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An Application of the Quantitative Models to Forecasting the World Markets of Bulk Carriers[1]

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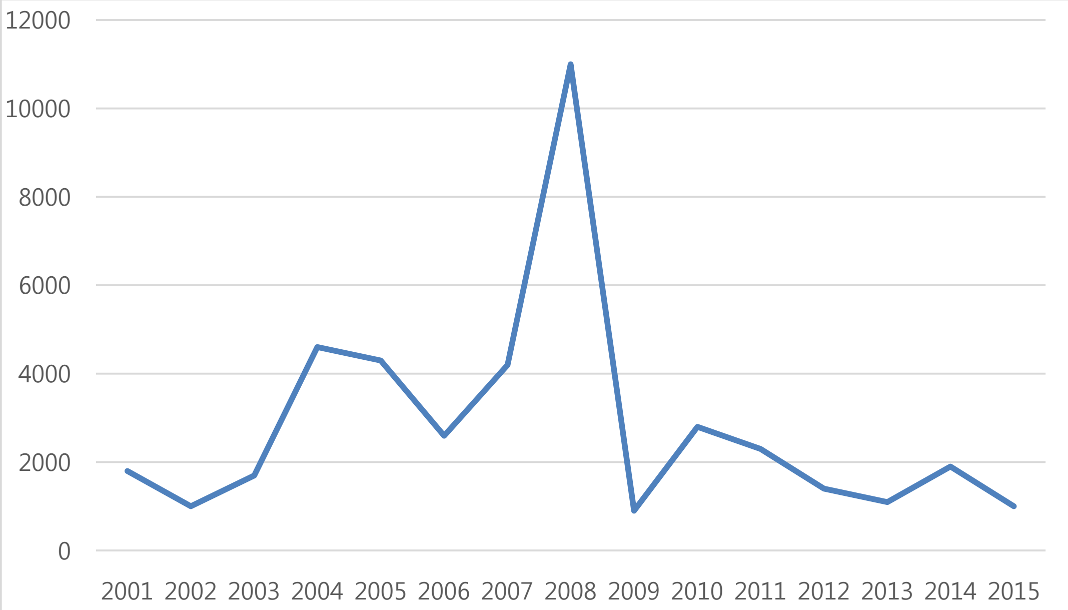
ABSTRACT

This paper deals with a prediction of the world dry bulk carriers market which has been suffering a long recession since the financial crisis in 2009. A couple of statistical models were applied to forecasting the demand for and supply of the dry bulk carriers transporting grain, iron ore, coals, and others. The first step taken for this study was to analyze the historical data associated with the shipping market concerned, where we are able to figure out the quantitative models suitable for a specific prediction.

As a result of careful data scanning and statistical tests, a couple of multiple-regression models were hypothesized to forecasting the cargo volume of iron ore, coal, grain, and other bulk cargo. We also considered using a time series model to forecast the net change in supply of bulk tonnage which resulted from a difference between scrappage and delivery tonnage of bulk carriers annually. As a result of this study, the world market of dry bulk carriers is expected to be normalized from 2019 and to stay in an expansion stage for a couple of years.

Keywords: dry bulk carriers market, statistical models, forecasting the demand and supply, multiple-regression model, time series model

INTRODUCTION



<Fig.1> Historical index trend in world dry bulk shipping market

The world shipping markets, including liner and tramper, have suffered the long depression since 2008 in which the subprime mortgage financial crisis triggered the world economic recession. As a result, many shipping firms have been subject to bankruptcy. Particularly tramper business sector has revealed a dramatic market fluctuation as shown in <Fig. 1>.Even if there have been many attempts to predict the shipping markets, the methodologies and theories turned out imperfect in forecasting the erratic markets which have been very vulnerable to the impacts of various international economic crises.

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The primary researches associated with prediction of the shipping markets include, Zannetos(1966), Beenstock and Vergottis(1993). Sjogren(1999), Veenstra(1999), Chen and Wang(2004), and Batchelor(2007).

