日本郵船

IAME 2020 Hong Kong Online

Stationarity of Spot Freight Rates Considering Supply/Demand Effect

June 11, 2020

Research Group, NYK Line

& Tokyo University of Marine Science and Technology

Koichiro Hayashi

Are Freight Rate Processes Mean-Reverting?

日本郵船

- Yes!
  - A classic understanding of maritime economics (e.g., Stopford) assumes that freight is decided by supply and demand over the long run.
  - This understanding is in line with the view of the shipping industry.

- No!
  - Many (though not all) preceding studies using modern time-series analysis show that freight rate processes have a unit root.

Stationarity / Unit Root

日本郵船

- A unit root process can be expressed as below:

$$Y_t = Y_{t-1} + c + \varepsilon_t$$

- A unit root process is not stationary. It neither diverges nor converges to a specific value, but it drifts (“random walk”)

- Some statistical techniques cannot be applied to unit root processes (e.g. spurious regression). Therefore whether a timeseries has a unit root is very important for industry analysts.

Two “means” for two processes

日本郵船

- This conflict may originate from the "mean" being considered for two different processes:
  - The freight rate process itself
  - The freight rate’s deviation from the supply/demand ratio, e.g the “mean” is zero.

- If the former process is not mean-reverting but the latter is, the contradiction will be solved.

Preceding Studies (1)

日本郵船

Shipping market modelling using supply and demand

- This line of study began with Tinbergen (1931, 1934) and Koopmans (1939) and has long since been at the center of maritime economics
- However, it had been almost abandoned after Beenstock and Vergottis (1993)
- In recent years AIS has been reviving this approach.

Preceding Studies (2)

日本郵船

Conditions of freight rate process when it has a unit root.

- Many preceding studies have done unit root tests. However, few of them aim to reveal in what case the process has a unit root.

- Adland and Cullinane (2006) show that freight rates are mean-reverting only in extreme markets and have a unit root during other periods.

Objective of Study

日本郵船

- Defining and solving the below model:

Actual Freight rates (a)

= Estimated freight rates based on demand/supply (b)

+ Deviation (c)

- Applying two methods to validate mean-reverting nature of (a) and (c)

  - Doing unit root tests
  - Applying AR(1) model to check their φ value. If φ is close to 1, the process is likely not mean-reverting. If φ is far smaller than 1, the process is mean-reverting.

Data (1)

- Focusing on Panamax spot market between Feb. 2009 and May 2017
  - The Panamax market is the most liquid and competitive among all vessel sizes.
  - Market turmoil continued through 2008 after the financial crisis.

- Baltic 4T/C Average is used as a spot rate
  - Values are logarithmized to express the exponential relationship between freight rates and the demand/supply ratio.

Data (2)

- Supply: Clarkson's Panamax DWT Fleet
  - Idle time is not considered (e.g., drydock, lay-up)
  - Vessel speed is assumed to be constant

