Seasonal Analysis and Comparative Study of Tanker Freight Rate Indices

Christos N.Stefanakos*

*** Technological Educational Institute of Athens, Athens, Greece**

ABSTRACT

The seasonal variability of various tanker freight rate indices is examined, and their seasonal behavior is studied comparatively with other indices. The calculations are performed using a nonstationary stochastic modeling, appropriate for separating the different time scales involved in daily time series. This modeling, which has been extensively used for time series of wave data, is applied to this kind of data for the first time. As input data, the daily time series of the last two and a half years of the various BITR indices is used. The results are very satisfactory, permitting us to make concrete conclusions for the variability of the related indices.

1. INTRODUCTION

There is a wealth of information concerning the maritime market on a daily basis. For example, the independent maritime organization Baltic Exchange publishes daily four composite indices concerning the dry cargo market and two concerning the tanker market.

The calculation of each one these composite indices is based on a number of individual routes representing all major cargo sizes and vessel types. For example, concerning the Baltic Dirty Tanker Index (BITR Dirty), the routes are shown in Table 1. In the same table the DWT of the ships taken into account in each specific route is given.

Table 1. Baltic Dirty Tanker Index routes (BITR Dirty), along with Worldscale assessment as of 7 June 2002

Route No.	Description	Size (mt)	W/S
TD1	M.E. Gulf to US Gulf	280000	38.75
TD2	ME Gulf to Singapore	260000	41.88
TD3	ME Gulf to Japan	250000	41.88
TD4	W Africa to US Gulf	260000	43.38
TD5	W Africa to USAC	130000	67.25
TD6	Cross Mediterranean	135000	78.25
TD7	North Sea to Cont	80000	104.00
TD8	Kuwait-Singapore (Crude and/or DPP Heat 135F)	80000	93.45
TD9	Caribs to US Gulf	70000	166.25
TD10	Caribs to USAC	50000	163.38

Then, the BITR Dirty is a daily composite index calculated from the reports of an independent international broker panel. The panel members are required to make a daily assessment on a basket of voyage routes in the tanker bulk shipping market representative of BITR (Dirty) vessels. For more information on this subject, see the web site of the Baltic Exchange (http://www.balticexchange.com).

In the present work, we will examine the seasonal patterns of the indices of certain individual. Namely, we will consider routes TD3, TD5, TD7 and TD9 from the BITR Dirty, and TC2, TC3 from the BITR Clean (Baltic Clean Tanker Index). Also, the seasonal behavior of these indices will be studied comparatively, i.e. TD3 vs. TD5, TD7 vs. TD9, and TC2 vs. TC3.

For the investigation of the seasonal patterns, a nonstationary time series modeling is proposed for the modeling of the daily time series of indices. This modeling has been introduced in [1], and has been extensively applied to time series of wave data [2-6]. This modeling, which is applied (for the first time) to time series of tanker freight rate indices, is briefly described in Section 2. Then, the time series of the monthly mean values and of the monthly standard deviations are obtained. These time series form the basis for calculating the seasonal mean value and seasonal standard deviation of each index. See Section 3. Finally, our findings concerning the seasonal behavior of the indices are given in Section 4.

2. MODELLING AND ANALYSIS OF DAILY TIME SERIES (OF THE INDICES)

Let us denote by $X(\tau_i)$, $i = 1, 2, ..., I$, the daily (hopefully many-year long) time series of one of the cargo indices *TD3, TD5, TD7, TD9, TC2 or TC3* (or of an appropriate transform of it); see Figures 1. Usually, the shifted logarithms are considered, i.e., $X(\tau) = \log[TD3 + c]$, where c is a small positive constant to be estimated. The constant c is introduced in order to avoid zeros and minimize the skewness of the probability distribution of $X(\tau)$.

According to the modelling introduced in [1], such a time series admits to the following decomposition:

$$X(\tau) = \overline{X}_{tr}(\tau) + \mu(\tau) + \sigma(\tau)\ \ W(\tau), \qquad (1)$$

where $\overline{X}_{tr}(\tau)$ is any possible long-term (climatic) trend, $\mu(\tau)$ and $\sigma(\tau)$ are deterministic periodic functions with period of one year, and $W(\tau)$ is a zero-mean, stationary, stochastic process. The functions $\mu(\tau)$ and $\sigma(\tau)$ are called seasonal mean value and seasonal standard deviation, respectively, and are used to describe the exhibited seasonal patterns.

