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Determining Shipping Cycle by Supply/Demand Ratio and Markov Regime Switching

Abstract

In the dry bulk chartering market, the level of charter rates is determined by the ratio of demand to supply over a medium term. However, in the long term, this relationship changes; the same supply-demand ratio can cause different charter rates over different periods. The author noticed that the timing of these changes is very similar to the "shipping cycle" (widely known market fluctuation cycle of three to five years) and tried to confirm this relationship statistically.

The Markov Regime Switching Model (MRSwM) is employed in this study. MRSwM is a model used to analyze time-series data in which state switching occurs because of unobservable variables. The model is widely used in economics and finance, including determining business cycles.

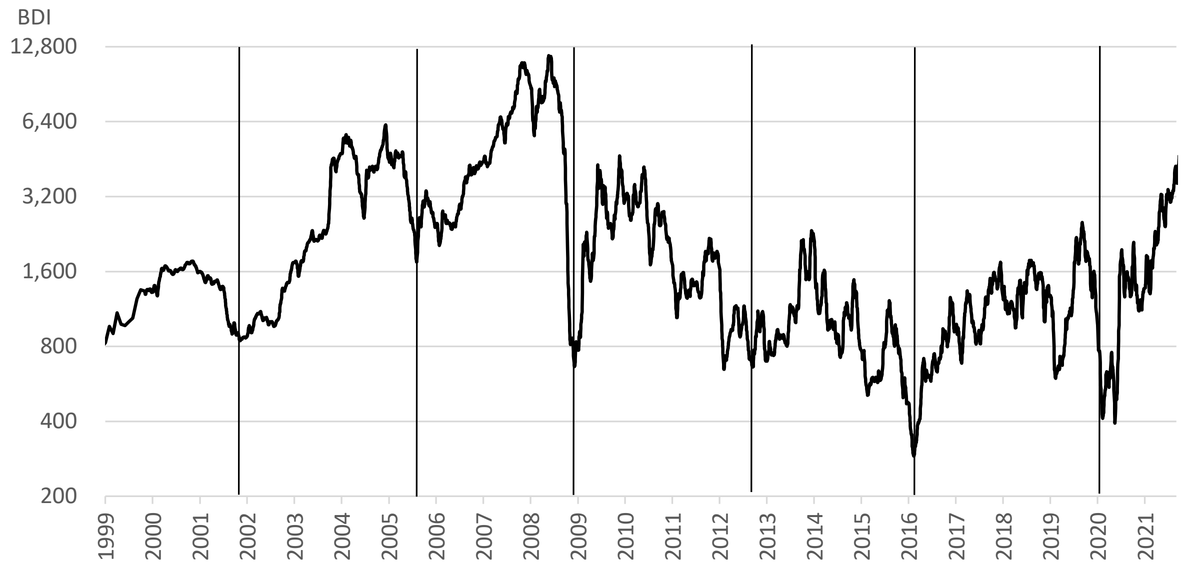
This study revealed that MRSwM can split the target periods into regimes without fragmentation. However, synchronism with the market cycle differs based on the situation. When there is no disturbing factor in the market, regimes are consistent with the shipping cycles understood in the industry and the explanatory power is high. However, when a disturbing factor exists, regimes are split according to the disturbing factor and the explanatory power lowers.

Keywords: *Drybulk market, shipping cycle, regime switch*

1. Introduction

It is widely known that there are cyclical fluctuations of different durations in the shipping market. Stopford (2009), a standard textbook of maritime economics, indicates three cycles: a long-term cycle of 60 years because of technological changes, a medium-term cycle of three to 12 years based on business cycles, and a short-term cycle of one year due to seasonal changes. This classification is generally accepted in both the academic and industry community. Of these three cycles, the medium-term cycle is the most important in terms of a shipping company’s decisions, such as investments. Therefore, the term "shipping cycle" is often used to refer to the medium-term cycle. This study focuses on this medium-term cycle, and the term "shipping cycle" will be used below to refer to the medium-term cycle. The duration of the shipping cycle varies depending on the era and the type of ship. In the dry bulk shipping market after 2000, which is the subject of this study, the industry considers the duration to be three to five years. Fig 1 shows the shipping cycles of the dry bulk shipping market understood in the industry, based on the Baltic Dry Index (NYK Line, 2021).

Figure 1 - Shipping Cycles in Dry Bulk Shipping Market



Source: NYK Line (2021)

The author has been working on a hypothesis about fluctuation of the dry bulk shipping market and has published a series of studies. The hypothesis is that fluctuations in charter rates can mainly be expressed as a combination of a simple regression to the supply-demand ratio and irregular fluctuations that diminish over several months, but in the medium term, both cyclical deviation from the supply-demand ratio level and discontinuous changes of the regression model occurs.

Hayashi (2020) analyzed the relationship between the charter rates and the supply-demand ratio of Panamax bulkers during a period of stable market conditions. The result is that the relationship is a simple regression and a random deviation of the charter rate from the supply-demand ratio decrease over months.

Hayashi (2019) analyzed the deviation of the charter rates from the supply-demand ratio with cycles of longer than one year. The result is that the cycle of 39-month length is detected by using a correlogram. In addition, it is found that the deviation cycle seems to be related to the time lag between newbuilding order and delivery. Previous studies such as Timbergen(1934) and Koopmans(1939) have pointed out that the time lag affects the charter rates. What is new in Hayashi (2018) is that the effect is not only caused by fleet capacity but also by the shipowner's speculative sentiment. This cyclical fluctuation is consistent with the above-mentioned "shipping cycle" in terms of length, but its size is not as large as the "shipping cycle".

This study focuses on the discontinuous change of the regression model, which is not investigated in previous studies. Such discontinuous changes are recognized within the shipping industry. For example, Clarkson (2009) describes the relationship between charter rates and the supply-demand ratio changes every few years in the Aframax tanker shipping market. Research on this subject area has been slow in both the academic and the industry communities. There are no previous academic studies. The analysts in the industry have not studied the specific timing of the change nor the reason for the change.

