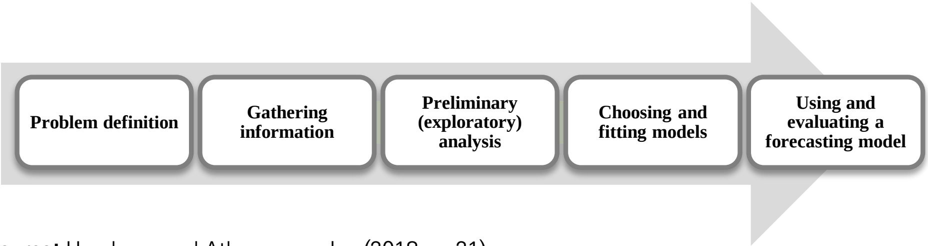
Regarding causal and econometric modelling, an application presented by Chou, Chu and Liang (2008) used leading indicators such as macroeconomic variables as dependent variables for regression models to predict short-term volumes of import containers in Taiwan. After comparing the accurate prediction of modified regression and traditional regression the predictive performance of modified regression had less error than traditional regression. Gosasang, Chandraprakaikul and Kiattisin (2011) built a linear regression model regarding dependent variables: GDP, exchange rate, population, interest rate, inflation rate and fuel price. The model was applied to predict monthly container throughput at Bangkok port.

In the current study, total cargo throughput at Haiphong port, selected because it is ranked as one of three largest port complexes of Vietnam and has the largest capacity in the northern region, was inputted into some commonly used models for forecasting purposes. Even though there are several studies on forecasting port cargo throughput, up to now there has been no practical study conducted at Haiphong port. Furthermore, this study concerns a comparison of different methods to choose the best suited model to forecast regarding the simplicity and rapidity in decision making.

3. Methodology

According to Hyndman and Athanasopoulos (2018), forecasting task usually involves five basic steps as can be seen in Figure 1. In the beginning, defining the problem carefully requires an understanding of the way the forecasts will be used, who requires the forecasts, and how the forecasting function fits within the organization requiring the forecasts. A forecaster needs to spend time talking to everyone who will be involved in collecting data, maintaining databases, and using the forecasts for future planning. Next, it is necessary to gather enough statistical data from the past, then analyze it to understand the nature and identify the pattern of datasets. After that, we choose and validate models. The best model to use depends on the availability and pattern of historical data, and the accuracy of forecasts measured through parameters. Finally, once a model has been selected and its parameters estimated, the model is used to make forecasts, then the results should be clearly presented to people who may use.

Figure 1. The basic steps in a forecasting task



Source: Hyndman and Athanasopoulos (2018, p. 21)

Based on the length of time, it is divided into long-term forecast, medium-term forecast and short-term forecast. Long-term forecasts are used in strategic planning with a forecast period of up to 15 years. Such decisions must take account of market opportunities, environmental factors and internal resources. Medium-term forecasts are needed to determine future resource requirements, in order to purchase raw materials, hire personnel, or buy machinery and equipment. Short-term forecasts are needed for the scheduling of personnel, production and transportation. The choice depends on the purpose of forecasters, what data are available and the predictability of the quantity to be forecast. In this paper, six commonly used forecasting models for the time series in the short-term are presented.

3.1. Naive model

The naïve forecast models assume that the nearest periods are the best estimates for the future. They can be represented as follow:

$$\hat{Y}_{t+1} = Y_t + (Y_t - Y_{t-1}) \text{ or } \hat{Y}_{t+1} = Y_t . \frac{Y_t}{Y_{t-1}} \quad (1)$$

$$\hat{Y}_{t+1} = Y_{t-11} \quad (2)$$

$$\hat{Y}_{t+1} = Y_{t-11} + \frac{(Y_t - Y_{t-12})}{12} \quad (3)$$

Where $\hat{Y}_{t+1}$ is the forecast value in period t+1, which is estimated based on the actual value in the past. (1) is applied for time-series data with trend component while (2) is used if the monthly data is adopted or the data contains seasonal component. (3) is adjusted naïve method, which is applied for the data has both trend and seasonal components.

3.2. Moving averages model

The moving averages model uses some of the closest observations as forecast values, which is shown by the following formula:

$$\hat{Y}_{t+1} = \frac{Y_t + Y_{t-1} + \cdots + Y_{t-11}}{k} \quad (4)$$

Thus, the moving average for period t is the mean value of k the closest observations. In a moving average, the weights of each observation are equal to 1/k. The moving averages forecasting model is suitable for stationary series.

3.3. Exponential smoothing model

The exponential smoothing method is based on averaging all the past values of the data series as exponentially decreasing weight. There are three common methods, which is presented as follow:

3.3.1. Simple exponential smoothing model

$$\hat{Y}_{t+1} = \alpha .\ Yt + (1-\alpha)\ \hat{Y}_t \quad (5)$$

Where: $\hat{Y}_{t+1}$: the forecast value in period t+1, α: exponential coefficient, Y_t: the actual value in period t, $\hat{Y}_t$: the forecast value in period t.

Thus, the simple exponential smoothing model assumes that the new forecast value is an average between the actual value and the predicted value in period t. The exponential coefficient value determines the degree of influence of the current observation on the predicted value.

3.3.2. Holt's exponential smoothing model

Holt's exponential smoothing model is presented in the three following equations:

Estimate current average value:

$$L_t = \alpha Y_t + (1-\alpha).\ (L_{t-1} + T_{t-1}) \quad (6)$$

Estimate trend value:

$$T_t = \beta .\ (L_t - L_{t-1}) + (1-\beta)\ T_{t-1} \quad (7)$$

Forecast the future value in period p:

$$\hat{Y}_{t+P} = L_t + p.\ T_t \quad (8)$$

Where: L_t: the estimated current average value, α: the exponential coefficient of L_t ($0<\alpha<1$), Y_t: the actual value in period t, β: the exponential coefficient of T_t ($0< \beta<1$), T_t: the estimated trend value, p: the forecast period, $\hat{Y}_{t+P}$: the forecast value in period p

In short, Holt's exponential smoothing model is suitable for data series with trend component.

3.3.3. Winter's exponential smoothing model

Winter's exponential smoothing model is presented in the three following equations:

Estimate current average value:

$$L_t = \alpha\frac{Y_t}{S_{t-s}} + (1 - \alpha)(L_{t-1} + T_{t-1}) \quad (9)$$

Estimate trend value:

$$T_t = \beta. (L_t - L_{t-1}) + (1- \beta) T_{t-1} \quad (10)$$

Estimate seasonal value

$$S_t = \gamma\frac{Y_t}{L_t} + (1 - \gamma)S_{t-s} \quad (11)$$

Forecast the future value in period p:

$$\hat{Y}_{t+P} = (L_t + pT_t). S_{t-s+p} \quad (12)$$

Where: L_t: the estimated current average value, α: the exponential coefficient of L_t ($0<\alpha<1$), Y_t: the actual value in period t, β: the exponential coefficient of T_t ($0< \beta<1$), T_t: the estimated trend value, γ: the exponential coefficient of S_t, S_t: the estimated seasonal value, p: the forecast period, $\hat{Y}_{t+P}$: the forecast value in period p

To sum up, Winter's exponential smoothing model is applied for data series with trend and seasonal components.

3.4. Regression-based trend model

Trend is the up and down movement of data for a long time. This movement can be described by a straight line (linear trend) or a curve (nonlinear trend). The trend can be modeled by an appropriate regression function between the forecast variable (variable Y) and time (variable t). This regression function is then used to generate future forecast values. The commonly used model is presented as follow:

$$Y_t = \beta_1 + \beta_2.t + U_t \quad (13)$$

3.5. Time-series decomposition model

In this model, the time series is decomposed into four separate components: trend, cyclical, seasonal and irregular factors. Of these four components, forecasting models can only analyze the trend and seasonal changes. The cyclical component requires a data series of at least 30 years while unusual fluctuations cannot be predicted. Therefore, time-series decomposition model mainly refers to trend and seasonal components in order to understand how these components relate to the original data series. There are two types of models: the multiplicative model and the additive model. In this paper, we take the multiplicative approach and state the time series as:

$$Y_t = TR_t \,.\, SN_t \,.\, CL_t \,.\, IR_t \qquad (14)$$

Where Y_t is the observed value of the time series in time period t, TR_t is the trend component in time period t, SNt is the seasonal component in time period t, CLt is the cyclical component in time period t, IRt is the irregular component in time period t. In this method, the concept is eliminating the seasonal component first, then applied the aforementioned models to the after-adjusted data series.

Table 1. A guide to selecting an appropriate forecasting method

Forecasting method	Data pattern	Forecast horizon
Naive	Stationary	Very short
Moving averages	Stationary	Very short
Simple exponential smoothing	Stationary	Short
Holt's exponential smoothing	Linear trend	Short to medium
Winter's exponential smoothing	Trend and seasonality	Short to medium
Regression-based trend	Linear and nonlinear trend	Short to medium
Time-series decomposition	Trend, seasonal and cyclical patterns	Short, medium and long

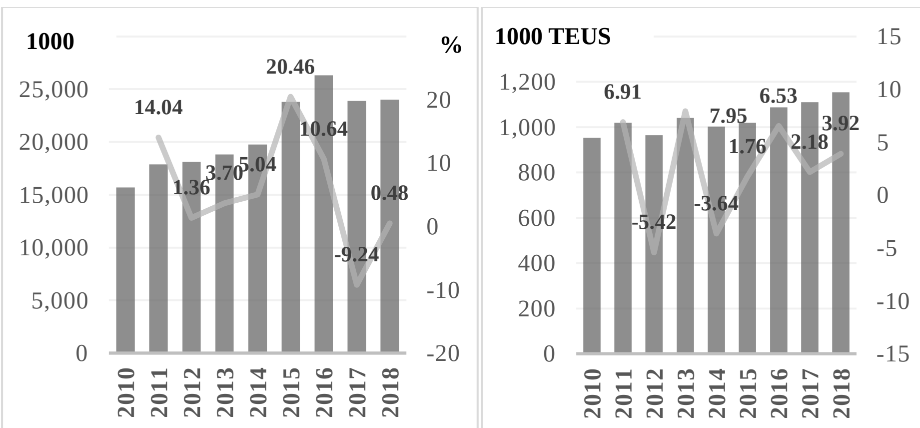
Source: Hanke and Wichern (2005)

4. Empirical study

4.1. Haiphong port overview

Vietnam’s seaport system consists of six groups with 44 seaports in total. Among these, group 1 and group 5 account for largest percentage regarding cargo throughput with 35% and 62% respectively. Belonging to group 1, Haiphong port established in early 1874 has a long-lasting history. It is ranked as one of three largest port complexes of Vietnam, along with Danang and Ho Chi Minh city. Besides, Haiphong port is considered as the leading seaport in the North of Vietnam. In recent years, many new container port terminals have been developed in the downstream area, which accommodates larger container vessels and reduces the need for transshipments.