In the sequel, we shall consider that $\overline{X}_{tr}(\tau) = \overline{X} = const$ and this constant will be incorporated into $\mu(\tau)$. Let it be noted that the whole methodology presented herein can be equally well applied to the case where a trend $\overline{X}_{tr}(\tau)$ is present, if the data (from the same or other sources) permits us to identify such a trend.

Thus, in the present work, decomposition (1) will be rewritten as

$$X(\tau) = \mu(\tau) + \sigma(\tau)\ \ W(\tau)\,. \qquad (2)$$

The time series $X(\tau)$ is usually reindexed, in order to properly treat variability at different time scales, by using the double Buys-Ballot index (j, τ_k), where j is the year index and τ_k ranges within the annual time [1]. In the present work, a triple index of similar philosophy, introduced by Athanassoulis *et al.* [6]; see also [5]) and denoted by (j, m, τ_k), will be used. The first component j is again the year index. The second component m is a month index, ranging through the set of integers $\{1, 2, ..., M = 12\}$. The third component τ_k represents the monthly time, the index k ranging through the set of integers $\{1, 2, ..., K_m\}$, where K_m is the number of α-hourly observations within the m-th month. Clearly, the meaning of the symbol τ_k in the triple index (j, m, τ_k) used herewith is different from the meaning of the same symbol in the double index (j, τ_k), used in previous studies [1,2,4].

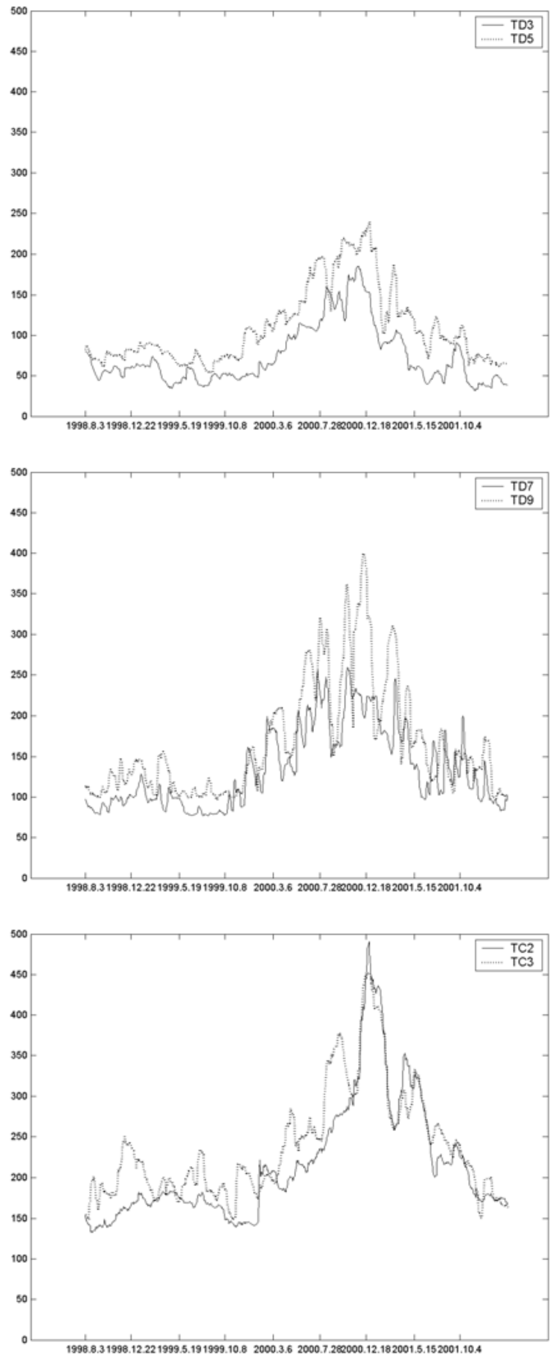

Figure 1. Daily time series of the following indices: (a) TD3 (solid line), TD5 (dotted line), (b) TD7 (solid line), TD9 (dotted line), and (c) TC2 (solid line), TC3 (dotted line)

According to the new, three-index notation, the time series $X(\tau_i)$ is reindexed as follows:

$$\{X(j, m, \tau_k),\quad j = 1, 2, ..., J,\quad m = 1, 2, ..., M,\quad k = 1, 2, ..., K_m\}. \qquad (3)$$