Most of these preceding studies were performed to forecast the non-liner shipping markets such as tankers, dry bulk carriers, and general cargoes, on the basis of demand for and supply of specific ship tonnage under the specific market condition. It is very logical to forecast the freight rates by predicting both the cargo volume to be transported and the shipping tonnage available for transport service. Considering these historical studies, this paper also deals with a research work for forecasting the dry bulk market fluctuating by the interaction of demand for and supply of tonnage. The following chapter shows the models formulated in attempting to forecast the dry bulk carriers market which must be very critical to survival of non-liner shipping companies.

MODEL BUILDING AND FACTORS RELEVANT TO FLUCTUATION IN SHIPPING MARKETS

Factors

There are many factors influencing the shipping markets characterized by dramatic and cyclical patterns shown in <fig. 1>. Firstly, world economic condition itself must be a primary factor directly impacting on the freight rates from the side of demand for tramper shipping tonnage. Consequently, if the world economy condition becomes favorable to industries, the world seaborne cargo volume also increases dramatically.

On the contrary, if the world economy is in recession stage, its volume also suffers a decrease in demand seriously. The main seaborne dry bulk cargo consists of iron ore, coal in bulk, grain, and other dry bulk cargo. Once the future seaborne cargo volume of each sector is hypothesized to be estimated and aggregated properly, then the total demand for dry bulk tonnage can be figured out.

Meanwhile, the total supply of dry bulk tonnage in a certain year can be estimated by the summation of existing tonnage and newly delivered bulk tonnage. There are some other factors affecting the supply of dry bulk tonnage. For instance, the annual scrappage of bulk carriers apparently reduces the total supply of shipping tonnage, and the speed-up of navigating the carriers definitely increases it more or less.

Once the future annual bulk carriers' delivery and scrapped tonnage are predicted, then the future supply of dry bulk tonnage can be also estimated. Assuming that both the future annual demand for and supply of dry bulk tonnage simultaneously, these estimated demand and supply data allow us to point out the year in which the additional demand for the shipping tonnage offset all the overflowing tonnage. Theoretically, that year will be a recovering point for the dry bulk shipping market.

Model Building

As we already stipulated, the world dry bulk carriers market is assumed to be changed under an interaction between demand for and supply of tonnage concerned. Assuming that the bulk tonnage available for shipping service is 350-million dwt greater than that of demand, the following equation is formulated to figure out the year in which the supply tonnage is equal to the demand tonnage:

$$\sum_{i=1}^{t}(\Delta Di - \Delta Si) = 350 - million\ dwt. \ldots \quad (1)$$

where, $\Delta \mathrm{D}i$ means a summation of each bulk cargo sector's annual increase(or decrease) and ΔSi means a summation of net increase(or decrease) in tonnage available for shipping service.

The following two models are established to support the model (1).

$$\Delta \mathrm{D}i = \sum_{i=1}^{t}(\Delta Ii + \Delta Ci + \Delta Gi + \Delta Oi)$$

where, $\Delta \mathrm{I}i$: net change in seaborne cargo of iron ore in year i

$\Delta \mathrm{C}i$: net change in seaborne cargo of coal in year i

ΔGi: net change in seaborne cargo of grain in year i

ΔOi: net change in seaborne cargo of other bulk cargoes in year i

And $\Delta Si = \sum_{i=1}^{t}(Xi - Yi)$

where, Xi means bulk tonnage delivered in year i and Yi means bulk tonnage scrapped in year i