The purpose of this study is to detect intermittent changes in the model of the relationship between ship charter rates and the supply-demand ratio using statistical methods. Since intermittent changes in the model have a significant impact on practice, the detection of such changes itself has value. In addition, it is necessary to use the statistically determined timing of changes when analyzing the causes of model changes in the future.

In this study, the author examined the above hypothesis statistically using the Markov Regime Switching Model (MRSwM). MRSwM is a method used to analyze time-series data in which state switching occurs because of unobservable variables. The model is widely used in the fields of economics and finance, including detecting business cycles.

The examined shipping market is the Panamax spot charter market, which has the highest liquidity among markets of all dry bulk ship types. Two periods are examined to verify in what conditions MRSwM works well; one in which disturbance factors do not have a significant impact on the relationship between spot charter rates and the supply-demand ratio, and one in which they do. The former is Period 1, which is 96 months from 2013 to 2020. The latter is Period 2, which is 96 months from 2001 to 2008[1]. Period 2 includes the shipping bubble period, when Panamax charter rates rose in tandem with that of its bigger Capesize cousin.

The results of the analysis were as follows.

Period 1 is divided into three regimes: Regime 1: Jul. 2016-May 2020 (47 months), Regime 2: Nov. 2013-Jun. 2016 (32 months), and Regime 3: Jan.-Oct. 2013 and Jun.-Dec. 2020 (17 months). Regimes are divided without fragmentation. Also, Regime 1 and Regime 2 roughly correspond to the shipping cycles understood by the industry. The coefficient of determination of these regimes are high: 0.87 for Regime 1 and 0.95 for Regime 2. The regression coefficient was 0.27 in Regime 1 and 0.14 in Regime 2, indicating that the sensitivity of the spot charter rate to the supply-demand ratio changed greatly over different regimes.

Period 2 is divided into two regimes — Regime 1: Mar. 2004-Oct. 2005, Feb. 2007-Dec. 2008 (43 months); and Regime 2: Jan. 2001-Feb. 2004, Nov. 2005-Jan. 2007 (53 months). These regimes do not correspond to the shipping cycles understood by the industry but to high/low states of the market. The coefficient of determination is lower than those of Period 1; 0.29 for Regime 1 and 0.60 for Regime 2. Also, the regression coefficient was -0.16 in Regime 1, which implies that the spot charter rate was decided by factors other than the supply-demand ratio.

The outcome of this study is as follows.

First, this study confirmed that MRSwM is useful to split the time-series of the shipping market into regimes. The regimes are not fragmented.

Second, the regimes correspond to the shipping cycles understood by the industry only when there are no disturbance factors. For the period with disturbance factors, the regimes do not correspond to the shipping cycles.

[1] All years in periods and regimes are based on the final month of the 12-month moving average.

In addition, the coefficient of determination is lower than the other period.

The reminder of this paper is structured as follows. Section 2 introduces the preceding studies. Section 3 presents the approach and data profile. Section 4 presents the result of the statistical analysis. Section 5 presents discussions of the results. And the final section concludes this paper.

2. Literature Survey

Preceding studies about the below three subjects are surveyed in this study: shipping cycles, the relationship between the supply/demand factors and the shipping market, and application of MRSwM to shipping and other markets.

As for the first subject, the preceding studies on shipping cycles can be categorized into two approaches. One approach is to assume the existence of a shipping cycle and create a mathematical model that can reproduce it. The other is to apply statistical methods to the time-series data on the shipping market to detect the presence of shipping cycles and identify their duration if they exist.

The former approach has been employed since the beginning of maritime economics. One of the significant results is the model created by Tinbergen (1934) and Koopmans (1939). In this paper, the model is referred to as the "Tinbergen-Koopmans model."

In the Tinbergen-Koopmans model, shipping cycles are caused by the time lag between the shipping and shipbuilding market. The number of newbuilding orders is linked to the shipping market; the higher the shipping market goes, the more vessels are ordered. However, it takes two or three years for a vessel to be delivered after the order. As a result, vessels ordered at the peak of the shipping market are delivered when the market is peaked out. This causes further fall of the shipping market and the consequent decline in newbuilding orders. When the shipping market hits bottom and turns upward, vessel delivery continues to decline because of the time lag. This decline in delivery pushes up the shipping market. The merit of the Tinbergen-Koopmans model is that it can explain the occurrence of shipping cycles without using a change of demand (cargo volumes) or external economic trends.

After the Tinbergen-Koopmans model, Beenstock and Vergottis (1993) became a milestone in the studies of this approach. This model is referred to as the Beenstock-Vergottis model in this paper.

The Beenstock-Vergottis model explains shipping cycles by the interaction of four submarkets: the shipping market, the newbuilding market, the secondhand market, and the scrapping market. The number of newbuilding orders is linked to the price of a newbuilding vessel, and its price is determined by that of a secondhand vessel and the expectation of price changes in the next period (at the time of delivery). The price of a secondhand ship is determined by the charter rate and the expectation of price changes in the next period. There are time lags in these relationships, and they cause cyclical fluctuations in prices.

The Beenstock-Vergottis model was published when the research trends changed in maritime economics. Since then, this kind of approach to create a mathematical model that can reproduce shipping cycles has not been a mainstream subject in maritime economics, and the number of studies with this approach has decreased.

Among these studies, Karakitsos and Varnavides (2014) presented a model in which the shipping market fluctuates with expectations of future interest rate changes on the top of the supply-demand ratio, and changes in these expectations trigger shipping cycles.

Also, Tvedt (2003) assumes that the interdependence between the shipping market and the shipbuilding market has a time lag, and the price elasticity of demand (cargo movement) varies according to the charter rates. Under these assumptions, the simulation with the geometric Brownian motion of demands showed the fluctuation in the shipping market, which is very similar to those in reality.

Studies of shipping cycles with the second approach, which employ statistical methods to detect the presence of shipping cycles, are of the mainstream after the Beenstock-Vergottis model was released.