Figure 2. Total cargo throughput of Haiphong port from 2010 to 2018



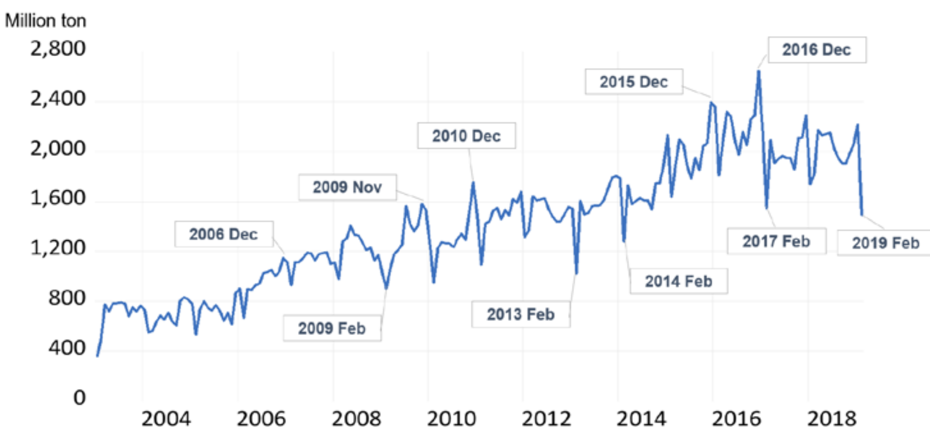
Source: Planning and Statistics Department – Haiphong Port

From 2010 to 2018, there is an upward trend in total cargo throughput of Haiphong port. Only in 2017 and 2018 did the number decrease coming from the restructuring and merging of company in 2017. The highest number can be seen in 2016 with over 26 million tons of cargo throughput. In which, container accounts for over 75% of total throughput, followed by other categories. Over the period from 2010 to 2018, the container throughput has increased slightly from 900 thousand TEUS to nearly 1.2 million TEUS. Moreover, the figure is forecasted to be considerably greater in the next following years when Lach Huyen port terminal is fully operating.

4.2. Data description

The monthly data of Haiphong Port's total throughput used in this study are from the planning and statistics department of Haiphong port, covering the period from January 2003 to February 2019, as illustrated by Fig. 3. We considered data from January 2003 to December 2016 as training set (in-sample) and the observations from January 2017 to February 2019 as test set (out-of-sample). In order to save space, the original data are not listed here.

Figure 3. Total cargo throughput of Haiphong Port by month from 2003 to 2019 February



Source: Planning and Statistics Department – Haiphong Port

As shown in Figure 3, the time-series data of the total cargo throughput is a series with trend and seasonal components. From January 2003 to February 2019, the total cargo throughput witnessed a continuous fluctuation. Although the volume of throughput did not increase steadily every year, the overall trend during the studied period was an upward trend. In addition, the data series also contains seasonal component. Specifically, the total volume of throughput usually plummets in the first months of the year (January, February, March) and often has a significant increase in the last months of the year (November, December).

This can be explained by the end of the year, the demand for transporting goods for the Chinese New Year holidays increased sharply. However, in the first months of the year, this demand tends to decrease, especially in the months after the holiday, when the productions are not busy as before, leading to a decrease in the demand for maritime transportation.

According to Hanke and Wichern (2005), appropriate forecasting methods applied for time - series data with trend and seasonal components are presented as follow:

- Adjusted naïve method (trend & seasonality)
- Winter's exponential smoothing method
- Time-series decomposition method (after eliminating the seasonal component, we can apply one of these methods for adjusted time-series data: Adjusted naïve method (trend), Holt's exponential smoothing method, Regression-based trend method)

4.3. Validate model

Since there is no universally accepted measure of accuracy or forecast error that can be applied to every forecasting situation, several criteria are normally used to give a comprehensive assessment of forecasting models. A forecast error is the difference between an observed value and its forecast. In this study, we measure accuracy or error of the forecast models by using the root mean squared error (RMSE) criteria, which defined as follows:

$$RMSE = \sqrt{\frac{\sum e_t^2}{n}} = \sqrt{\frac{\sum(Y_t - \hat{Y}_t)^2}{n}} \quad (15)$$

Where Y_t and $\hat{Y}_t$ are the actual and the predicted values of the time series in period t, respectively. Obviously, RMSE is positive in value and the smaller the RMSE value obtained is the better the performance of the forecasting method.

With the support of EViews 10 software, we evaluate the aforementioned models to conclude which model gives the smallest error (the difference between the actual value and the forecast value in test dataset is smallest). The comparative results of forecasting accuracy of the five methods applying the test dataset of total cargo throughput of Haiphong port from January 2017 to February 2019 are presented in Table 1:

Table 2. Performance of methods of forecasting total cargo throughput of Haiphong port

No.	Forecasting method	Forecasting error
1	Adjusted naïve method (trend & seasonality)	RMSE = 236,844.389
2	Winter's exponential smoothing method	RMSE = 101,143.700
3	Adjusted naïve method (trend)	RMSE = 219,279.801
4	Holt's exponential smoothing method	RMSE = 111,180.000
5	Regression-based trend method	RMSE = 231,410.510

Table 2 shows that the Winter's exponential smoothing is clearly the best forecasting model since it has the lowest value of RMSE. The Holt's exponential smoothing appears to be the second best model for forecast accuracy. On the other hand, adjusted naïve method is found to be the worst method for predicting total throughput of Haiphong port.

4.4. Forecast results

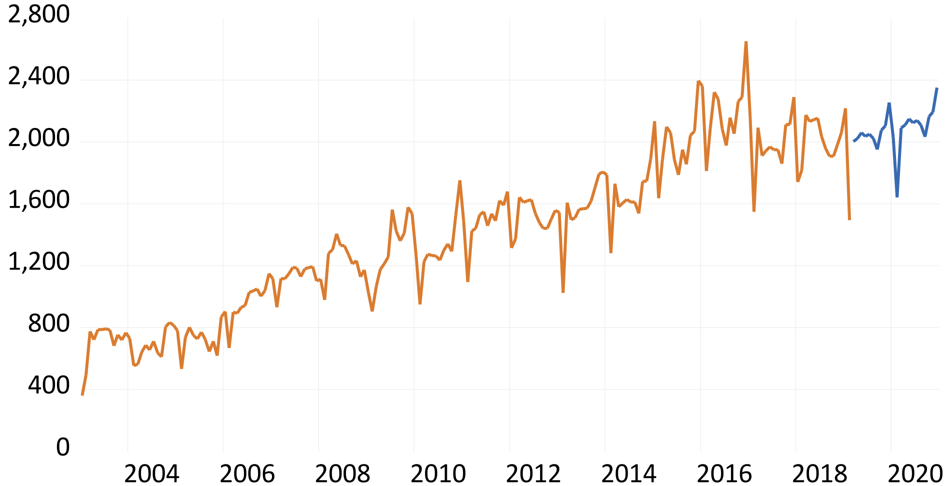
With the support of EViews 10 software, we forecast the volume of total cargo throughput of Haiphong port until 2020 by applying Winter's exponential smoothing method. The results are presented in Table 2.

Table 3. Forecast results of cargo throughput by month

No.	Month	Forecast results (tons)	No.	Month	Forecast results (tons)
1	2019 Mar	2,003,027	12	2020 Feb	1,641,276
2	2019 Apr	2,021,922	13	2020 Mar	2,090,604
3	2019 May	2,059,060	14	2020 Apr	2,110,004
4	2019 Jun	2,035,747	15	2020 May	2,148,435
5	2019 Jul	2,049,976	16	2020 Jun	2,123,792
6	2019 Aug	2,022,088	17	2020 Jul	2,138,318
7	2019 Sep	1,950,252	18	2020 Aug	2,108,916
8	2019 Oct	2,075,011	19	2020 Sep	2,033,697
9	2019 Nov	2,104,561	20	2020 Oct	2,163,478
10	2019 Dec	2,254,781	21	2020 Nov	2,193,971
11	2020 Jan	2,028,310	22	2020 Dec	2,350,235

To give a clearer view of the comparison, we plot the actual and the predicted values generated by the best method (Winter's exponential smoothing method) in Figure 4.

Figure 4. Forecast results of cargo throughput by month (thousand tons)



From the forecast results, the cargo throughput of Haiphong port, in general, is predicted to follow the upward and seasonal pattern as in the past. To specify, comparing the forecast results of the coming months in 2020 to those in the previous period, the overview can be seen as an increasing trend. On the other hand, it is easy to notice that seasonal component in the coming months continue to appear in the series of data on the throughput of goods. The total volume of goods throughput continued to decline sharply in the first months of the year (January, February, March) and significantly recovered in the last months of the year (November and December).

5. Conclusion

Port throughput forecasting is fundamental in port optimization. Accurate cargo throughput forecasting, especially in the short-term, not only facilitates the future development trend of ports, but also help to shorten transport time, reduce trade costs, and manage the port transportation system effectively. By monitoring the changes in seasonal patterns and business cycles in months or quarters, the predicted values help port managers in decision making and planning in the context of small and unexpected changes.