In order to select appropriate forecasting models for both demand and supply, we need to check the historical data plotting as shown in <Fig. 2 > and <Fig. 3>. Firstly, <Fig. 2> shows the historical data for major bulk cargoes' seaborne trade volume, where those of iron ore, coal in bulk, and grain are characterized by almost linear trends. But that of other bulk cargo shows a non-linear behavior. As a result, we apply a multiple linear regression model for estimating Di which aggregates the each dry bulk cargo quantity available for marine transport as follows:

$$Qki = f\{Qk(i-1), t\}$$

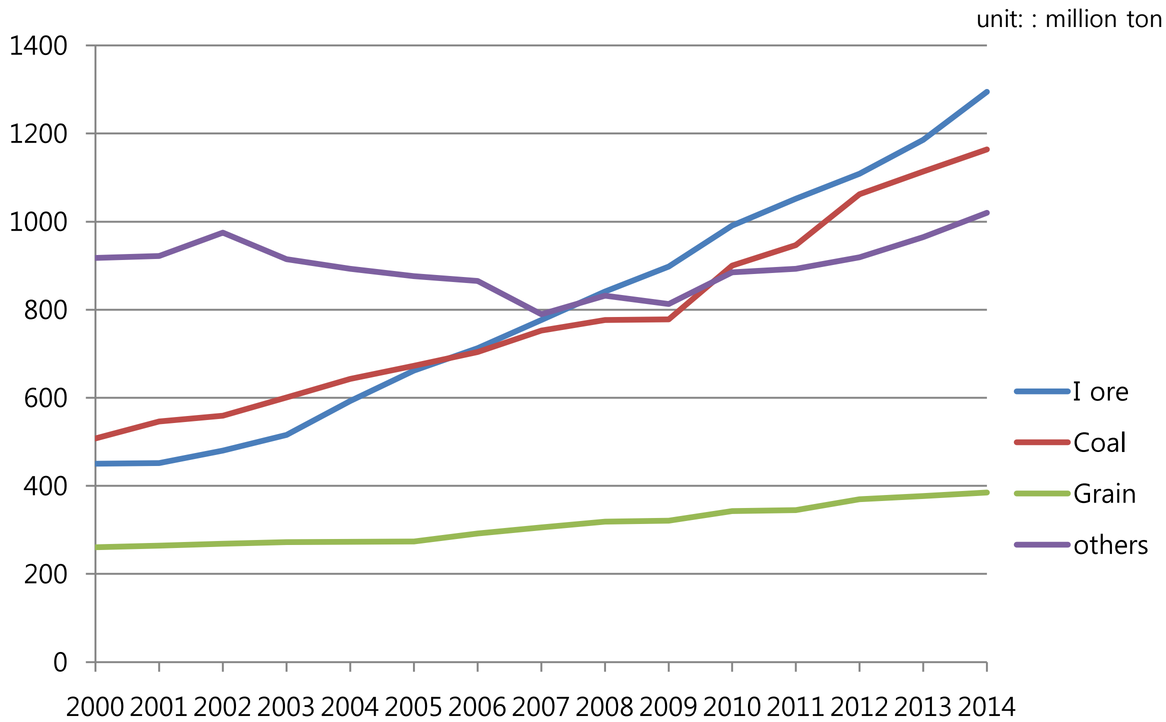
Where, k: 4 kinds of dry bulk cargo (iron ore, coal, grain, and others) and t = 1. 2. 3. 4. … n

$Qk(i-1)$: previous year's quantity of seaborne cargo k .