The three indices j, m, τ_k, represent three different time scales, making it possible to explicitly define statistics with respect to each one of them, separately. In the following sections, use will be made of the subscripts 1, 2, 3 to denote various statistics (mean value and standard deviation) with respect to the corresponding (first, second, third) index. In order to clarify the structure of this notation, we present a number of examples, some of which will also be used in the sequel:

$$M_1(m,\tau_k) = \frac{1}{J}\sum_{j=1}^{J} X(j,m,\tau_k)\,, \tag{4a}$$

$$S_1(m,\tau_k) = \sqrt{\frac{1}{J}\sum_{j=1}^{J}\left[X(j,m,\tau_k) - M_1(m,\tau_k)\right]^2}\,, \tag{4b}$$

$$M_3(j,m) = \frac{1}{K_m}\sum_{k=1}^{K_m} X(j,m,\tau_k)\,, \tag{4c}$$

$$S_3(j,m) = \sqrt{\frac{1}{K_m}\sum_{k=1}^{K_m}\left[X(j,m,\tau_k) - M_3(j,m)\right]^2}\,. \tag{4d}$$

We also define two-index statistics, which are obtained by successively taking mean values with respect to two indices. For example:

$$M_{13}(m) = \frac{1}{K_m}\sum_{k=1}^{K_m}\frac{1}{J}\sum_{j=1}^{J} X(j,m,\tau_k) = M_{31}(m). \tag{4e}$$

In the next sections, we formulate appropriate estimates of seasonal patterns $\mu(\tau)$ and $\sigma(\tau)$, based on the above presented statistics.

3. MODELLING AND ANALYSIS OF MONTHLY MEAN VALUES

It is a straightforward matter to define the time series of monthly mean values (MMV) of $X(\tau_i)$. In fact, eqn. (4c) defines this time series by averaging α-hourly observations over each month. In Figures 2a, 3a and 4a, the MMV time series, obtained from the daily time series is presented. Averaging $M_3(j,m)$ over all the examined years, we obtain the overall MMV (per month):

$$\tilde{M}_3(m) = \frac{1}{J}\sum_{j=1}^{J} M_3(j,m) = M_{31}(m) = M_{13}(m)\,. \tag{5a}$$

The time series of monthly standard deviations (MSD) of $X(\tau_i)$ is defined by means of the eqn. (4d). See also Figures 2b, 3b and 4b, where these series are shown. Averaging $S_3(j,m)$ over all the examined years, we obtain the overall MSD (per month):

$$\tilde{S}_3(m) = \frac{1}{J}\sum_{j=1}^{J} S_3(j,m)\,. \tag{5b}$$

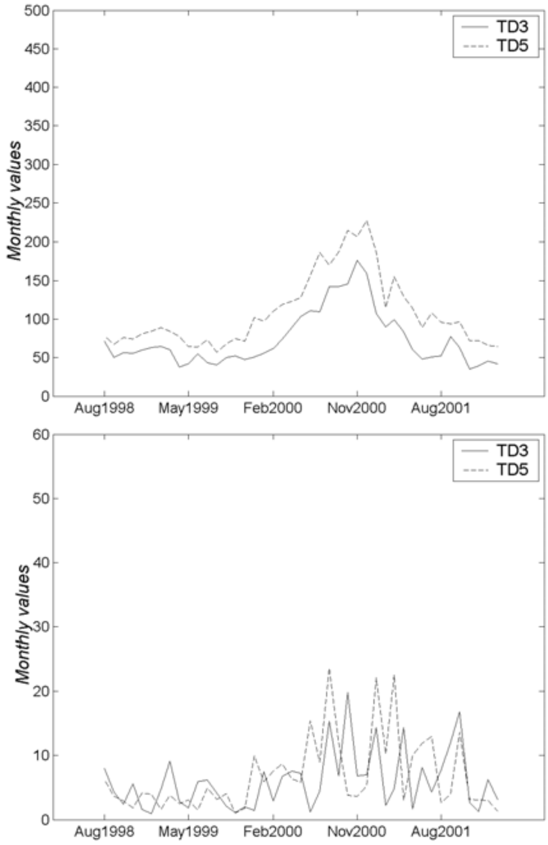

Figure 2. Time series of (a) monthly mean values, (b) monthly standard deviations of TD3 (solid line) and TD5 (dashed line)