One method is to map the status of the shipping markets into the four stages of the shipping cycle (trough, recovery, peak, and recession) and to confirm whether the time-series of statuses follow this order. Gavalas and Syriopoulos (2016) defined shipping cycles from market confidence in the industry; they created a four-quadrant chart that combines high/low levels and rises/declines and mapped them to the four stages of the shipping cycle. For the period between Jan. 2006 to Aug. 2014, the plots circulate in the right order and coincide with changes in the shipping market.

Another method is to apply mathematical methods that break down a time-series shipping market data into multiple cyclic fluctuations. Some cycles detected in studies with this method have a duration corresponding to the shipping cycle. For example, Chiste and van Vuuren (2013) applied Fourier analysis to BDI time-series and extracted cycles of four- and seven-year length. Angelopoulos (2017) applied empirical mode decomposition (EMD) to BDI time-series and extracted five cycles (11.3-11.6 years, 3.4-5.3 years, 2.9-3.8 years, 1.4-2.3 years, and 0.94 years). Of these, the cycles of 3.4-5.3 years and 2.9-3.8 years are similar to the shipping cycle.

As for the second subject, the relationship between the supply/demand factors and the shipping market is treated differently before and after the Beenstock-Vergottis model. Both the Tinbergen-Koopmans model and the Beenstock-Vergottis model assume that charter rates are determined by supply and demand. More specifically, demand (cargo volume) is assumed to be independent of the shipping market, while supply (fleet capacity) matches the demand by changing the speed of vessels.

Some studies after the Beenstock-Vergottis model assume that factors other than supply and demand can affect the shipping market. For example, Karakitsos and Varnavides (2014) assume that the shipping market can be affected by the expectations of future interest rate changes.

Also, Stopford (2009) compares spot charter rates of Aframax tankers between 1990 and 2007 with the supply-demand balance (calculated from the annual rate of change in cargo movements and shipping capacity) and showed that three supply curves can be drawn for different periods. This analysis only presents the graphical mapping of spot charter rates and supply-demand balance; no statistical analysis is employed.

In recent years, few academic studies have investigated the relationship between the shipping market and supply-demand using statistical methods. This is because of a lack of business knowledge in academia. These days, many indicators of the dry bulk shipping market are specific to ship types (e.g., Capesize, Panamax) and researchers need to understand such specific indicators to conduct accurate analyses. Among other things, cargo volume (demand) of specific ship types concerns a mixture of commodities (e.g., iron ore, coal, grain) and exporting countries, and business knowledge is needed to calculate it.

Hayashi (2020) is one of the studies employing industrial knowledge to estimate cargo volumes. It focuses on the Panamax shipping market and pair a commodity with its major exporter to determine the effect on the Panamax shipping market. The monthly summaries of these pairs are used as the demand for the analysis of the shipping market along with the supply (fleet capacity).

In recent years, AIS data has begun to be used as a demand for the shipping market and to remove the constraint of industrial knowledge. AIS was originally introduced to prevent collisions by sending radio wave messages containing information on a ship's position and speed (IMO, 2019). However, AIS data contains information on whether a ship is laden or empty and can be used to calculate real-time fleet usage. Some information providers have started to gather and sell AIS data to the public, and studies based on AIS data have appeared. For example, Kanamoto et al. (2019) used AIS data from Jan. 2016 to Aug. 2018 to predict the rise and fall of BCI, a market index for Capesize vessels, after 30 days.

As for the third subject, MRSwM was introduced into the field of economics for the first time by Hamilton (1989) to explain economic fluctuations, as mentioned above.

The main application of MRSwM in commodities and shipping markets is to check the effectiveness of the hedging strategy. Alizadeh and Nomikos (2004) focused on FTSE 100 and S&P 500 indices, and Lee and Yoder (2007) focused on corn and nickel ore. Kavussanos and Alizadeh (2002) is the first use of MRSwM in the shipping market. This study assumes the structure of the tanker shipping market contains a magnitude of variation from seasonality that varies with the regime and applies a model integrating MRSwM with seasonality to analyze each tanker type from Jan. 1978 to Dec. 1996. Alizadeh et al. (2015) also used a model integrating MRSwM with GARCH to determine whether the effectiveness of hedging with FFA on the tanker shipping market improves from 2005 to 2013.

Based on the literature survey in the above three subjects, the author believes that this study has originality, as noted below.

With regard to the determination of the shipping cycle, previous studies focused on the fluctuation in charter rates themselves. This study is the first to focus on the relationship between charter rates and the supply-demand ratio.

Concerning the relationship between supply/demand factors and the shipping market, most existing studies assume that the relationship is constant. A few studies indicate that the relationship may change over time, but this study is the first to investigate the change statistically and claim the change is related to the shipping cycle.

With respect to the application of MRSwM to the shipping markets, existing studies focus on the effectiveness of the hedging strategy and investigate the volatility of freights and spot charter rates. This study is the first to focus on the shipping market itself (not volatility) and to investigate its relationship with the supply-demand ratio.

3. Data and Methodology

This study followed the below steps to detect the changes in the relationship between the shipping market and the supply-demand ratio.

(1) Decide the mathematical model of the relationship between the shipping market and the supply-demand ratio. This study employs a simple linear regression model: [charter rate (logarithmic)] = α x [supply-demand ratio] + β. This model is proposed by Hayashi (2020), which shows the model works well by selecting an appropriate period and applying a moving average to remove seasonal fluctuations and irregular noise.

(2) Apply MRSwM to the model covering a target period. The result is the split regimes and estimated parameters (α and β in the above equation) for each regime. This calculation is carried out multiple times with different numbers of regimes.

(3) Select the most suitable number of regimes. BIC (Bayesian Information Criterion) is used for the selection.

(4) Compare the split timing of regimes with the shipping cycles understood in the shipping industry (Figure 1). Statistical characteristics of the model are also examined.

This study focuses on the market of Panamax size bulkers. This is because the Panamax market is the most liquid and competitive market among all vessel sizes (Capesize, Panamax, Handysize, and Handymax). The Handymax and Handysize markets are divided into commodities and therefore are less liquid than markets of larger vessels. On the other hand, the Capesize market depends almost solely on iron ore trades, especially between Australia/Brazil and China. Also, a few big mining companies hold large trading shares and therefore have a strong influence on the market. The Panamax market has two major cargoes (i.e., coal and grain) and their markets are integrated. Also, there are no players holding a dominant share, such as in iron ore.