- Demand: the sum of export volume of coal and grain from major export countries

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

  - Transport distance (e.g., ton-mille) is not considered

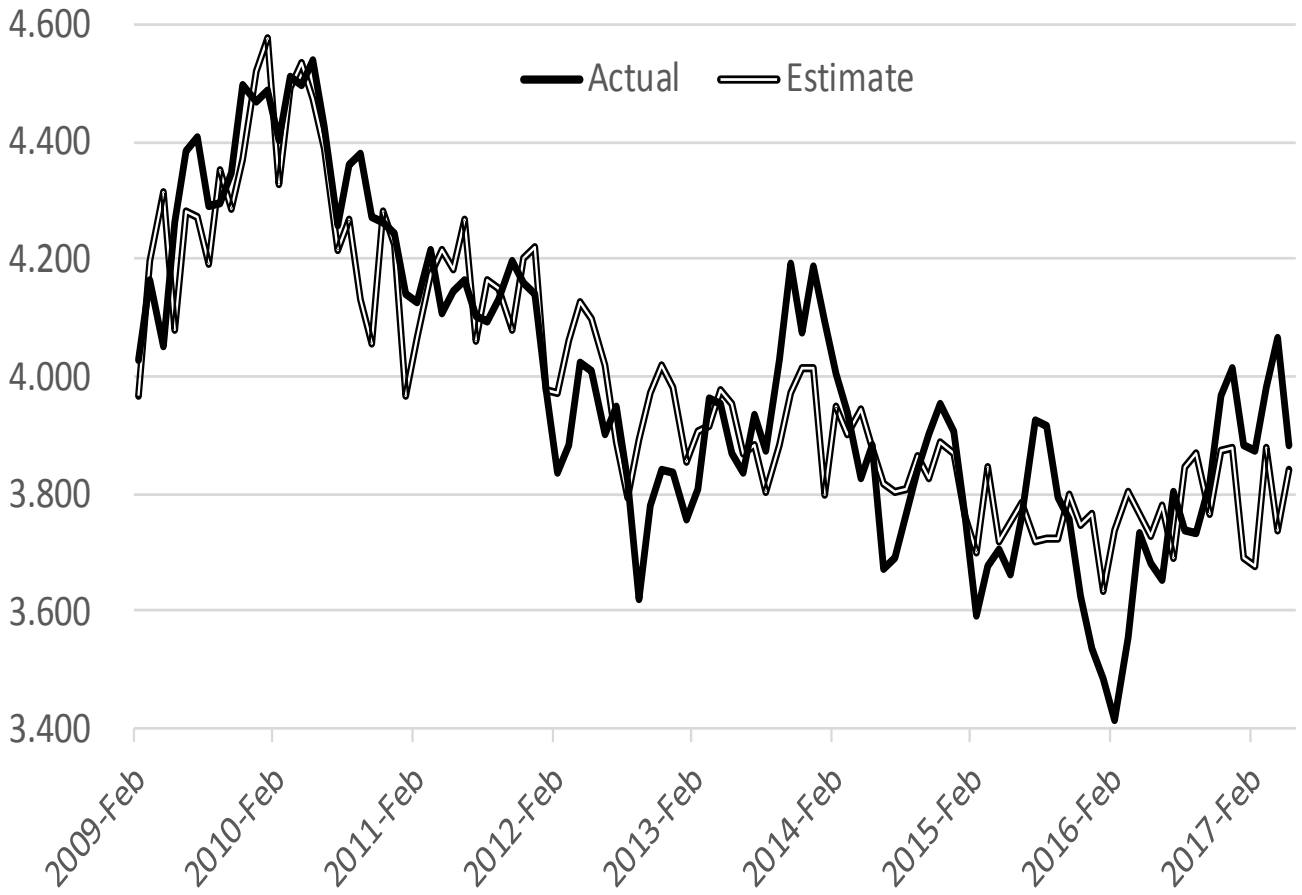
Methodology to Calculate Deviation

A) Doing linear regression between logarithmized Baltic 4T/C average spot rate and demand/supply ratio

B) Calculate the estimated spot rate based on the formula from step A)