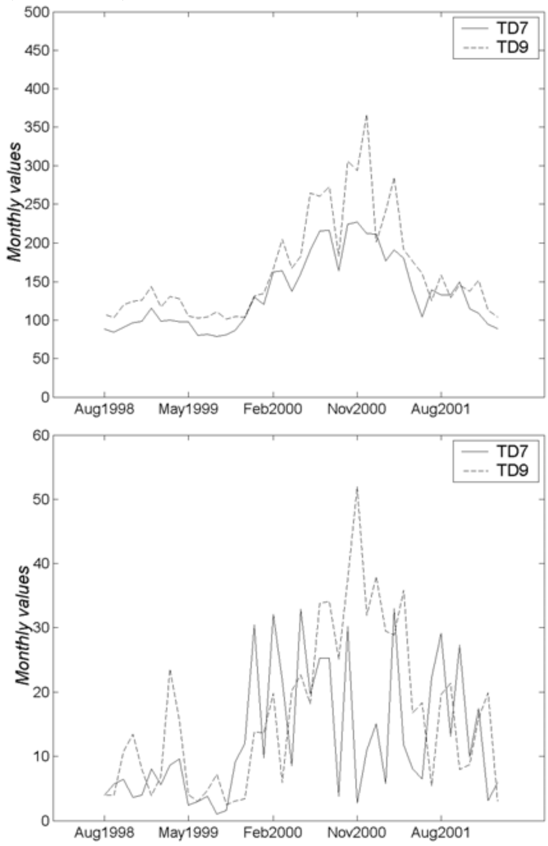

Figure 3. Time series of (a) monthly mean values, (b) monthly standard deviations of TD7 (solid line) and TD9 (dashed line)

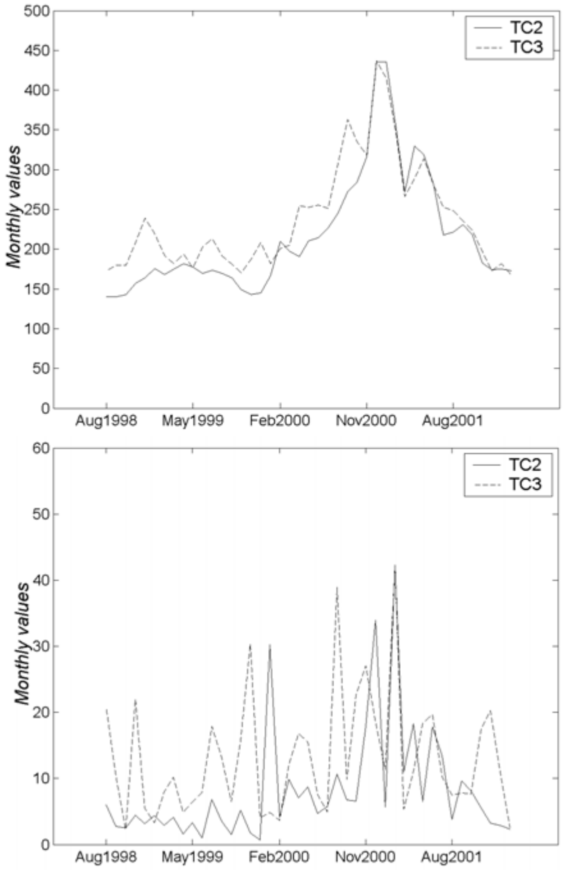

Figure 4. Time series of (a) monthly mean values, (b) monthly standard deviations of TC2 (solid line) and TC3 (dashed line)

It should be noted that $\tilde{S}_3(m)$ is not the standard deviation of the time series $M_3(j,m)$. The selection of $\tilde{S}_3(m)$ as the representative quantity for the variability of MMV $M_3(j,m)$ about the overall MMV $\tilde{M}_3(m)$ has been dictated by the data analysis.

Now, the quantity $\tilde{M}_3(m)$, describing the seasonal variability of MMV, is called the *seasonal mean value* of the initial time series $X(\tau)$. Similarly, the quantity $\tilde{S}_3(m)$, describing the seasonal variability of MSD, is called the *seasonal standard deviation* of the initial time series $X(\tau)$. The seasonal mean value and standard deviation of the various examined indices are shown in Figures 5-7.

