Physica A 444 (2016) 547–559

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Multifractal analysis of spot rates in tanker markets and their comparisons with crude oil markets

Shiyuan Zheng*, Xiangang Lan

School of Transportation, Shanghai Maritime University, Shanghai, China

HIGHLIGHTS

- We investigate the dynamic features of the spot rates for different tanker markets.
- The non-periodic cycles for these markets are detected by the V-statistic.
- The tanker markets are more fractal than the crude oil commodity markets.

ARTICLE INFO

Article history:
Received 29 January 2015
Received in revised form 22 May 2015
Available online 23 October 2015

Keywords:
Tanker markets
MF-DFA
Time-dependent Hurst exponent
Singularity spectrum
Non-periodic cycle

ABSTRACT

This paper investigates the dynamic features of the spot rates for VLCC/ULCC, Suezmax, Aframax, Panamax and Handysize tanker markets by means of multifractal detrended fluctuation analysis (MF-DFA). The Hurst exponents, especially the time-dependent Hurst exponents, of the daily rate returns are calculated to capture the fractal properties of these different tanker markets. The origins of multifractility in these markets are identified by comparing their multifractal scaling exponents based on the original data, the shuffled data and the surrogate data. Furthermore, the non-periodic cycles for these markets are detected by the V-statistic. Finally, the comparisons of the fractal properties between the tanker markets and the crude oil commodity markets suggest that the tanker markets are more fractal than their upstream counterparts.

1. Introduction

Shipping market is viewed as a volatile and unpredictable market derived from world economy and trade. Moreover, shipbuilding cycles further complicate and magnify its volatility [1]. In recent years, research focuses have been shifted from building full scale econometric models to direct specifications of freight rates process in the maritime literature [2]. For the tanker market, studies are rich. Most studies make a commonly used assumption that the tanker market is an efficient or weakly efficient market (efficient market hypothesis, EMH by Fama [3]). Technically, they employ econometrics models (e.g., ARIMA, VAR, VECM, GARCH) to study the dynamic features of the tanker freight rates and their impact factors. Table 1 makes a brief summary on these studies.

However, given the untradeable feature of a transportation service, EMH does not apply to the tanker freight rate process. Zannetos [17] points out that the lay-up option and the limited ship capacity in short run lead to a supply function that is near-perfectly elastic for very low freight rates and perfectly inelastic once the fleet operates at full capacity. This hockey-stick shape of the short-run supply function and the very inelastic oil shipping demand make the spot freight rate in

* Corresponding author.
E-mail addresses: syzheng@shmtu.edu.cn (S. Zheng), 544698448@qq.com (X. Lan).

http://dx.doi.org/10.1016/j.physa.2015.10.061
0378-4371/

Table 1
Summary of literature on tanker market based on EMH.

Authors	Methodology	Achievements/conclusions
Beenstock and Vergottis [4]	Simultaneous equations model	Establish models describing the freight rate behaviors and their relations with the new building and second-hand ship markets.
Kavussanos [5]	ARCH	Oil prices are negatively related to rates of change in tanker prices and positively related to their volatilities. Monthly prices of smaller vessels are less volatile than larger ones.
Berg-Andreassen [6]	Cointegration test	Four of the five common theories of the freight rate are rejected, and only the Conventional Wisdom Hypothesis is accepted.
Glen and Martin [7]	GARCH	The risk of tanker increases systematically with its size and is greater in the spot market than in the period market.
Veenstar [8]	VAR	The spread or the difference between the time charter and spot fixtures equals to the present value of a series of spot fixtures plus a positive or negative liquidity premium.
Wright [9]	VAR	There exists cointegration relationship among the freight rate indices for three tanker size classes of 30,000 dwt, 130,000 dwt and 250,000 dwt, and the one-year time charter rates for the 30,000 dwt tankers.
Wright [10]	VAR	The rational expectation hypothesis can be accepted to interpret the long-term relation in the tanker market.
Kavussanos [11]	Cointegrating Error Correction ARCH models	Time charter rates have lower volatilities than spot rates, and freight rates of larger vessels have higher volatilities than smaller vessels.
Adland and Cullinane [12]	General non-parametric Markov diffusion model	The spot freight rate is mean reverting only in the extremes of the empirical range. The volatility of freight rate changes increases with the level of freight rate.
Adland and Strandenes [13]	Kernel regression	Chartering decisions can be based on the identification of peaks and troughs in the freight market cycles.
Alizadeh and Nomikos [14]	VECM	The proposed trading model can be used as an indicator for making decisions on the timing of investment or divestment.
Syriopoulos and Roumpis [15]	EGARCH, VAR	There exist contemporaneous relationships between returns and trade volume in the markets of Handysize and Aframax tankers. Price changes have an impact on trading volume.
Zhang et al. [16]	Brownian distance correlation, Granger causality analysis	The new ship market is relatively distant from the second-hand ship and freight markets before and after the financial crisis. During the crisis period, these shipping markets become more closely related to each other.

the tanker market show small and large volatilities together, which is referred to as volatility clustering. Furthermore, Zannetos [17] and Strandenes [18] think that the tanker freight rates should revert towards the long-run equilibrium costs of providing the transportation service. All these researches reveal that the tanker freight rates may have the characteristics of nonlinearity and non-normality. They also suggest that the tanker freight rates may have the memory effects, which leads to the use of ARCH and GARCH models inappropriate since these two models are suitable for stationary situations.

The fractal analysis technique uses nonparametric specifications to deal with the nonlinear and non-stationary time series with the characteristics of fat-tailness of probability distributions and volatility clustering. However, there are very limited studies on shipping market using the fractal analysis method. Table 2 makes a brief description.

In this paper, we apply MF-DFA to investigate the dynamic properties of spot rates in the tanker markets. Our work tries to contribute to the literature in the following ways. First, currently there are few studies on the multifractal properties of the tanker market. The nonlinearity and non-normality of the tanker freight rates make it necessary to apply MF-DFA to the tanker market. We calculate the Hurst exponents of the daily rate returns in VLCC/ULCC, Suezmax, Aframax, Panamax and Handysize tanker markets. Especially, we use the time-dependent Hurst exponents to capture the dynamic fractal properties of these tanker markets. Moreover, the singularity spectrums are used to provide the most detailed test to their multifractal features. Second, we track the origins of multifractility in these markets by comparing their multifractal scaling exponents with the original data, the shuffled data and the surrogate data. Third, we detect non-periodic cycles for these markets. It is known that there are not only periodic cycles, but also non-periodic or chaotic cycles in shipping market. We use the V-statistic to find the non-periodic cycles in the above tanker markets. Fourth, we investigate the relationship of the multifractal properties between the spot crude oil markets and the spot tanker markets, which are the different parts in the same commodity supply chain. We compare their Hurst exponents of the daily rate returns, their origins of multifractility and their non-periodic cycles. By these comparisons, we analyze the spillover effects among the related markets in the crude oil industry and give explanations.