In this paper, we review some commonly used forecasting methods applied for the time-series data in the short-term. The monthly data of Haiphong port's total throughput covering the period from January 2003 to February 2019 was used in this study, which was a series with trend and seasonal components. The available dataset was separated into two portions, training data (from January 2003 to December 2016) and test data (from January 2017 to February 2019). After measuring the accuracy of the models through forecast errors (RMSE), the most suitable model chosen to forecast total cargo throughput by month for Haiphong port until 2020 was the Winters exponential smoothing method.

In the future, the cargo throughput of Haiphong port is predicted to follow the upward and seasonal pattern as in the past. Noticeably, the total volume of goods throughput continued to decline sharply in the first months of the year (January, February, March) and significantly recovered in the last months of the year (November and December). These forecast results can be used as a reliable scientific source for the port managers and the departments to make short-term plans for upgrading facilities and setting up effective loading and unloading plans, contribute to avoiding congestion and reducing unnecessary waste.

The study suggests that the port authority should realize the important role of forecast to the development of port in general and short-term forecast in particular. Besides, in behalf of the simplicity and rapidity of the chosen method, the port should continue collecting and updating data for the upcoming periods. If there are discrepancies between the forecast results and the actual results, there should be timely adjustments to the forecasting model and the forecasting method. Due to the lack of scientific papers focusing on forecasting in Haiphong port, we believe that this is one of the most important contributions of this study. However, in the future, other more sophisticated methods are necessary in order to lower the forecast errors.

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Assessing the Economic Impacts of Ocean Acidification on Asia's Mollusk Mariculture

Lance Yu*

ABSTRACT

Ocean acidification is coming fast and will exert negative economic impacts on global seawater mollusk fisheries. Asia is by far the top seawater mollusk producer on Earth, therefore, it is more necessary for it to be carried out related researches than the rest of the word. This analysis is an attempt to conduct a regional assessment of the direct economic impacts of ocean acidification on Asia's mollusk mariculture. The results show that the accelerating ocean acidification poses increasing economic risks to the industry and the total financial losses vary with the degrees of ocean acidification, from 16.08 billion USD to 71.48 billion USD, from 42.66 billion to 189.61 billion USD, and from 121.11 billion USD to 498.28 billion USD, respectively, based on a discount rate of 2%, 3%, and 4%. In addition, we define a microeconomic model to illustrate how ocean acidification affects the mollusk industry's economy. Considering that economic losses greatly depend on policy effects, it is safe to say that effective polices can reduce the negative impacts of ocean acidification and mitigate the risks of the sudden collapse of the industry as well as the resulting social problems.

Keywords: Mollusks; Ocean acidification; Economic assessment

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1. Introduction

Ocean acidification (OA) is the other CO_2 crisis besides global warming (Doney et al., 2009), attracting increasing attention all over the world (Chen et al., 2018). It is a chemical change that causes declines in ocean pH due to excessive absorption of atmospheric CO_2 by seawater (Caldeira and Wickett, 2003). Since the beginning of the Industrial Revolution, the global ocean pH has dropped by 0.1 units, i.e., decreasing pH from 8.2 to 8.1, and it is estimated to drop by another 0.14-0.35 units by the end of the 21st century (IPCC, 2011). This means that OA is dramatically accelerating (Solomon et al., 2007).

OA reduces the availability of calcium carbonate in the oceans (Ries et al., 2009), which will directly affect the growth and development of marine organisms such as mollusks, crustaceans, and corals (Orr et al., 2005). The problem and threat can also send ripples to other species through food web or niche (Le et al., 2011), thus endangering the entire marine ecosystem and human survival (Kroeker et al., 2010). According to the Conference of the Parties to the Convention on Biological Diversity, global marine species will have reduced by 30% to 40% by 2100 due to the impact of OA, of which, the reduction in seawater mollusk species will probably have been as high as 70% (Xu et al., 2016).

Asia is by far the top seawater mollusk producer on this planet, accounting for more than 90% of the total world production (FAO, 2019). As a direct consequence of the irreversible OA process, Asia's mollusk mariculture is likely to suffer severe financial losses in the future. Therefore, it is more necessary for Asian countries to conduct research on the economic impacts of OA on mollusk mariculture than the rest of the world. This paper aims to assess the potential economic impacts of OA on the Asian mollusk mariculture, to make early warning on the future development of the industry, and to provide some evidence for decision makers to prevent its excessive expansion or/and timely implement the industrial restructuring.

2. Literature Review

Since Caldeira and Wickett (2003) first put forward and expounded it in the prestigious journal Nature, many studies have found that OA exerts a series of influence on mollusk's early development (Portner, 2008; Liu et al., 2012), calcification (Felly et al., 2004; Zhang et al., 2011), immunity (Bibby et al., 2008; Liang et al., 2017), physiology (Melzner et al., 2009; Liu et al., 2012; Wang et al,

2014) , reproduction (Kurihara et al., 2009), etc. After Gazeau et al. (2007) proving the relationship between OA and mollusk mortality based on experimental results, researches have expanded into Applied Economics and Management. Some scholars have started studying the economic impacts of OA from the perspective of industrial development.

Cooley and Doney (2009) calculate the potential revenue losses of US mollusk fisheries in 2060 by using three discount rates of 0%, 2%, and 4%. They combine experiment data on the growth rates of mollusks under OA with data on US fisheries harvests and prices, assume that ecological and economic conditions (i.e. catch, prices, and revenues) remain constant. The present value of losses in revenue is estimated to be US$ 2,557 million using the median discount rate of 2%.

Moore (2011) develops a biogeochemical-economic model to assess the potential impacts of OA on the US market for oysters, scallops, clams and mussels from 2010 to 2100. His model includes compensation variables representing changes in consumer welfare, and the estimated impact equals the loss in consumer welfare due to rising mollusk prices caused by OA. The present value of lost consumer welfare is calculated to be US$ 735 million in terms of a discount rate of 5%.

Finnoff (2011) argues that the welfare implications of OA need to be measured by changes in consumer and producer surplus rather than changes in gross revenues. Despite no attempt of estimating values for OA impacts, he makes the point that integrating highly complex ecological processes into an economic model is a real challenge. On the one hand, a reduced form model may be overly simplified and miss non-convexities in the ecological system. On the other hand, a detailed structural model may better capture the complexities of the system but become intractable.

Armstrong et al. (2012) analyze global mollusk production under the best and worst OA scenarios up to 2100. Their study not only identifies the marine ecosystem services that are likely to be affected by OA but also shows that OA may have positive and negative effects on the provisioning services of fisheries and aquaculture. In addition, the study considers a discount rate of 4% to be best in the present value calculation for future OA impacts.

Narita et al. (2012) estimate the value of global losses of mollusk production due to OA from 2000 to 2100. They follow the method of Cooley and Doney (2009) but adopt a higher loss rate of calcification and assume that demand for mollusks increases with income. Hence, they figure out worse results, i.e., the annual global costs in 2100 could be over US$ 100 billion, under a business-as-usual emission trend of CO_2. Narita and Rehdanz (2017) even focus their attention on European mollusk production losses, indicating that every year's costs will exceed US$ 1 billion after 2100 and France, Italy and Spain, the current major producers, will be the hard-hit areas.

Onofri and Pald (2017) construct a microeconomic model to evaluate the economic impacts of OA on the world's top ten mollusk and crustacean markets. The yields affected by OA are critical variables in the model that affect three objective functions for consumers, producers, and policymakers. Their results show that OA can both generate gains or losses according to the biological scenarios they embrace for producing predictions.

In summary, though there are very few economic studies that measure the impacts of OA on mollusk mariculture, they provide an effective way to predict the future development trend of the industry from an economic perspective. They are of great practical value, except only focusing on the US or European mollusk industry and no enough attention for Asia’s future.

3. Methodology

3.1 Research design

It is important to note that OA does not directly affect the industrial economy, but affects it by reducing the production of mollusk mariculture. The assessment of OA impacts accordingly requires an integration of research findings that can bridge disciplinary boundaries (Brander et al., 2014).

Assessing the direct economic impacts of OA on Asian mollusk mariculture of the future involves two key steps.

(1) To determine the degree of OA and the relationship between it and seawater mollusk production is the first one. It involves some knowledge of marine chemistry or biogeochemistry. To cross the chasm in this field, we quote the published results of renowned scholars and the research conclusions issued by authoritative organizations such as the Intergovernmental Panel on Climate Change (IPCC).

(2) To estimate the value of the lost production caused by OA is the other one. This step mainly belongs to the research category of microeconomics and is what we focus on in this paper.

In terms of the specific operation, we use a net present value (NPV) method based on different discount rates to assess the economic impacts of OA. The method takes into account essential indicators, e.g., inflation and risk compensation, and eliminates the interference of many variables, e.g., supply and demand, breeding costs and sales prices. Thus, it can present the potential financial loss of the future intuitively and make the estimation feasible and straightforward.

3.2 Data collection

The index and future trends of OA in this paper are quoted from IPCC. IPCC has simulated the best, medium and worst three scenarios of global OA at the beginning of the next century, which predicts that amounts of CO_2 in the ocean are 550ppmv, 700ppmv, and 950ppmv and the corresponding seawater pH balances are 7.95, 7.85, and 7.7.

The mortality of seawater mollusks due to OA is quoted from the experimental findings of Gazeau et al. (2007). Those findings, suggesting that death rates are 9%, 25% and 40% under three scenarios respectively, have been proved by Cooley and Doney (2009) and are also currently recognized by academia.

The yield and value data of Asian seawater mollusks are obtained through FishStatJ, which is an official statistical software of the World Food and Agriculture Organization (FAO). According to recent statistics, the Asian mollusk yield is about 15.81 million tonnes, and its value is equivalent to 24.66 billion USD.

3.3 Calculating formula

In terms of yield in the future, the equation is given by:

$$Q_t = Q_0(1 - d) \tag{1}$$

where Qt represents the yield of Asian seawater mollusks after t years, here, t is set to 100, Q_0 represents the current yield, and d is the mortality caused by OA, equaling 9%, 25% or 40%.