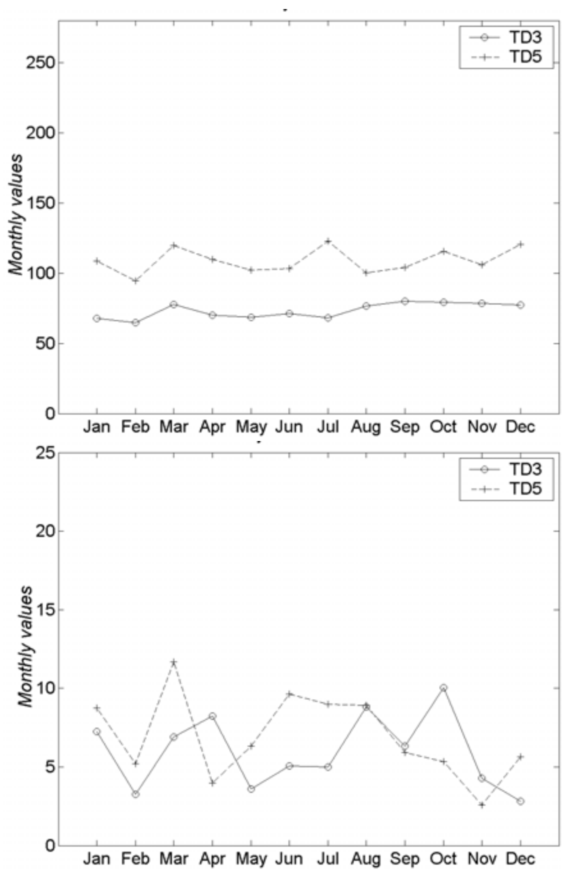

Figure 5. Seasonal variability of the (a) mean value, (b) standard deviation of TD3 (solid line), TD5 (dashed line)

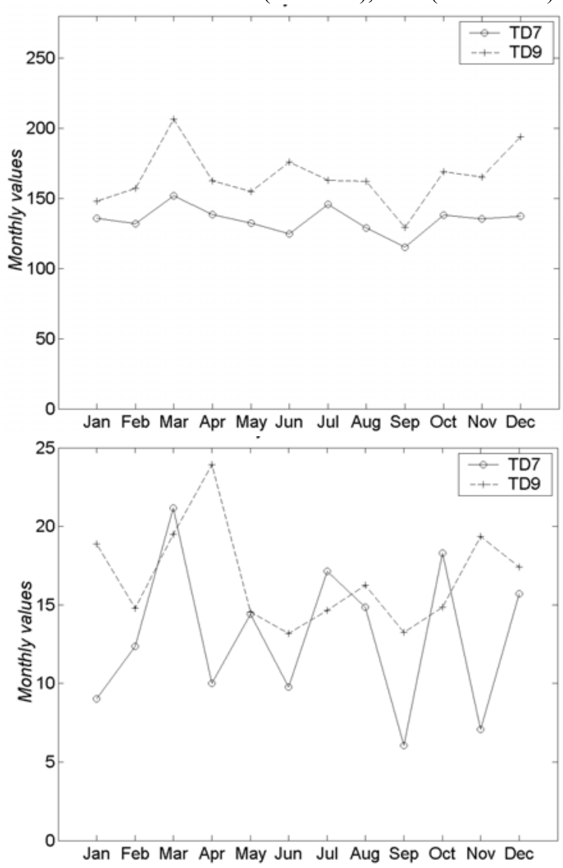

Figure 6. Seasonal variability of the (a) mean value (b) standard deviation of TD7 (solid line), TD9 (dashed line)

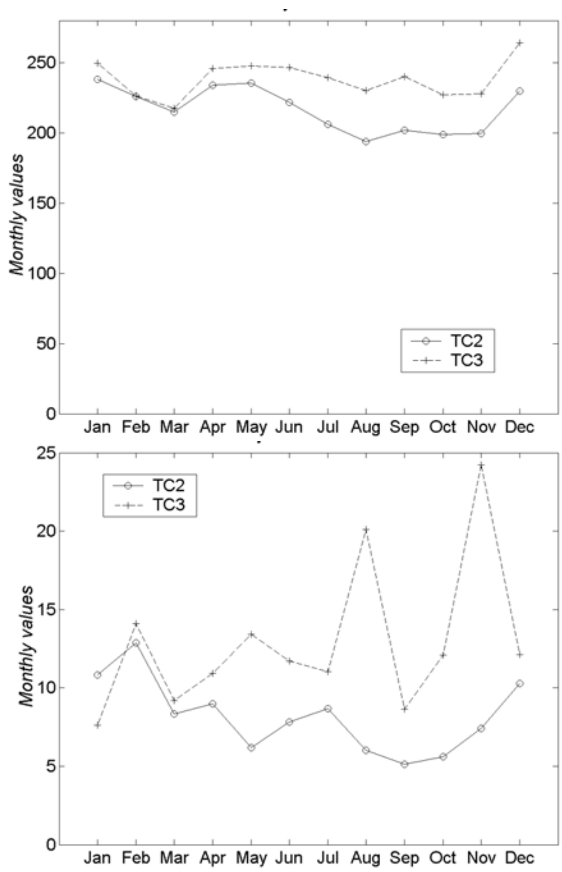

Figure 7. Seasonal variability of the (a) mean value (b) standard deviation of TC2 (solid line), TC3 (dashed line)