The shipping market indicator used in this study is Baltic Panamax 4T/C, which is widely regarded as the standard indicator of the Panamax spot charter rates in the shipping industry. To express the exponential relationship between freight rates and the demand/supply ratio, the values are logarithmic.

This study uses cargo volumes as the demand. They are based on customs export statistics retrieved from online database Trade Data Monitor (Trade Data Monitor, 2021). These volumes are the total of major commodities from major export countries, which are listed in Table 1.

Table 1 – Major export countries of Panamax cargoes

Commodity	Export Countries
Coking Coal	USA, Australia, and Canada
Steam Coal	Australia, South Africa, and Indonesia
Wheat	USA, Canada, Russia, and Australia
Corn	USA, Argentina, Ukraine, and Brazil
Soybean	USA, Brazil, and Argentina

Fleet capacity is used as the supply and based on "Fleet Development (in DWT)" retrieved from Clarkson's online database "Shipping Intelligent Network" (Clarksons, 2022).

In addition to the cargo volumes and fleet capacity, the below factors will affect supply and demand conditions:

- Non-operational period of vessels, caused by drydock, lay-up, and congestion
- Transport distance of each cargo (in ton miles)
- Average speed of vessels

However, these values are not included in this study. This is because no indicators for these values could be obtained over the investigated period.

The length of the examined period is eight years, because as mentioned in the introduction, the length of a shipping cycle is considered to be three to five years in recent years. Eight years is long enough to cover one cycle from beginning to end.

To confirm whether MRSwM can properly split the period into shipping cycles, this study investigates two periods and compare the results: one in which there is a major external disturbance to the relationship between charter rates and the supply-demand ratio, and the other in which there is no such disturbance.

The selected periods are from Jan. 2013 to Dec. 2020 (Period 1) and from Jan. 2001 and Dec. 2008 (Period 2). In period 1, the market was stable at low levels and there were no major disturbing factors in the relationship between the supply-demand ratio and the shipping market. Period 2 was a period during the shipping bubble when soaring spot charter rates for Capesize vessels affected other vessel types, such as Panamax.

The MRSwM should be solved with a mathematical method. Commonly used methods are the EM algorithm and the MCMC algorithm. The former is easier to solve but can only be applied to simple models. Since the model in this study is a simple linear regression and only parameters (α and β) change, the author used the EM algorithm, specifically the MRSwM package in R.

3. Results

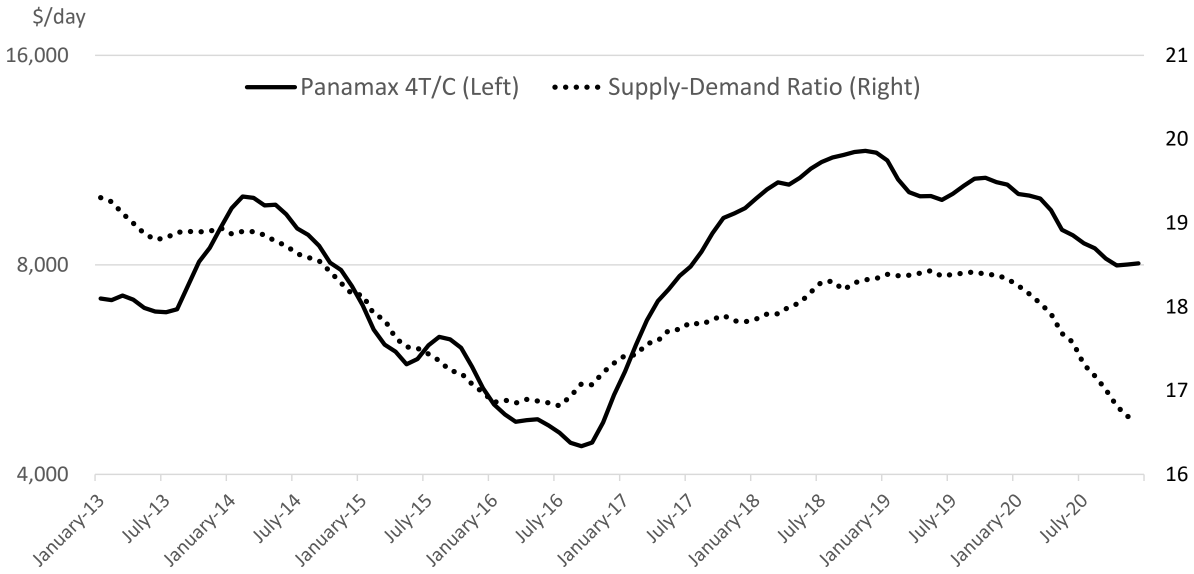
As for Period 1, descriptive statistics for Panamax 4T/C and the supply-demand ratio are calculated in Table 2.

Table 2 – Descriptive statistics for Period 1

	Panamax 4T/C (Logarithmic)	Supply-Demand Ratio
No. of Records	96	96
Mean	3.89	17.97
Maximum	4.07	19.30
Minimum	3.64	16.69
Std. Deviation	0.12	0.69

Also, Figure 2. is a visual comparison of Panamax 4 T/C and the supply-demand ratio in Period 1 (Panamax 4T/C values are original and its scale is logarithmic).

Figure 2 - Charter Rates and Supply-Demand Ratio in Period 1



The BIC values of each number of regimes and the coefficients of determination in each regime are shown in Table 3. As BIC was lowest in the three regimes, the author regards this as the most suitable regime separation in Period 1.

Table 3 – Results for each number of regimes in Period 1

	BIC	Coefficients of Determination			
No of Regimes		Regime 1	Regime 2	Regime 3	Regime 4
1	-160.61	0.34			
2	-253.25	0.00	0.90		
3	-271.09	0.87	0.95	0.56	
4	-271.07	0.75	0.97	0.93	0.99

Figure 3 is the detected regimes overlaid on Figure 2. Descriptive statistics in each regime are shown in Table 4. Detected regimes are: Regime 1: Jul. 2016-May 2020 (47 months), Regime 2: Nov. 2013-Jun. 2016 (32 months), and Regime 3: Jan.-Oct. 2013 and Jun.-Dec. 2016 (17 months).