The lost net present value in the future, is expressed as:

$$NPV = R_t - R_t' \tag{2}$$

where R_t represents the theoretical future revenue of Asian seawater mollusks if free from negative OA impacts, is given by:

$$R_t = R_0(1 + r)^t \tag{3}$$

and R_t' represents the actual future revenue of Asian seawater mollusks when subjected to negative OA impacts, is given by:

$$R_t' = R_t(1 - d) = R_0(1 + r)^t \times (1 - d) \tag{4}$$

Combining equation (2) with (3) and (4), we can rewrite the expression as:

$$NPV = R_t \times d = R_0(1 + r)^t \times d \tag{5}$$

all meanings of parameter R_t, R'_t, t and d are the same in the above equations, R_0 represents the current revenue of Asian seawater mollusks, r is the discount rate, in this paper, r is set to 2%, 3%, and 4% to calculate the lost present value, respectively.

4. Results

The current yield of Asian seawater mollusks is about 15.81 million tonns in total. No matter which scenario occurs, it will potentially be reduced by OA in the future. As shown in Table 1, the future loss of Asian mollusk mariculture is estimated to be 1.42 million tonnes, 3.95 million tonnes and 6.32 million tonnes under the best, medium and worst scenarios, respectively. In each scenario, the species with the higher yield now are the ones more affected by OA negative impacts in the future. Consequently, clams, oysters, scallops, mussels, abalones, and miscellaneous mollusks are in descending order of the loss in volume.

Table 1. Current yield and future loss of Asian seawater mollusks (Unit: million tonnes)

Species	Yield in 2017	Loss in 2117 (Best Scenario)	Loss in 2117 (Medium Scenario)	Loss in 2117 (Worst Scenario)
Clams	5.58	0.50	1.40	2.23
Oysters	5.44	0.49	1.36	2.17
Scallops	2.16	0.19	0.54	0.87
Mussels	1.17	0.11	0.29	0.47
Abalones	1.03	0.09	0.26	0.41
Miscellanea	0.42	0.04	0.10	0.17
Total	15.81	1.42	3.95	6.32

Sources: own elaboration and calculation from FAO (2019)

Table 2 lists the present value of Asian mollusks in 2017 and that in the next 100 years if the yield maintains the current state and there are no negative OA impacts. According to the NPV method, the present value of Asian mollusks in 2117 will theoretically be 178.69 billion USD, 474.02 billion USD and 1245.7 billion USD at a discount rate of 2%, 3%, and 4%, respectively. Compared with Table 1, mussels make a significant change in rankings. The reason for the dropping of this species, from 4th in yield to 6th in value, is ascribed to its low price per quality unit.

Table 2. Present value of Asian seawater mollusks in current and the future (Unit: billion USD)

Species	Value in 2017	Value in 2117 (*r* = 2%)	Value in 2117 (*r* = 3%)	Value 2117 (*r* = 4%)
Clams	9.47	68.60	181.98	478.22
Oysters	5.98	43.32	114.93	302.03
Scallops	5.53	40.05	106.24	279.20
Abalones	2.06	14.94	39.63	104.14
Miscellanea	1.05	7.57	20.09	52.80
Mussels	0.58	4.20	11.15	29.31
Total	24.66	178.69	474.02	1,245.70

Sources: own elaboration and calculation from FAO (2019)

With the aggravation of OA, direct financial losses of Asia's mollusk mariculture probably will increase and the amounts of the losses will depend on OA levels. If OA can be mitigated by effective polices in the future, i.e., under the "best scenario" simulated by PICC, the total loss in 2117 will be 16.08 billion USD, 42.66 billion USD and 112.11 billion USD. In case of happening the "medium scenario", the total loss of the same year will nearly triple, ranging from 44.67 billion USD to 311.42 billion USD. Once the "worst scenario" comes out in reality, which indicates that the OA crisis will intensify in the future, then the total direct loss will nearly triple again, from 71.48 billion USD to 498.28 billion USD.

Table 3. Financial losses of Asian seawater mollusks due to ocean acidification in the future

(Unit: billion USD)

Species	Loss in 2117 Best Scenario)			Loss in 2117 Medium Scenario)			Loss in 2117 Worst Scenario)		
	r = 2%	r = 3%	r = 4%	r = 2%	r = 3%	r = 4%	r = 2%	r = 3%	r = 4%
Clams	6.17	16.38	43.04	17.15	45.49	119.56	27.44	72.79	191.29
Oysters	3.90	10.34	27.18	10.83	28.73	75.51	17.33	45.97	120.81
Scallops	3.60	9.56	25.13	10.01	26.56	69.80	16.02	42.50	111.68
Abalones	1.34	3.57	9.37	3.73	9.91	26.03	5.98	15.85	41.66
Miscellanea	0.68	1.81	4.75	1.89	5.02	13.20	3.03	8.04	21.12
Mussels	0.38	1.00	2.64	1.05	2.79	7.33	1.68	4.46	11.72
Total	16.08	42.66	112.11	44.67	118.51	311.42	71.48	189.61	498.28

Sources: own calculation from FAO (2019)

It can be seen from Tables 2-3 that the discount rate has a significant impact on the calculation results. A 2% discount rate, i.e., the liberal IPCC discount rate (much lower than the 7% conservative IPCC discount rate), is usually considered the lower limit to estimate the possible financial losses generated via the NPV equation. A 3% discount rate is argued by some scholars to be the government accepted discount rate for a medium to long-term prediction, which is also a fairly representative rate in economics. While a 4% discount rate is considered by Armstrong et al. (2012) to be the best one for a global forecast.

5. Discussions

5.1 The choice of discount rate

For the above discount rates, we tend to utilize a 4% discount rate to assess the economic impacts for the future basing on the following considerations.

(1) The lower discount rate reflects the more extended periods. Considering that the time set for the "future" in this paper is one hundred years later,

which is equivalent to experiencing about three generations, and US government guidance is to use discount rates of both 3% and 7% for valuing costs and benefits within a single generation (IPCC, 2017), hence, the discount rate should not be set too high, say, over 5%.

(2) The higher discount rate corresponds to faster economic growth. Asia's economic growth is faster than the world average. Notably, Asian newly industrializing economies, which are also the top seawater mollusk producers, are growing at a high rate (6.5 % for the year of 2018). Therefore, the discount rate should be higher than 3% as long as Asia's economic growth remains at a relatively high speed.

Therefore, a 4% discount rate may not only accord with the concept of bounded rationality in mainstream economics but also be helpful to reduce the social cost of OA.

5.2 Revelations for policymaking

Given that consumers, producers, and policymakers jointly determine the development of mollusk mariculture.

The consumers' utility (*U*) depends on the consumed quantity (*Q*), the buying price (*p*) and the ocean environmental quality (*K*), while Q depends on two other variables *p* and *K*, so the basic equation is mathematically expressed as:

$$U_y = Q\left(p_y;\ K_y\right) \tag{6}$$

where subscript y indicates the year. If $\frac{\partial U_y}{\partial Q_y} \cdot \frac{\partial Q_y}{\partial p_y} < 0$, marginal price increase will reduce consumers' spending. Nevertheless, it is not enough to make a quantitative prediction because variable p is not directly affected by OA. Thus, a further assumption of $\frac{\partial U_y}{\partial Q_y} \cdot \frac{\partial Q_y}{\partial K_y} \neq 0$ need making, and in this case, OA will affect *Q* and *U* in turn.

The producers' profit (π) depends on the produced quantity (*Q*), the selling price (*p*), the production cost (*c*) and the ocean environmental quality (*K*) that affected by OA, while Q depends on *p*, *c*, and *K*. The objective function for producers is expressed as:

$$\pi_y = Q\left(p_y; c_y; K_y\right) \tag{7}$$

If $\frac{\partial \pi_y}{\partial Q_y} \cdot \frac{\partial Q_y}{\partial p_y} = \frac{\partial \pi_y}{\partial Q_y} \cdot \frac{\partial Q_y}{\partial c_y}$, i.e., the marginal cost is equal to the marginal revenue, π will be maximized. In this case, π is also affected by $\frac{\partial \pi_y}{\partial Q_y} \cdot \frac{\partial Q_y}{\partial K_y} \neq 0$, which means that OA will affect Q and π in turn through the direct impacts on K.

Policymakers have to consider the total social welfare (*W*) in the future, i.e., the sum of the consumers' surplus and the producers' surplus. The objective function for policymakers is expressed as:

$$W_y = U_y + \pi_y = Q(p_y;\ K_y) + Q(p_y; c_y; K_y) \tag{8}$$

It is evident that W much depends on variable Q that affected by OA. Therefore, the variation of OA in the future can ultimately determine social welfare, which also suggests that understanding what potential losses OA will bring to social welfare helps in making policies.

5.3 The cost of inaction

Generally speaking, for policymakers, only when the social welfare of implementing policies is higher than the cost of making them, they have the willingness to do so. According to our estimation based on a 4% discount rate, the financial losses of Asia's mollusk mariculture due to OA in 2117 will range from 112.11 billion USD to 498.28 billion USD. It also means that the losses will be as high as 498.28 billion USD if we neglect the problem or pay attention but fail in implementing effective polices.

However, a key thing worth emphasizing is that these figures may even underestimate the real losses for the following reasons.

(1) Due to the absence of a better solution, we have to estimate the potential losses in yield by multiplying the current volume by the experimental mortality. Though the inflection-point yield for the future is hardly predictable, facts show that the scale of Asia's mollusk mariculture stays expanding. Thus, from this angle, the yield losses in the future may be more than what we estimated, as well as the financial losses.

(2) We assume a linear relationship between the yield losses and the degrees of OA from a biochemical perspective to make the assessment more workable. But it is also possible that producers may accelerate their departure due to reduced production and financial results. In such a circumstance, the yield losses will be the resultants of both natural changes and human activities. That might further cause an extreme situation, i.e., even though the total yields decline significantly, the total value perhaps create new high because the prices increase more significantly due to supply shortages during a certain period of time.

6. Conclusion

With the increased combustion of fossil fuels due to rapid industrialization, urbanization, and population growth, oceans have begun to taken up excessive amounts of CO_2, resulting in an acceleration of OA. This irreversible trend can make serious economic impacts on the global mollusk mariculture. As the top mollusk producer by far, Asia may well bear the brunt of the crisis.