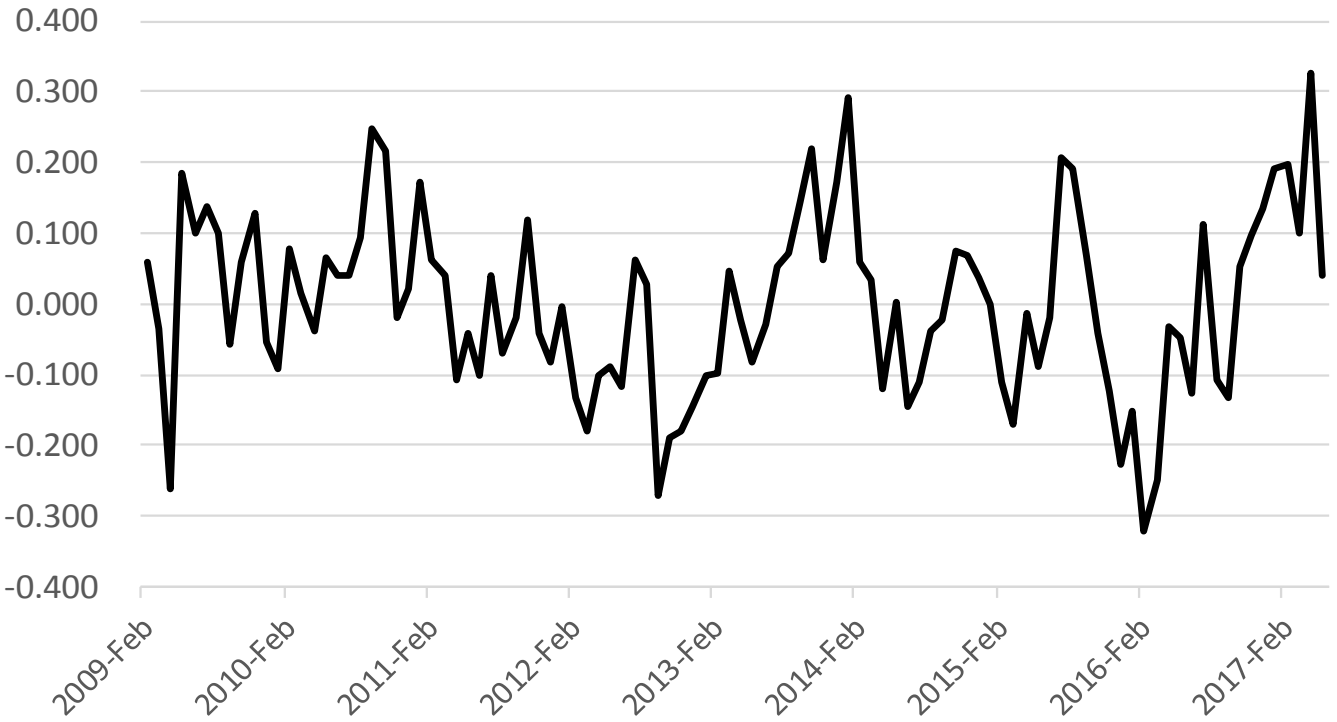
C) Subtracting the estimated spot rate from the actual one to get deviation

Actual and Estimated Spot Rates



Estimated freight rate = 0.0902 × (demand/supply ratio) + 2.2007

Deviation of Actual Rate from Estimated



	Actual Freight Rates	Estimated Freight Rates	Deviation
Numbers of observations	100	100	100
Mean	3.9898	3.9898	0.0000
Maximum	4.5390	4.5779	0.3251
Minimum	3.4150	3.6344	-0.3203
Std. Deviation	0.2602	0.2265	0.1280

Result of ADF Tests

日本郵船

	Value	Lags
Actual Freight Rates	-2.496	4
Estimated Freight Rates	-2.303	4
Deviation	-3.723	4
Critical values - 1%	-4.052	
Critical values - 5%	-3.452	
Critical values - 10%	-3.153	

- Both actual and estimated freight rates failed to reject the presence of a unit root at 10% level of significance.

- Deviation rejected the presence of a unit root at 5% level of significance.

Parameters of AR(1) Models

日本郵船

	Actual Freight Rates	Estimated Freight Rates	Deviation
Autoregression coefficient ϕ	0.9258	0.8849	0.5187
Intercept μ	3.6937	3.5305	0.0000
Variance of innovation $\sigma 2$	0.0098	0.0113	0.0121

- Ljung-Box tests for all three residuals rejected the presence of autocorrelation and autocovariance at 5% level of significance.

- Φ of actual and estimated freight rates are close to 1, while that of deviation is far smaller than 1.

Implications

- Both actual and estimated freight rates have unit roots and φ close to 1. This means they are not a mean-reverting process.

- Their deviation does not have a unit root and its φ is far smaller than 1. This means the process is mean-reverting.

- Also, the above results mean actual and estimated freight rates (e.g., freight rates and demand/supply ratio) are cointegrated.

Future Works

日本郵船

- Extend the period to include the shipping bubble era
- Apply this approach for other markets (e.g., Capesize)
- Test the nature of different frequencies (other than monthly (e.g., weekly or daily))
  - This can be done with AIS data.