Figure 3 - Regimes overlaid on Figure 2

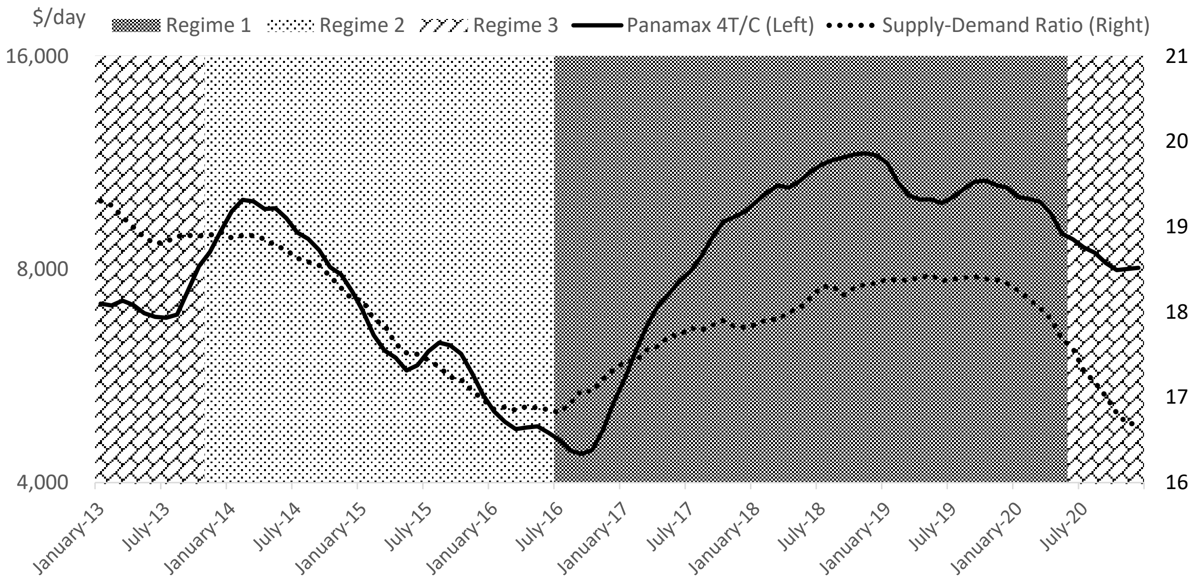


Table 4 – Descriptive statistics of each regime in Period 1

Regime	Period	Regression Coefficient	Intercept	Coefficient of Determination
1	Jul. 2016 - May.2020	0.27	-0.84	0.87
2	Nov. 2013 - Jun. 2016	0.14	1.33	0.95
3	Jan. 2013 - Oct. 2013, Jun. 2020 - Dec. 2020	0.03	4.39	0.55

Period 1 was divided into three regimes without fragmentation, and Regime 1 and Regime 2 were almost identical to the shipping cycles understood in the industry (Figure 1). The coefficients of determination were high at 0.87 for Regime 1 and 0.95 for Regime 2, indicating a good fit. The regression coefficients show a large difference, 0.14 in Regime 1 compared to 0.27 in Regime 2, indicating that charter rates are more sensitive to the supply-demand ratio in Regime 2.

In Regime 3, the coefficient of determination is as low as 0.55. Also, the regression coefficient is 0.03, which is very low. This may be because Regime 3 comprises the beginning and end of Period 1 and those two parts belong to different shipping cycles, and thus the parameters were not estimated properly.

The Q-Q plot of Period 1 (Figure 4) shows that there is no extreme bias and the distribution is generally linear. Also, there is no large partial autocorrelation (Figure 5).

Figure 4 - Q-Q plot of Period 1

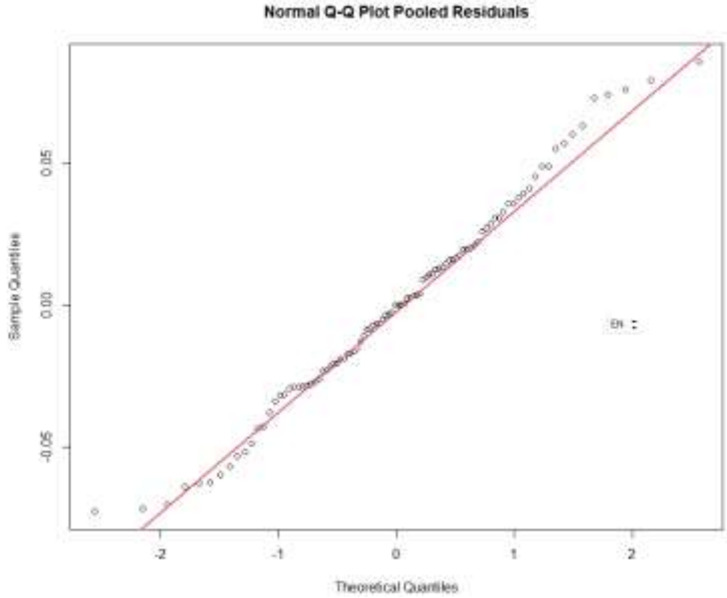
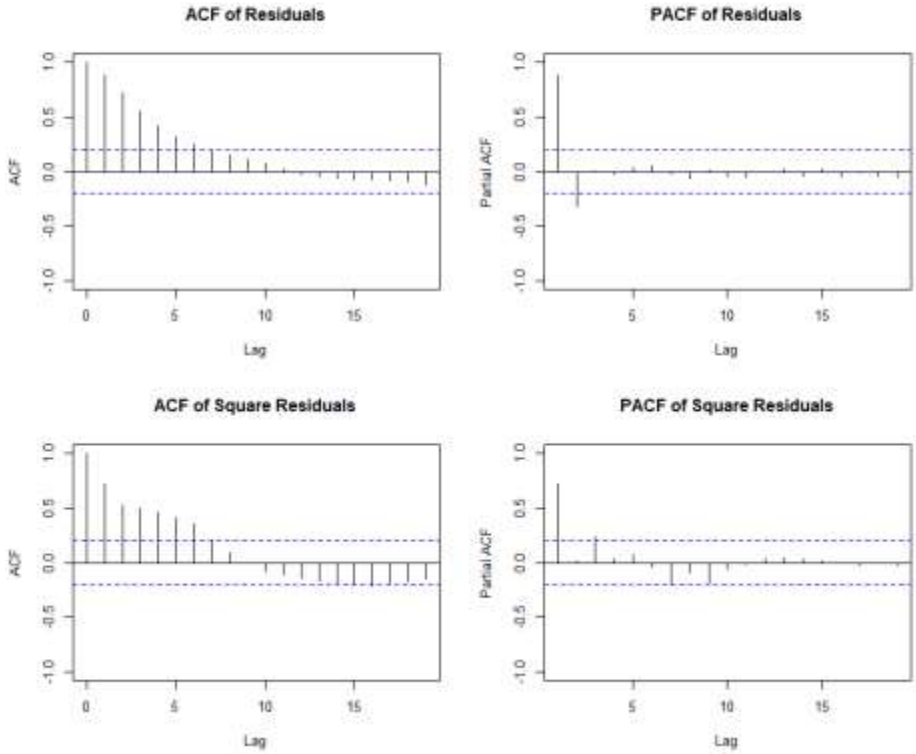