In this paper, we have empirically analyzed the potential economic impacts of OA on Asia's mollusk mariculture by using the net present value method. According to our estimation, the direct financial losses of the industry vary with the changes of OA degree and they can exponentially increase under the best, medium and worst scenarios simulated by IPCC. Once the worst scenario occurs in the future, Asia will trigger a total financial loss of 4.5 times higher than that under the best scenario. The potential hazard implies that it is urgent for Asia to establish a set of risk prevention system.

The microeconomic model applied in this paper further help us understand the mechanism of OA action on the mollusk economy and let us get clear about what policymakers really consider. It is obvious that the losses of the Asian mollusk mariculture may be incredibly huge-up to nearly 500 billion USD in 2117 unless effective measures are taken in time.

Furthermore, the final financial losses of the Asian mollusk mariculture greatly depend on policy effects. If policies are effective, the losses of the industry can be small -- and vice versa.

Therefore, it can be concluded that even though formulating and implementing targeted policies cannot completely eliminate the negative impacts of OA, at least it can mitigate the risks of the sudden collapses of the industry as well as some resulting social problems.

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Mongolia's Transition to Maritime-linked Country from Land-locked Country: Focusing on Artic Route linked with Inland Water Transport

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ABSTRACT

Mongolia is a landlocked country and has a poor environment in terms of logistics. This is limiting the export of Mongolia's abundant resources at normal prices, and it is in the form of exploitation that can only be cheaply sold between Russia and China. However, due to the global warming, there is a possibility that Mongolia will be developed into a new maritime linked country by utilizing Arctic sea route and Russian inland waterway. Possible routes include the Selenga River in Northern Mongolia, Lake Baikal and Yenisei river-NSR in Russia. This study examined the status and the possibility of linking this route. In the past, Russia and Mongolia signed an agreement in 1925 to link the Selenga-Ulan-Ude-Baikal.

One hundred years ago, when global warming was not in full swing, this agreement was intended to link the inland and land / shipping. Global warming may be an opportunity for the development of the region, with better conditions now underway in the commercialization of Arctic routes. Therefore, in order for Mongolia to leap as a maritime nation, the international complex logistics of the new Northern logistics market based on the development of East Siberia of Russia and the activation of the Arctic route, strengthens logistics linkage between Mongolia and Russia, and builds a complex logistics system, it is necessary to establish a system while carrying out a further research.

Key words: Mongolia, Inland waterway, NSR, Connectivity

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1. Introduction

In September 2019, Russia and Mongolia upgraded their relationship to "inclusive partner relations". Russian President Putin, who visited Mongolia at the time, announced plans to invest in transportation logistics infrastructure through the Russia-Mongolian Joint Investment Fund (Tass, 2019). Mongolia's share of foreign trade in Russia is 0.2% in 2018, which is only 59th (ru-stat, n.d.) in the overall ranking of Russia's trading partners. Nevertheless, the biggest reason Russia is interested in investing in logistics infrastructure in Mongolia is its strong willingness to reduce its trade distance with China through Mongolia, which borders its borders, and to secure transportation routes to Asia. And for many parts of Siberia that are close to Mongolia (Republic of Buryatia, Republic of Tuva, Irkuchuk Oblast, Republic of Altai and Javakalkal Krai), Mongolia is the second most important economic cooperation partner after China, and since these regions are deeply inland, they are able to access China's transportation logistics network through Mongolia rather than using domestic rail and Far East ports. This is because it is more advantageous in terms of distance (Jeh et al., 2016). Meanwhile, Russian President Putin announced on May 7, 2018, that through the "National Government Development Goals and Strategic Tasks by 2024", the use of Arctic routes will be increased to 80 million tons by 2024. This is more than four times the 17 million tons in 2018 (Ludmila, 2019). As a result, Russia needs to develop a new logistics system connected with Mongolia and develop East Siberia in order to activate the Arctic route.

Mongolia has also recently implemented foreign policy considering traditional motive and a new international situation. Recognizing that the lack of transportation and logistics infrastructure connected to overseas markets is the biggest obstacle to industrial development and export growth, Mongolia proposes the 'Steppe Road' initiative utilizing the designated and geopolitical advantages located between Russia and China. The strategy is to build a transportation and logistics network that connects China and Russia by maintaining and constructing railroads, roads, power grids, and oil and gas pipelines that cross the territory of the country (Jeh et al., 2016). As such, Russia seeks to secure a logistics route to inland China via Mongolia's railway, while Mongolia secures a logistics route connecting Russia's ports and even Arctic routes through trans-Siberian trains and inland waterways to escape China's dependence on logistics. This is an urgent need.

In this study, it will examine the logistics cooperation between Russia and Mongolia through the development of Russia-Mongolia's transportation infrastructure and explore the possibility of connecting the Arctic route through the Siberian inland waterway of Mongolia. The structure of the study is as follows. Following the introduction of Chapter 1, Chapter 2 first examines the possibility of linking the inland waterway and the Arctic sea route in East Siberia. Chapter 3 analyzes the foreign trade between Russia and Mongolia and investigates the current logistics infrastructure status. In addition, the current state of infrastructure investment in Mongolia, which has much underdeveloped transportation infrastructure and the Russia-China logistics infrastructure project, will be examined. Based on this, Chapter 4 examines the possibility of linking the water transport between Russia's Siberian Region and the Mongolia's northern waterway, which can be connected to the Arctic route as a means of linking the logistics route between Siberia and Mongolia. In the conclusion, the previous studies are reviewed and the possibility of linking the Arctic route in Mongolia and the implications of the paper are drawn.

2. Literature Review

2.1 Inland Water Transport

Due to the climate change, the availability of Arctic sea routes and the increase in Arctic energy development have led to active research on logistics routes using inland waterways and Arctic sea routes in Siberia. In addition to serving as a hinterland for the Arctic Ports, it is intended to develop Siberian inland waterway as a major element of the Russian inland logistics linkage. Sherbanin (2016) published the Russian Federation's Inland Water Development Strategy 2030, announced by the Russian government in February 2016, which demanded oil and gas companies, as well as transporters, from oil fields in Siberia and the Arctic. He stressed that the Siberian transport network using inland waterway in the meridian is essential for the transportation of special materials used for development, large quantities of machinery, and the efficient transport of developed resources. Sherbanin also anticipated that the development of the Arctic route would be a substantial aid to the development of Siberian oilfield and hydrocarbon development projects, which would intensify maritime transport and generate large quantities of cargo transported by sea to the southern railway. Goncharenko (2006) continues to insist that Russian transport corridors be included in international transport corridors. He further expanded the existing corridor in Russia and Europe to the east and underlined the TSR through the large cities of Siberia, creating a route that connects the Arctic route, emphasizing the need to build an international corridor connecting both Southeast Asian countries and Western Europe. To this end, Siberian Rivers, the only meridian transit route on the Eurasian continent, are very important and argue that Russian inland waters should be opened to foreign vessels. In this case, the increase in freight transport would lead to the development of transport corridors and the reduction of Russian costs for the maintenance of waterways and hydraulic structures.

He took the Yenisei-Arctic route system as an example, while many of the underground mineral resources in the Yenisei-Angara basin are in high demand from Europe and Asia, while large factories in regions such as Irkutsk and Novokuznetsk have to import raw materials from outside Austria, France, Germany, etc. That's why it's necessary to use a route that connects the Arctic route to the waterways of Dudinka, Igarka and Lesosibirsk. In addition, Maslennikov (2017) cited the resource deposits in the Sakha Republic as an example and mentioned the necessity of utilizing inland water transport considering the characteristics of resource deposits. He also emphasized the construction of river transshipment infrastructure based on the rivers and arctic routes of the Arctic Siberia region, and Zachesov (2006) insisted on developing and utilizing Siberian inland waterways as the shortest logistics route between Europe and Asia. In this case, Siberian economic development would be possible. Galin (2014) cited the reasons for the decline of the inland transport business in the 21st century, the development measures and the need for government support. He said that inland transport of certain cargoes should be supported to ensure inland transport participation in the national transport infrastructure. As mentioned above, research on the Siberian inland waters has been actively conducted in various areas such as TSR / NSR linkages and related national policies and development plans.

Internationally, Lee (2017) proposed the use of Siberian inland waterways as one of the gradual approaches to address obstacles in the commercialization of Arctic routes. He stressed that the export of minerals and forest resources buried throughout Siberia through water transportation would compensate for the shortage of cargo on the Arctic route. In addition, the absence of a logistics route connecting North and South to Siberia should be resolved by linking NSR and TSR through Siberia's inland waterways such as Ob', Yenisei and Lena. In addition, Ye and Bae (2016) mentioned the necessity of developing the Arctic port infrastructure linked to the river transport network in Siberia in the Russian Arctic Strategy through analysis of Russian strategic documents.

2.2 International Inland Logistics Linkage

In this study, studies on inland water transport as well as previous studies on the connection of water and land transport in neighboring countries are necessary. First, Sokolova (2012) refers to the Marco Polo II program, where EU countries convert 15% of intercity and intercity cargo into inland water by 2030 to improve the environment and reduce highway loading, it emphasized the need to increase the utilization of the single-depth system, the inland waterway in

Russia and Europe, developed earlier than the Siberian inland waterway. He also emphasized the need for autonomous navigation of foreign vessels, comparing the autonomous operation of overseas vessels on the Rhine-Main-Danube Canal with the restriction of one foreign vessel navigation in the current inland waters of Russia and Europe. Truxinova (2016) now raises bottlenecks and low-level problems in the single-depth system of Russia's European region. To solve this problem, the construction of low-pressure hydraulic systems on the Volga River in the Nizhni Novgorod region and hydroelectric power plants on the Don River in the Bagaevskii region should address the bottlenecks of the single-depth system in Russia's European region.

Meanwhile, as a transportation logistics network that connects Central Asian countries on the Eurasian continent with Russia, UNESCAP is in the process of linking roads between countries through the TIR agreement (Customs Convention on the Int'l Transport of Goods under cover of TIR Carnets)[1]. Most of Central Asian countries are landlocked countries, but the role of railway and road sectors is important, but the infrastructures such as road width, number of lanes, pavement, road sign, and safety facilities are not evenly developed. The use of international transportation is low due to unrestricted transportation restrictions and related regulations. Indeed, as introduced in the Cooley (2016) study, the import and export period of goods in Central Asia is twice as long as in Southeast Asia and three times as much as in the Middle East and North Africa. In order to improve these problems, efforts are being made to improve connectivity to infrastructure, customs, and institutions.