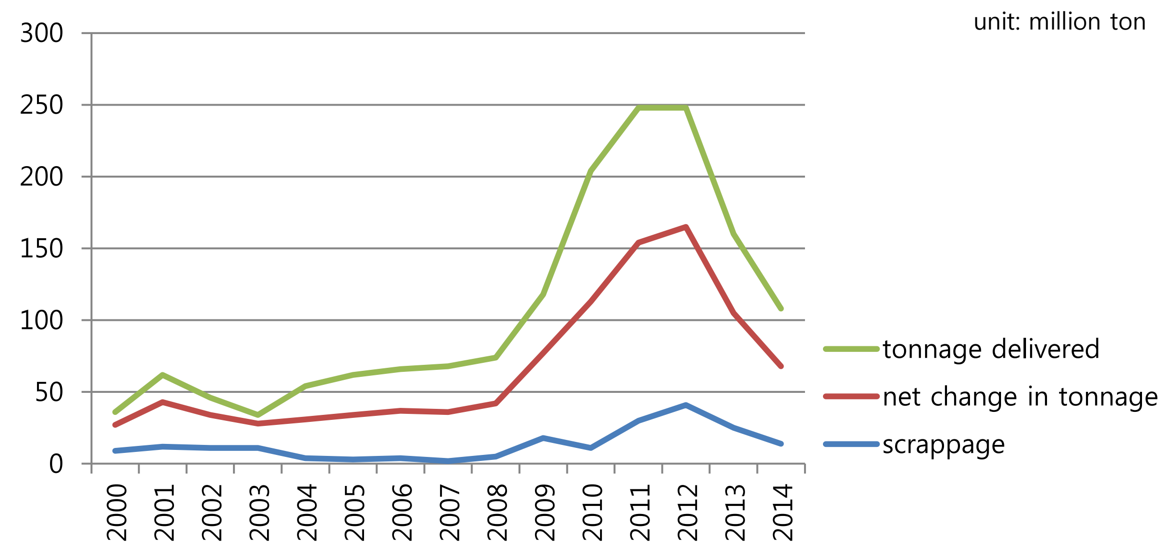
Meanwhile, since the historical change in seaborne cargo volume of other dry bulk shows a non-linear series, we use a non-linear model. <Fig. 3> depicts the historical data for tonnage delivered and scrapped, and thereby the net annual increase or decrease quantity of dry bulk shipping tonnage, which also shows a non-linear pattern, can be figured out. As a result, a Box-Jenkins model is attempted to forecast these non-linear time series data. This model can be expressed by an ARIMA(Auto-Regressive Integrated Moving Average) process of order(p, d, q) which is defined as below:

$$\varphi(B)(1-B)dzt = \theta 0 + \theta(B)at$$

where $\varphi(B)$ and $\theta(B)$ are operators in B of degree p and q respectively.



<Fig. 2> Historical seaborne cargo volume data of major bulk cargoes(2000-2014)



<Fig. 3> Historical data for bulk tonnage scrapped and delivered (2000-2014)

APPLICATION OF THE QUANTITATIVE MODELS TO FORECASTING THE DRY BULK MARKET AND THE RESULTS

In this section, the afore-mentioned forecasting models were applied to estimating the future demand for dry bulk cargoes including coal, iron ore, grain, and others. The results of linear regression analyses were epitomized in <Table 1>.Judging from the estimated coefficients and their t-ratios, the models for predicting dry bulk cargo volume are statistically robust. Other statistical values are also acceptable.

Table1. *Statistics associated with estimated demand functions.*

Dependent Variables	Independent Variables	Estimated Coefficients	T-Ratio	F-Statistics	Adjusted R	D.F.
Iron Ore	T(year)	75.0	12.8	841.8	.992	12
	Qi(t-1)	-.22	-2.66			
	Constant	428.7	18.5			
Coal	T(year)	46.8	6.8	139.6	.952	12
	Qc(t-1)	-.03	-2.08			
	Constant	469.2	10.9			
Grain	T(year)	10.4	11.8	140.1	.952	12
	Qg(t-1)	-.07	-1.85			
	Constant	257.9	27.9			
Others	T(year)	-.13	-3.5	80.3	.755	12
	Qo(t-1)	.04	1.72			
	Constant	888.2	15.5			

The estimated parameters of the four demand functions for each dry bulk cargo allow us to forecast the annual quantity. <Table 2> shows the results of future cargo demand covering 2015-23. The seaborne cargo quantities of iron ore, coal, and grain are expected to increase steadily, while other dry bulk cargo quantity is predicted to decrease for a couple years ahead and to increase after 2018. In general, the total dry bulk cargo quantity is likely to increase gradually.