Figure 5 - Autocorrelation in Period 1



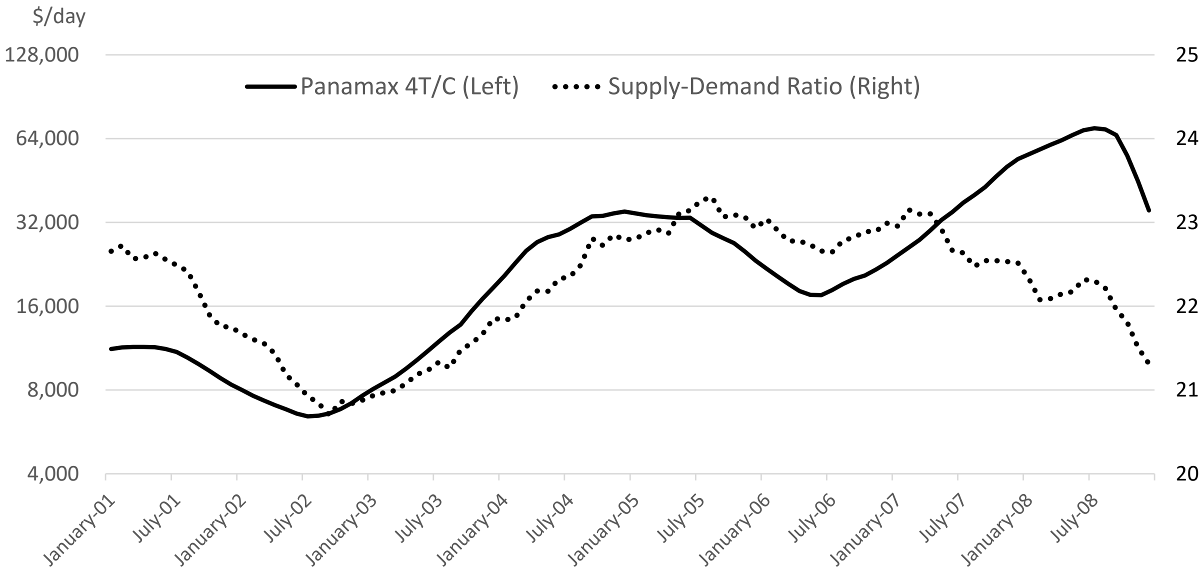
As for Period 2, descriptive statistics for Panamax 4 T/C and the supply-demand ratio are calculated in Table 5.

Table 5 – Descriptive statistics for Period 2

	Panamax 4T/C (Logarithmic)	Supply-Demand Ratio
No. of Records	96	96
Mean	4.31	22.22
Maximum	4.84	23.31
Minimum	3.80	20.70
Std. Deviation	0.30	0.71

Also, Figure 6 is a visual comparison of Panamax 4 T/C and the supply-demand ratio in Period 2.

Figure 6 - Charter Rates and Supply-Demand Ratio in Period 2



The BIC values of each number of regimes and the coefficients of determination in each regime are shown in Table 6. As BIC was lowest in the two regimes, the author regards this as the most suitable regime separation in Period 2.

Table 6 – Results for each number of regimes in Period 2

No of Regimes	BIC	Coefficients of Determination		
		Regime 1	Regime 2	Regime 3
1	19.32	0.31		
2	-80.50	0.28	0.60	
3	99.60	0.96	0.88	0.08

Figure 7 is the detected regimes overlaid on Figure 5. Descriptive statistics in each regime are shown in Table 7. Detected regimes are: Regime 1: Mar.

2004 - Oct. 2005 and Feb. 2007 - Dec. 2008 (43 months), Regime 2: Jan. 2001 - Feb. 2002 and Nov. 2005 - Jan. 2007 (17 months).