The previous studies focus on the development of Siberia's inland waterway, the development of resources in Siberia, the linkage of NSR-TSRs, and the use of Arctic routes. Some studies have also considered alternatives to improve terrestrial logistics networks with neighboring countries. On the other hand, this study suggests a method of linking Siberia with Mongolia's waterway, that is, foreign rivers and Siberian waterway, to broaden the scope and possibility of inland water transport and to propose a new way of establishing inland transportation routes in Eurasia.

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*1 The Convention on International Transport of Goods Under Cover of TIR Carnets (TIR Convention) is a multilateral treaty that was concluded at Geneva on 14 November 1975 to simplify and harmonies the administrative formalities of international road transport.

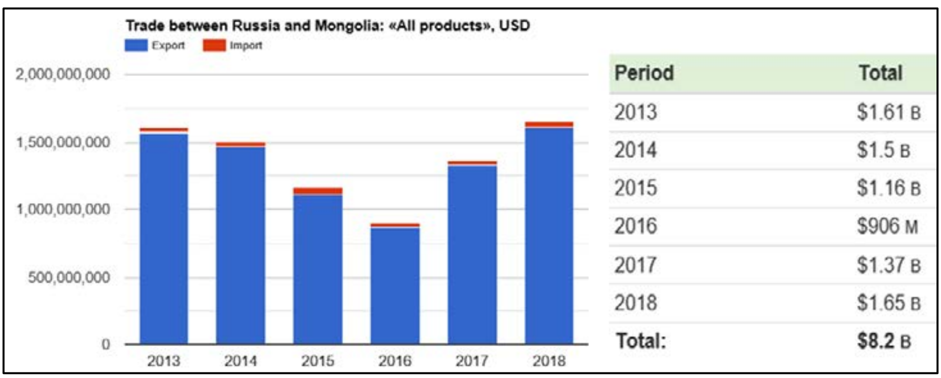
3. Logistics Infrastructure between Russia and Mongolia

3.1 Foreign trade between Russia and Mongolia

Mongolia's economy depends heavily on mining. It is the world's three richest uranium rich country and its coal reserves rank tenth in the world. Mongolia has a wide range of useful minerals, including the world-class ‘Tavan Tolgoi’ coal mine and ‘Oyu Tolgoi’ gold and copper mines. It accounts for 56% of industry’s total output and 90% of total export, and the resource dependence of industry and export is very high (Jung, 2019).

Mongolia's exports rely on China (93.8%), UK (3.8%), and Russia (1.1%), while imports rely on China (34.3%), Russia (29%), Japan (9.7%) and Korea (4.3%). From China, minerals such as copper concentrate and coal are exported, and power energy is imported. Russia is mainly importing petroleum products (KOTRA, 2019). As about 90% of freight between Russia and China is transported using Mongolian railways, Mongolia can be seen as a strategic center for Russia-Middle freight rather than a Russian trading partner. However, Mongolia's railway and road infrastructure is very poor, requiring modernization and expansion through investment (Douglas et. al., 2019). Russia is also interested in investing in Mongolia's transportation infrastructure, as a trading partner facing Mongolia, as well as a route to energy and cargo transportation to China.

Figure 1. Russia's Trade with Mongolia (2013-2018)



Period	Total
2013	$1.61 B
2014	$1.5 B
2015	$1.16 B
2016	$906 M
2017	$1.37 B
2018	$1.65 B
Total:	**$8.2 B**

Source: https://en.ru-stat.com/date-Y2013-2019/RU/trade/MN (Date of access: 2019. 10. 25)

The largest share of foreign trade between Russia and Mongolia is mineral products, with trade amounts to 67.8% of the total trade between 2013 and 2018. Next food, beverage, tobacco products and industrial products ranked second and third with 6.7% and 5.1%, respectively.

Table 1. Russia's main imports with Mongolia (unit: $10,000)

Product	2013	2014	2015	2016	2017	2018	proportion	Rate of change
Minerals (salt, sulfur, earth and stone, gypsum material, lime & cement)	3,310	3,100	3,590	2,690	2,880	2,930	66%	-7%
Meat & meat product	120	580	550	500	660	730	13%	512%
Clothing & apparel accessories	120	130	97.2	200	390	440	6%	263%

Source: https://en.ru-stat.com/date-Y2013-2018/RU/import/MN(Date of access: 2019.11.13)

Table 2. Russia's main exports with Mongolia (unit: $ million)

Product	2013	2014	2015	2016	2017	2018	proportion	Rate of change
Mineral Fuel and Mineral Oil・Products	1,140	3,100	3,590	2,690	2,880	2,930	67%	-10%
Food, beverage and tobacco	108	90.4	76.1	79.5	92.6	101	7%	-6%
chemical products	62.9	55.2	50.9	57.4	93.3	98.8	5%	57%

Source: https://en.ru-stat.com/date-Y2013-2018/RU/import/MN(Date of access: 2019.11.13)

3.2 Transport infrastructure between Russia and Mongolia

3.2.1 Rail

More than 95% of Mongolia's import and export cargo is transported by rail. The Mongolian Transverse Railway (TMGR), Mongolia's main railway, is 1,108 km in length and connects Sukhbaatar – Ulaanbaatar - Zamiin-Uud. In addition, TMGR is linked to Europe with Russia's Siberian Transverse Railway (TSR) and is also used as a major logistics infrastructure in Northeast Asia because it is also linked with China's Transverse Railway (TCR).

In 2018, cargo shipments on the Ulaanbaatar Railway (UBTZ) (24.5

million tons) increased 1.8 million tons from 2017, 27% of which are transshipments and imports. By 2030, Ulaanbaatar Railway's transport volume is expected to increase to about 50 million tons, but this would not be possible without the development of railway infrastructure. Mongolia's coal exports in recent years have been a big boost to the national economy, outpacing other products. Mongolia's coal exports in 2018 were about $ 2.8 billion, nearly three times higher than in 2016 (Zagalova et. al., 2019). The development of the coal industry and the formation of product flows have a significant impact on Mongolia's railway development. Mongolia, which has the world's 10th largest coal reserves, is China's main coal exporter and China mostly uses roads. However, the current rail and road infrastructure alone has not kept up with the growing coal production, so the Mongolian government is trying to improve its China-dependent import and export logistics system. Construction of the Erdenet-Ovoot segment (see Figure 2) has begun, which will link both the Russian border and Ulaanbaatar railway to the north of Mongolia (Zagalova et. al., 2019).

Figure 2. Status of railways in Mongolia

Source: https://vcatuva.ru/news/2016/03/15/3933.html (Date of access: 2019.11.14.)

3.2.2 Road and Water transport

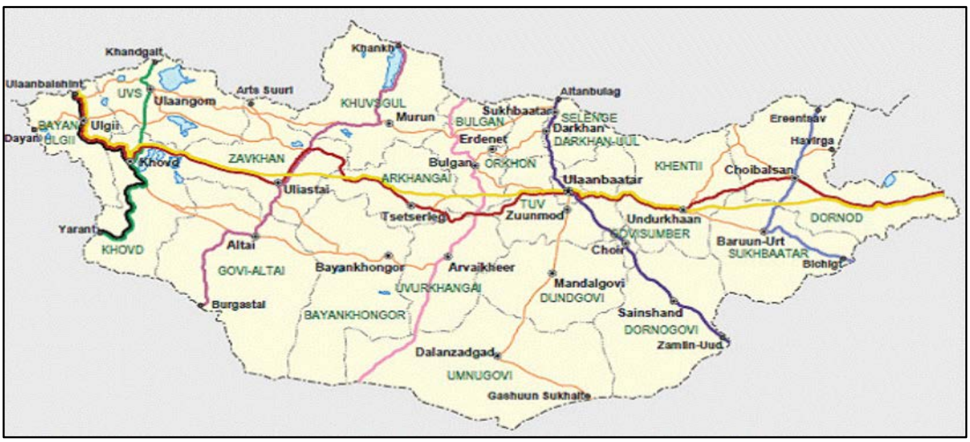
In 2017, Mongolia's road network was 10,355 km long. Among these, paved roads occupy 8,431 km, an increase of 5,414.8 km from 2010. Since 2001, Mongolia has been promoting the Millennium Road project to link the international transportation network with neighboring countries and to improve the domestic transportation network. Mongolia's Millennium Road includes the North-West Highway, which is a crossroad between the East-West Highway and the Interstate crossing of AH32 on the Asian Highway, and five main roads that cross the North and South. In other words, this road refers to a road (2,653km) from the eastern end of Mongolia to the western end via the capital Ulaanbaatar and five other roads (KHIDI, 2019).

Table 3. Mongolia's road and traffic status

	2010	2013	2014	2015	2016	2017	Rate of change
Road full length(km)	6,734	8,875	9,428	9,812	10,126	10,355	3.9
Improved road length(km)	3,015	5,838	6,461	7,125	7,456	8,431	9.6
Traffic volume (1,000 ton)	12,610	28,748	37,640	35,829	40,398	53,981	17.1

Source :www.khidi.or.kr/board/view?pageNum=1&rowCnt=10&no1=&linkId=48764140&menuId=MENU01826&maxIndex=00487816369998&minIndex=00348368939998&schType=1&schText=&schStartDate=&schEndDate=&boardStyle=&categoryId=&continent=AS&country=MNG (Date of access: 2019.12.15)

Figure 3. Road state in Mongolia



(red)	AH32	(purple)	AH3	(light pink)	Road4
(yellow)	Millennium Road	(green)	Road2	(light blue)	Road5
(black)	AH4	(pink)	Road3	(orange)	Road chain

Source :www.khidi.or.kr/board/view?pageNum=1&rowCnt=10&no1=&linkId=48764140&menuId=MENU01826&maxIndex=00487816369998&minIndex=00348368939998&schType=1&schText=&schStartDate=&schEndDate=&boardStyle=&categoryId=&continent=AS&country=MNG (Date of access: 2019.12.15)

The road leading to the Russian border is linked with the Russian road A340, which runs through Ulan-Ude, the capital of the Buryatia Republic. The A340 is linked to the Asian Highway (AH3), an international corridor that connects Russia, Mongolia and China, to Mongolia's Ulaanbaatar, Inner Mongolia and eastern China. In addition, the Russian roads leading to the Mongolian border include P256 (Novosibirsk-Mongolian border), P257 (Krasnoyarsk-Mongolian border), A333 (Kultuk-Mondi-Mongolian border) (Wikipedia, n.d.).