Table2. *Forecast volume of bulk cargo (2015-23)*

(Unit: Million ton)

Year	I,Ore	Coal	Grain	Others	Total
2014(A)	1,204	1,132	375	962	3,673
2015(F)	1,289	1,137	388	925	3,738
2016(F)	1,345	1,184	397	923	3,849

2017(F)	1,408	1,229	407	913	3,957
2018(F)	1,469	1,275	417	931	4,092
2019(F)	1,531	1,320	426	932	4,209
2020(F)	1,592	1,366	436	941	4,335
2021(F)	1,653	1,411	446	942	4,452
2022(F)	1,715	1,456	455	951	4,578
2023(F)	1,776	1,502	465	961	4,705

**(A): Actual Data (F): Predicted Data*

Next we deal with a non-linear estimation for predicting the change in shipping tonnage in supply side. A Box-Jenkins model (ARIMA model) is hypothesized to predict the net supply tonnage which can be estimated by subtracting the annual scrapped tonnage from the tonnage delivered. <Table 3> shows the result of non-linear estimation for predicting the net tonnage supplied in dry bulk market.

Table3. *Nonlinear Estimation Results*

Par.	Lag	Estimate	Std. Error	T-Ratio
MA	1	1.0854	.08462	12.827
SMA	1	-.68751	.11765	-5.844

**MA : Moving Average. **SMA : Seasonal Moving Average.*

This non-linear model also reveals the satisfactory results of statistical test in terms of standard error. So we apply this model to forecasting the annual increase in tonnage supplied.

<Table 4> shows the aggregated forecasting results in both demand for and supply of dry bulk tonnage. The final column "**∑(ΔD – ΔS)**"means the cumulative incremental demand for shipping tonnage. Since a slack tonnage of dry bulk carriers in the world was estimated to be 350-million ton in 2015, this overflowed shipping tonnage is expected to be offset in 2019. As a result, the world dry bulk shipping market is predicted to be normalized in 2020 and stay in booming stage for a couple of years.

Table4. *Estimated annual change in demand and supply of bulk tonnage.*

(Unit : Million)

Year	Increase in Demand(Δ D)					Increase in Supply(Δ S)			ΔD - ΔS	∑(ΔD – ΔS)
	(1) Ore	(2) Coal	(3) Grain	(4) Others	(1)+(2) (3)+(4)	(1) Tonnage Delivered	(2) Scrappage	(1)-(2)		
2015	85	5	7	-37	60	52	13	39	21	21
2016	56	46	9	-2	109	45	18	27	82	103
2017	63	35	10	-10	98	42	16	26	75	175
2018	61	49	10	18	138	33	11	22	116	291
2019	62	45	9	1	117	48	15	33	84	375
2020	61	46	10	9	126	69	20	49	77	452
2021	61	45	10	1	117	73	28	45	72	524
2022	62	45	9	9	125	86	35	51	75	598
2023	61	46	10	9	126	99	32	67	59	657
2024	61	46	10	10	127	117	29	88	29	686

CONCLUSIONS

There are many approaches to forecasting the world dry bulk carriers market involving such complexing factors as volume of bulk cargoes, delivery tonnage, scrappage and many unpredictable events. In this paper we attempted to apply the quantitative models to predicting the seriously depressed bulker market. Although the quantitative models allow us to provide the concrete results for the prediction, the real market is also subject to lots of qualitative factors. As a result, a Delphi method is recommended to support the forecasting results derived from the models applied actually.

Assuming that the predicted results of the demand for and supply of dry bulk tonnage remain robust, the world dry bulk market is likely to recover an equilibrium point around 0000, and thereafter the market becomes normalized. However, the dry bulk carriers market is expected to show a stable behavior for many years to come. To put it summarily, the market is predicted to get out of the depression from 2019 and to stay in a recovery stage for a couple of years.

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