Figure 7 - Regimes overlaid on Figure 6

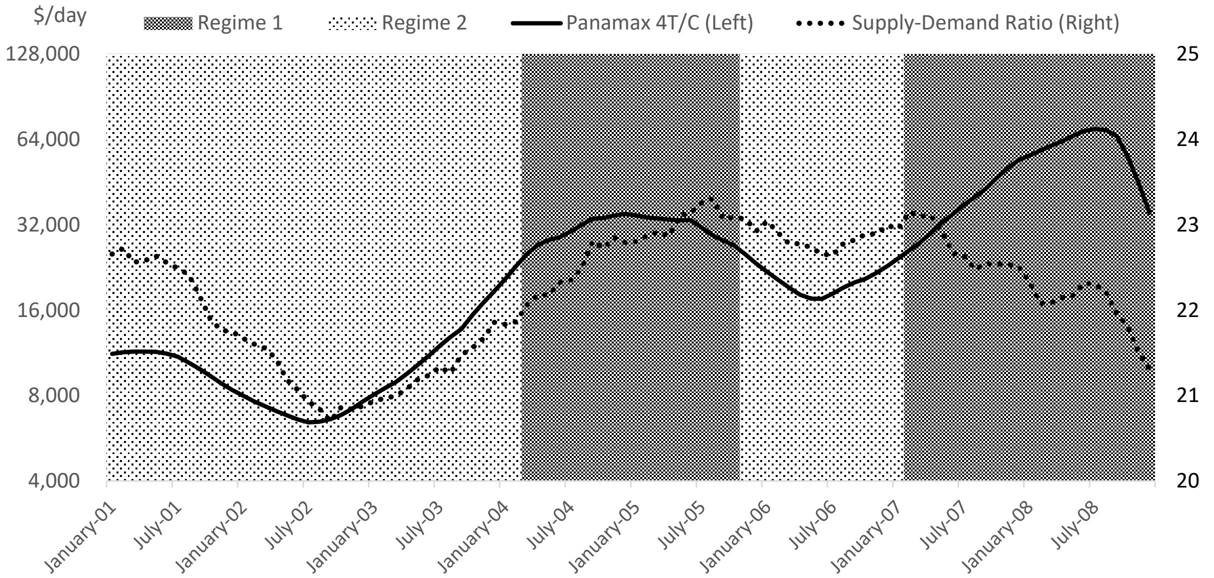


Table 7 – Descriptive statistics of each regime in Period 2

Regime	Period	Regression Coefficient	Intercept	Coefficient of Determination
1	Mar. 2004 - Oct. 2005, Feb. 2007 - Dec. 2008	-0.16	8.21	0.29
2	Jan. 2001 - Feb. 2004, Nov. 2005 - Jan. 2007	0.19	-0.15	0.60

Though regimes are not fragmented, they do not coincide with the shipping cycles understood in the industry (Figure 1) but were divided by high (Regime 1) and low (Regime 2) charter rates. The coefficient of determination is 0.29 in Regime 1 and 0.60 in Regime 2, which is much lower than those in Period 1. The regression coefficient of the model is -0.16 in Regime 1, which is an inverse correlation and suggests that factors other than the supply-demand ratio caused fluctuations in Regime 1. In Regime 2, the regression coefficient is positive, but the coefficient of determination 0.6 is not as high as those in Period 1.

The Q-Q plot of Period 2 (Figure 8) shows that the residuals are far skewed than those of Period 1 (Figure 4). This means there are factors not included in the model. Figure 9 shows that large partial autocorrelation does not exist and therefore is not the reason the residuals are skewed.

Figure 8 - Q-Q plot of Period 2

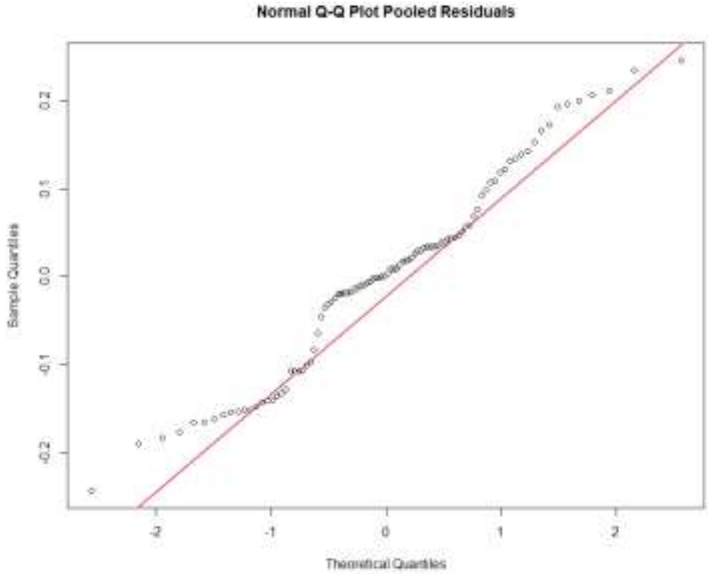
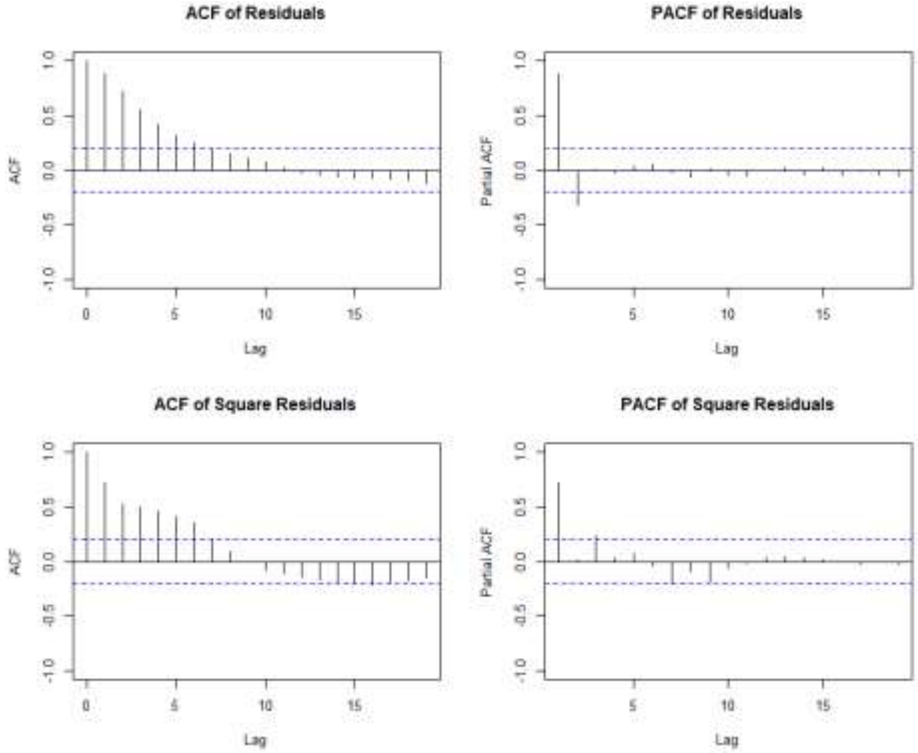


Figure 9 - Autocorrelation in Period 2



4. Discussions about the results

In both of the two periods analyzed in this study, the change in the relationship between the supply-demand ratio and spot charter rates can be determined by MRSwM. The regimes obtained by MRSwM are not fragmented, and therefore the separation seems to work well.