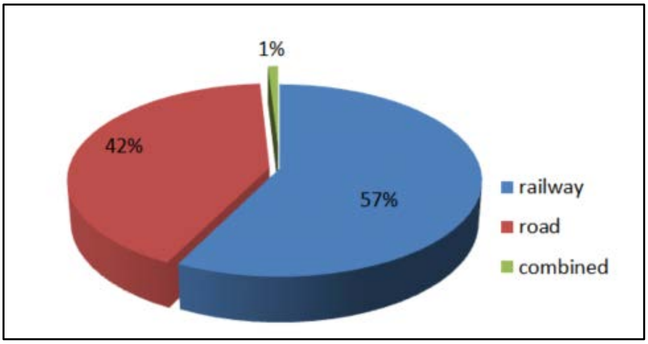
Mongolia's only inland waterway was developed by the Selenga river (270km) and its tributary Orkhon river (175km), which flows through the Russian border into Lake Baikal. It is very insignificant. Mongolia's rivers and lakes are total 580 km long. The Hubsugul is the only lake developed for transportation. The free shipping period is from May to September, but cannot be used (Wikipedia, n.d.). In Siberia, on the other hand, the Yenisei River, the Ob' River and the Lena River, which are connected to the Arctic route, are already used as water transport.

3.3 Mongolia Transportation Infrastructure Investment Status

Mongolia's transportation infrastructure is very backward and underdeveloped, and much of the funding is needed to maintain the current infrastructure level. Compared with other countries, middle-income countries spend only 0.75% of average GDP on their road infrastructure maintenance, while Mongolia spends only 0.15%. Even in order to maintain its current network, Mongolia needs to increase 84% of its current road capacity and 65% of its rail capacity by 2030 and increase by 284% and 306% of road and rail by 2050, respectively.

Given that the Ulaanbaatar railways in Mongolia carry most of the cargo between China and Russia, this infrastructure expansion is not an internal Mongolia but an important infrastructure development strategy at the international level. In addition, the severe imbalance of infrastructure between Mongolia's regions is why infrastructure investment is so important. As of 2016, railroads were applied to only seven of the 21 administrative districts in the country, and only 16 areas were linked to the capital, Ulaanbaatar. In 2019, Mongolia's transportation infrastructure project totaled $ 12.7 billion (Douglas et. al., 2019).

Figure 4. Transportation Infrastructure Project



Source: Douglas et. al., "Стратегическоепланированиеинфраструктурыдляустойчивогоразв итиявМонголии", ENV/EPOC/EAP(2019)10 (Date of access: 2019.12.22)

Table 4. Mongolia Transportation Infrastructure Investment Project

Project		Sector	Investment Amt.($million)	Investing Org.	Type
Ongoing	Altanbulag(Selenge) – Ulaanbaatar –ZamiinUud(Dornogov))	Road	3,500	Tsingis Land Development Group	New
	Erdenet–Ovoot(547km)	Railroad	1,250	China National Railroad	New
	Urban Transportation Development Investment Program	Road	273	The Asian Development Bank	existing
	Western Road Corridor Investment Program	Road	125	The Asian Development Bank	existing
Planning	Ukhaa Hudag (South gobi aimak) –Gashuun Sukhait	Railroad	970	BNP Paribas, European Bank for Reconstruction and Development	New
	Tavan Tolgoi-Gashuun Sukhait Railroad Infra.	Railroad	1,070	Shenhua Group, Sumimoto Trading Company	New
	Bogd–Khan Detour Route Program	Railroad	500	The Asian Development Bank, Mongolia Government	existing
	Tavan Tolgoi, Gashuun Sukhait Road(250km)	Railroad	256	National income	New
	Nariin Sukhait–Shivae Huren Railroad Infra.	Railroad	145	National income	New

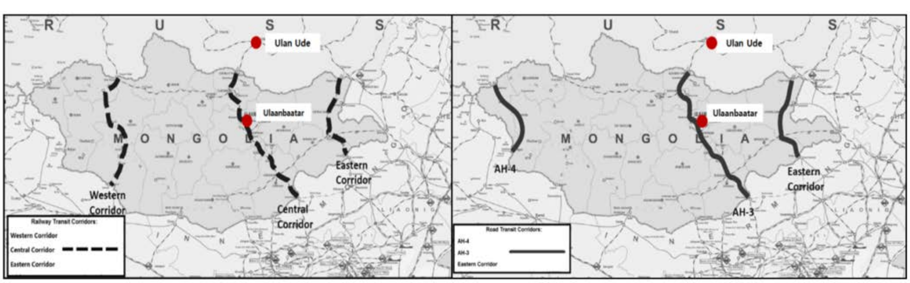
Sources: Douglas et. al., "Стратегическоепланированиеинфраструктурыдляустойчивого развитиявМонголии", ENV/EPOC/EAP(2019)10 (Date of access: 2019.12.22)

3.4 Building Economic Corridor between Russia-Mongolia-China

Discussions on the establishment of the Russia-Mongolia-China Economic Corridor first began at the Shanghai Cooperation Organization Summit held in Tajikistan in September 2014, and then in the summer of 2016. Delegates signed the Russia-Mongolia-China Economic Corridor Construction Program. The program aims to increase trade, mitigate border transport, develop infrastructure and increase the competitiveness of cooperative products in global markets. The five year period is planned and consists of 32 projects. The construction of the Russia-Mongolia-China Economic Corridor is linked to the strategies planned by each of the three countries, including the establishment of the Eurasian Economic Union in Russia, the one-on-one in China, and the Mongolian grasslands. Mongolia's interest in building a three-way corridor is to take advantage of its geopolitical potential to seize the opportunity to enter neighboring markets. Mongolia's development of mining industry and the active production of minerals have to find transportation routes for overseas exports, but the logistics infrastructure is very poor, so they are dependent on China and Russia. In particular, the backwardness of the Mongolian railroad is decreasing its potential as a transit route. In 2016, 1,700 containers of Chinese cargo via Kazakhstan and 1,200 containers of trans-Manchuria Railway were compared. There are only 170 containers via Mongolia. However, due to its location connecting China and Europe, Mongolia's Ulaanbaatar Railway can shorten 1,135km more than the Manchurian Railroad and 1,600km more than the railway via Kazakhstan (Frolova, 2017).

In Russia, the economic corridors of the three countries are expected to not only be a driving force for the economic development of the Eurasian economies, but also to play a major role in the development and modernization of Siberia and the Far East. The realization of this project will not only expand the basis of the Siberian Trans-Train, but will also diversify the transportation network, and China will be able to use the corridor through Mongolia to increase access to the ocean (Frolova, 2017).

Figure 5. Railway (left) and road (right) of ⟨Russia-Mongolia-China Economic Corridor⟩



Source: http://edrj.ru/article/13-06-17 (Date of access: 2019.11.15)

4. Logistics linkage between Russia and Mongolia

4.1 Utilization of water transport between East Siberia and Mongolia (Yenisei and Selenga)

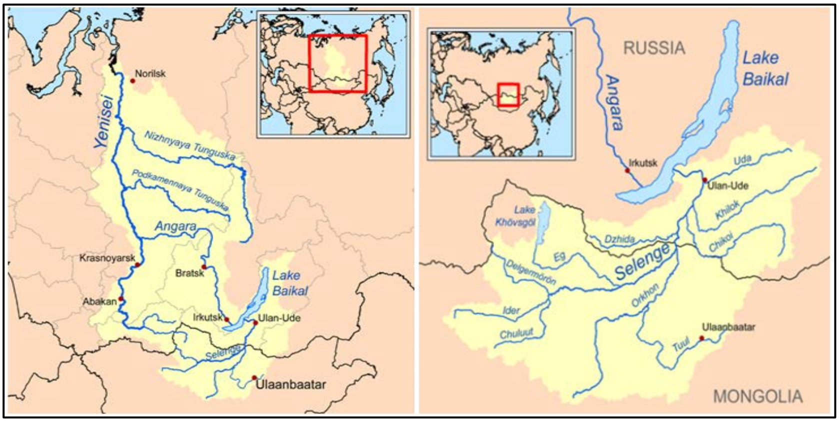
East Siberia is one of the largest deposits of Russian mineral resources, with a significant reserve of gold, copper, nickel, cobalt and aluminum, in addition to 30% of coal reserves, 40% of timber and 44% of water resources. Simultaneously, Krasnoyarsk krai, Zabaykalsky Krai, Irkutsk oblast, Chita oblast, Chiara, Republic of Buryatia, Republic of Tuva and Khakasiya and Yakutia(Vostok-Sibir, n.d.). East Siberia's economic zone accounts for about 24% of Russia's territory and 6% of its population. The region's industrial potential is fifth in the Russian Federation, including non-ferrous metallurgy (35%), forestry and wood processing (18.1%), electricity (7.4%), building materials industry (6.7%) and fuel industry (5.1%). , Chemical and petroleum industries (5.1%), mechanical engineering and metalworking industries (3%)(Gorchakov, 2002).

Trans-Siberian railroads in the East Siberia region pass through Naushki and Ulaanbaatar (Mongolian Cross Railway) to Beijing and Harbin (Manchurian Railway). Krasnoyarsk in krasnoyarsk Krai has the Siberian transverse railway station and the Yenisei River's port, which links railways and water transport (irkipediaru, n.d.). Besides that, Irkutsk also has two ports along the Angara River and the Siberian transverse railway station.