However, Period 1 and Period 2 differ in how well the regimes matched the actual shipping cycles. Period 1 contains two regimes almost identical to the shipping cycles understood in the industry, and those regimes have a high coefficient of determination. The Q-Q plot for the entire Period 1 also shows that the residuals are not skewed, suggesting there are no factors that are not included in the model and distort the result. On the other hand, in Period 2, the regimes are divided not by shipping cycles understood in the industry, but by high and low charter rates. The high charter rate period coincides with when the market was dragged up by the Capesize market, not by the supply-demand ratio. The fact that the regression coefficient is negative during this regime also supports this point. In addition, the Q-Q plot for Period 2 shows that the residuals are much more skewed than in Period 1. This means that in Period 2, there is a factor affecting the charter rates other than the supply-demand ratio and regime separation.

5. Conclusion and Further Discussion

The contributions of this study are as below:

This study proves that using MRSwM together with regression models of spot charter rates and the supply-demand ratio is effective for the segmentation of the shipping market. The segmented regimes are not fragmented.

However, whether the segmented regimes coincide with the shipping cycle depends on the existence of disturbing factors. When there are no disturbing factors (Period 1), the regimes were almost identical to the shipping cycles, and the model has strong explanatory power. On the other hand, when a disturbing factor exists (Period 2), the regimes are split by the disturbing factor, and the explanatory power of the model is low.

This means that shipping cycles coincide with the change of relationship between the supply-demand ratio and the charter rate, and MRSwM is useful in detecting the change. However, MRSwM should be used with caution because it will create inappropriate regimes when there are disturbing factors.

Future research required is to clarify the cause of the change in the relationship between the supply-demand ratio and charter rate. The outcome of this study is new to both academia and the industry, and therefore there is no existing hypothesis to explain the cause. However, detecting other shipping cycles statistically by MRSwM and comparing them with the shipping market or external conditions, we can get closer to the cause of parameter changes.

Also, from the viewpoint of the shipping industry, improving the usage of MRSwM is very important. This is because detecting the switching of the shipping cycle and estimating new parameters is of high practical value. Earlier detection of the shipping cycle and determining the presence of disturbing factors are among the improvement.

References

Alizadeh, A.H., Nomikos, N.K., 2004. A Markov regime switching approach for hedging stock indices., Journal of Futures Markets, 24, 649-674.
Alizadeh, A.H, Huang, C.Y., Dallen, S., 2015, A regime switching approach for hedging tanker shipping freight rates, Energy Economics 49, 44-59
Angelopoulos, J., 2017, Time-frequency analysis of the Baltic Dry Index, Maritime Economics & Logistics, 19(2), 211-233.
Beenstock, M. and Vergottis, A., 1993, Econometric Modelling of World Shipping (London, U.K.: Chapman and Hall)
Chiste, C. and van Vuuren, G., 2013, Investigating the cyclical behaviour of the dry bulk shipping market, Maritime Policy and Management, 41(1), 1-19.
Clarksons Shipping Intelligence Network, Clarksons Research, Date of access: 22/02/2022 https://sin.clarksons.net/
Gavalas, D., Syriopoulos, T., 2016, EXPLORING THE CYCLICAL STANCE OF THE SHIPPING MARKET; INTRODUCING THE SHIPPING CLIMATE TRACER, international journal of transport economics, 3.
Hamilton, J.H., 1989, A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle, Econometrica, 57, 357-384.
Hayashi, K., 2019, Cyclical fluctuation in dry bulk market caused by non-supply/demand factors, IAME 2019 Hong Kong conference full paper presentation
Hayashi, K., 2020, Stationarity of spot freight rates considering supply/demand effect, Journal of Shipping and Trade 5(24)
IMO, AIS transponders, Date of access: 24/02/2022 https://www.imo.org/en/OurWork/Safety/Pages/AIS.aspx
Kanamoto, K., Wada, Y., and Shibasaki, R., 2019, TRANSDISCIPLINARY ENGINEERING FOR COMPLEX SOCIO-TECHNICAL SYSTEMS, 10, 105-114
Karakitsos, E., Varnavides, L., 2014, The theory of shipping cycles In: Maritime Economics: A Macroeconomic Approach (New York, USA.: Palgrave Macmillan), pp.209-250
Kavussanos, M.G., Alizadeh, A.H., 2002, Seasonality patterns in tanker spot freight rate markets. Economic Modelling, 19(5), 747-782.
Koopmans, T.C., 1939, Tanker Freight Rates and Tankship Building (Haarlem, Holland)
Lee, H.-T., Yoder, J.K., 2007. A bivariate Markov regime switching GARCH approach to estimate time-varying minimum variance hedge ratios., Applied Economics, 39, 1253-1265.
NYK Line, 2021, 2021 Outlook for the Dry-Bulk and Crude-Oil Shipping Markets (Tokyo, Japan: The Japan Shipping Exchange)
Stopford, M., 2009, Maritime Economics, 3rd edition (London, U.K.: Routledge)
Tinbergen, J., 1934, Scheepsruimte en Vrachten, De Nederlandsche Conjunctuur, March: 23-35.
Trade Data Monitor, Trade Data Monitor, Date of access: 21/02/2022 https://www.tdmlogin.com/tdm/index.html
Tvedt, J., 2003, Shipping market models and the specification of freight rate processes, Maritime Economics and Logistics, 5, 327-346.