The role of water transport in East Siberia is enormous. Nearly three quarters of the region is not affected by the railway, and there are many areas where the road network does not reach. Yakutia, Tuva and northern part of Krasnoyarsk krai have no railway infrastructure (except between Dudinka and Noril'sk), while the enormous rivers of the Yenisei and Lena rivers, and their major tributaries, flow from south to north and into deep taiga forests and tundra areas. It also serves as a transport linking the aforementioned major industrial complexes (Norilsk, Igarka, Sangar, Yakutsk, Tommmot, etc.) to the Siberian transit train. The Yenisei River has the largest water transport system flowing to the Arctic Ocean. It is central of the three great Siberian Rivers that flow into the Kara Sea. The Yenisei River is connected to the Lake Baikal via the Angara River (wikipedia, n.d.).

The Yenisei River, which is connected to the Angara River from the Lake Baikal, flows into the North Pole, while the Selenga River, which flows through Mongolia and the Buryatia Republic of Russia, flows from Lake Mongolia and flows into Lake Baikal. During the Soviet era (1925), when the use of inland waters was very active, it signed a regulation for transporting water freight using the Selenga and Orhon rivers between the Soviet government and the People's Republic of Mongolia. Later, in 1964, the People's Republic of Mongolia decided to build inland watercraft on the Selenga River, with experts from the Siberia Inland Water Transport Company supporting the shipbuilding manpower and technology of the Selenga River (irkipedia, n.d.).

Figure 6. Yenisei River (left) and Selenga River (right)



Source: https://en.wikipedia.org/wiki/Yenisei_River, https://www.wikiwand.com/en/Selenga_River (Date of access: 2019.11.14)

Thus, there has already been an effort to transport cargo through the Selenga River in the Russian state of Irkutsk or Buryatia. And now, if you connect the Selenga and Yenisei rivers (via the Angara River) as well as the Ru-Mon border, China as well as Mongolia will have a route to the Arctic Ocean. Currently, most of the Russian minerals exported to Mongolia are located in areas that can be transported by rail except for the border with Mongolia; Samara oblast (37.4%), Kemerovo oblast (11.5%), Moscow (9.2%), Irkutsk Oblast (7.7%), Bashkiria oblast (3.2%), Republic of Buryatia (2.8%). However, the Yenisei River, which has ports in northern Siberia's industrial zone, is expected to be more diversified in the flow of transport as well as in the export of minerals and petroleum products to Mongolia. Mongolia will also have the potential to export its coal, which is increasing in production, to Europe via Arctic routes. Of the 32 projects of the China-Mongolia-Russia Economic Corridor program, 11 are related to transportation infrastructure, including 7 railway networks, 3 road networks, and 1 logistics company (Jeh et. al., 2016). There are two corridors from the Mongolian entrance to the maritime port (Primorye 1 and 2), penetrating the north-eastern part of China to Nakhodka and Zarubino, respectively, or bordering China and Russia. There is a problem to bypass the long distance along the road. For Mongolia, there is a need for a new alternative to the central railway corridor (Ulan-Ude-Ulaanbaatar-Beijing-Tianjin) that penetrates the interior of China. As a new alternative to international logistics in Mongolia and East Siberia, the Arctic route linking the Lake Baikal and the Yenisei River could play an important role.

4.2 Development of inland water port and logistics terminal in Buryatia

While the Yenisei River already plays a role as water transport in the region of East Siberia, the Selenga River can only be transported until a considerable amount of infrastructure has been developed. During the development of the Selenga River infrastructure, the port of connection between the Mongolian railway and the Yenisei River(via the Angara River) is suitable for the water port of the Ulan-Ude, the capital of Buryatia, where the Russian-Selenga River flows along the Russian-Mongolia border. The road network of the Republic of Buryatia consists of three federal roads (837.6 km), and the railroads that pass through the Republic are part of the East Siberian rail network, the East-West Trans-Siberian Railway, the Baikal-Amur Mainline, and the center of Ulan-Ude. There is a railroad in Russia, Mongolia and Naushki on the southern Mongolian border (Kang et. al., 2017).

The Republic of Buryatia is one of the regions with the longest border with Mongolia (1,213.6 km). The population is around 980,000, of which 110,000 (11.8%) live on the border with Mongolia. Cross-border cooperation has developed the railway networks of both countries (Ulan-Ude – Naushki – Ulaanbaatar - Beijing) and the road network (Ulan-Ude – Kahta - Ulaanbaatar and Kultuk - Mondi) by 2020. A customs clearance and logistics terminal will be built in the Nauski region of the Buryatia Republic in October, and the Wang Investment of the project signed a contract with the local government in July of this year (Logirus, 2018).

Figure 7. The Republic of Buryatia

Source: https://neftegaz.ru/news/gas/219761-bystraya-reaktsiya-gazprom-predlozhil-provesti-magistralnyy-gazoprovod-cherez-12-rayonov-buryatii/(Date of access: 2019.11.18.)

Products exported to Mongolia from the Buryatia Republic include food and beverage and tobacco products (17.5%), vegetable products (fruits, nuts, flour products, grains: 14.4%), automotive and machinery products (13.1%), meat and meat products (milk, Eggs, cheese, butter, honey: 11.8%). Mongolian products also include meat and meat products (74.4%) and vegetable foods (vegetables and grains: 10%) (ru-stat, n.d.). Although the Republic of Buryatia is the sixth-largest (2.8%) country in Russia between Russia and Mongolia, its border with Mongolia and its capital, Ulan-Ude, are the ports of the Siberian Trans-Train and Selenga river(Ulan-Ude port). All of these are likely to be possible to develop into a logistics hub between Russia and Mongolia. Ulan-Ude harbor is located in front of the delta where the Selenga River meets the Lake Baikal. It accounted for only 0.1% of Russia's total port revenues, but in 2015 it accounted for almost 6 times the revenue of 59.1 million rubles in 2018, compared to 860 million rubles in 2015 (Global Service, n.d.). In addition, Lake Baikal, located in the Irkutsk oblast, currently has the 'Baikal Port' at the point where the Angara River originates.

4.3 Mongolian-Russia-Arctic Complex Route

The inland water logistics route connecting the Selenga, Lake Baikal, and the Yenisei rivers coincides with the aforementioned logistical limitations of Mongolia and Russia's simultaneous inland water transport and Arctic route activation. Inland water logistics routes are obstacles arising from imports and exports of its resources due to the geopolitical limitations of Mongolia and the demand for Russia's simultaneous export of Siberia resources and sufficient traffic to activate the Arctic route. If the logistics route is properly opened, Mongolia will be able to grow from inland to marine and export its resources at a more competitive price. This may be a way to overcome Mongolia's weaknesses, which are relatively alienated from foreign investment. Of course, the pioneering of the inland transport logistics route in the region will require the maintenance of ports and logistics connection infrastructure for existing water transport and the consideration of seasonal limitations. However, with the global warming, various quaternary industrial technologies are developing, which can gradually contribute to the sustainable use of inland water logistics route connecting Mongolia and Russia. However, as the economic feasibility will arise from the initial price competitiveness, it is necessary to actively support the Russian and Mongolian governments and to improve the logistics connection system between the two countries.

Figure 8. Mongolia-Russia Inland Transportation Logistics Proposal

Source: Author

5. Conclusion

Russia, which is pursuing a new Eastern policy due to economic sanctions in the West, is seeking to enter the Asia-Pacific region through close cooperation with Eurasian economies. It also has a strong will to strengthen China's economic cooperation with China, while at the same time restraining China's entry into Central Asia under the “one-to-one” policy. From this point of view of Russia, Mongolia is a very geopolitical important country. Russia will continue to maintain Mongolia's dependence on Russia by using Mongolia, which has a long history of ties, to secure an efficient logistics route with China and to actively invest in Mongolia's infrastructure, energy and education. Mongolia is also very active in cooperation in developing infrastructure with the two countries, by proposing an initiative of the "Steppe Road" in order to occupy the strategic position of bilateral logistics transportation between Russia and China.

In addition, Mongolia, which is difficult to access to the sea, is using Russia's Siberian Transverse Railway to transport its products to the Far East. There are many infrastructure projects centered on railroads and roads, including economic corridors between Russia - Mongolia - China, and investment in transportation infrastructure in Russia. Among these are two transportation corridor construction projects for port access. However, Mongolia is struggling to transport bulk cargoes by being surrounded by land powers such as China and Russia. It is also true that China's relatively easy access to the sea makes it difficult to export Mongolian resources through a number of regulations. On the contrary, Russia, which is relatively easy for Mongolia, has to bypass too much distance when using existing railway infrastructure, and there is a limit to export of mineral and energy resources, which are low-cost bulk cargo.

In this situation, in order for Mongolia to export large quantities of mineral and energy resources economically, it is time to find ways to take advantage of the Selenga River in northern Mongolia to the Arctic Route through the Lake Baikal and the Yenisei River in Russia. It is possible to develop a new international complex logistics route that can go to the Arctic route through the Yenisei River, based on the agreement between Russia and Mongolia on the connection between the Selenga and Lake Baikal 100 years ago. In particular, East Siberia is the second most active inland waterway region after Russia's European region. Three-quarter of East Siberia is the Tiger Forest and Tundra region, which lacks rail and road networks, or has very poor infrastructure. But it is also a place with great potential for logistics route development because of the Yenisei River, which connects industrial complexes built along rich underground reserves with the Arctic Harbor and the Trans-Siberian Railway.

By linking the Russia-Mongolia railroad with the Yenisei River, and then developing the Mongolian waterway (Selenga) and linking it with the Yenisei River, Russia will be able to export and import minerals and grains in different regions. On the contrary, Mongolia will have a route to send rich mineral resources to Europe and Asia through Arctic routes. However, current information on the transport infrastructure of the Selenga River is very lacking, and both Russia and Mongolia have no specific plans for investment in inland water transport infrastructure.

Therefore, the development of inland water ports and logistics centers in the Ulan-Ude region of Buryatia Republic, which has both the Selenga river port and the Siberian transverse railway station in Russia, and the logistics center of the Lake Baikal, bordering Mongolia and Russia is necessary to precede. In addition, further research on the economic, institutional, and technological possibilities of linking Siberian inland waters to the Arctic route, along with data surveys on the infrastructure of the Selenga River in Mongolia, should be undertaken.

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