Further, in order to quantify the difference between the seasonal mean value (or standard deviation) of two indices of interest (e.g., TD 3 and TD5), we define the following Relative Difference:

$$Rdiff = \frac{\tilde{T}_3^i - \tilde{T}_3^j}{\tilde{T}_3^j}, \qquad (6)$$

where $\tilde{T}_3^i$ stands either for $\tilde{M}_3(m)$ or for $\tilde{S}_3(m)$ for two indices. See Figures 8a-c.

4. CONCLUDING REMARKS

In this paper, the seasonal variability of the indices TD3, TD5, TD7 TD9, TC2, TC3 is examined. For this, daily time series of the above-mentioned indices have been used; see Figures 1a-c.

First, the populations of the monthly mean values and monthly standard deviations are formed, using the daily time series of the indices; see Figures 2-4. Then, mean values and standard deviations for each month are appropriately defined. In this way, we obtain the seasonal mean value and the seasonal standard deviation of each index, and then we compare them by two (TD3 vs. TD5, TD7 vs. TD9, TC2 vs. TC3).

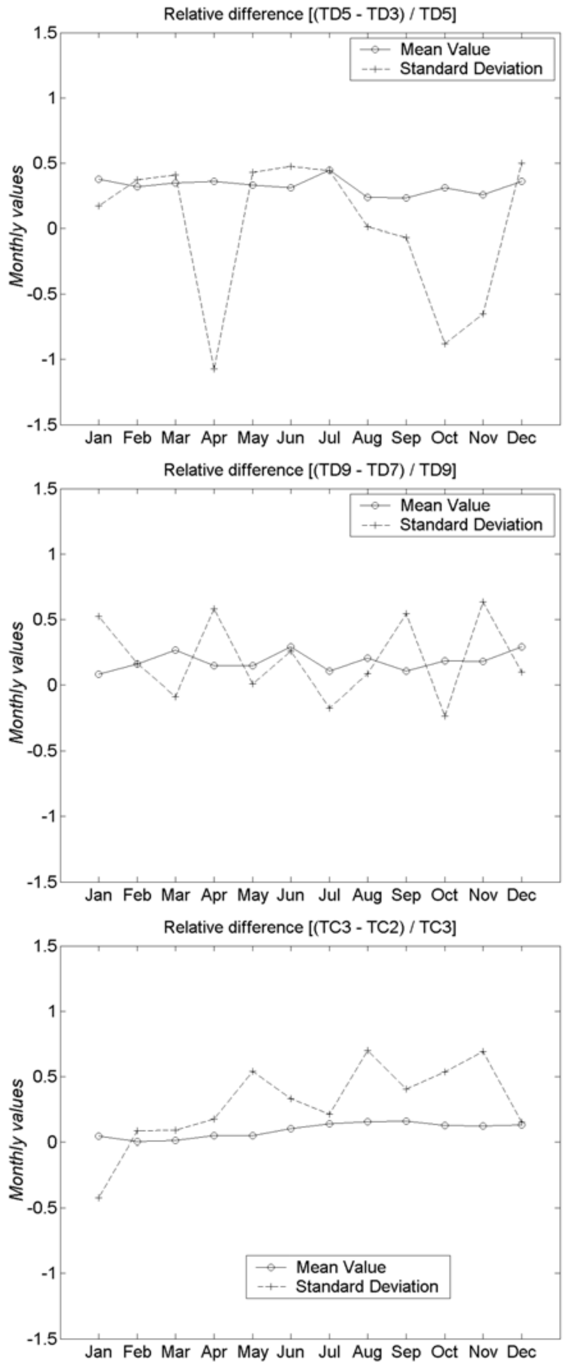

Figure 8. Seasonal variability of the Relative Difference of the mean values (solid lines) and the standard deviations (dashed lines) of the following pairs of indices: (a) TD3 - TD5, (b) TD7 - TD9, and (c) TC2 - TC3.

The results of these comparisons can be codified as follows:

a) Seasonal mean value:

In Figure 5a, the seasonal mean value of TD3 (red continuous line) is compared with the corresponding one of the TD5 (blue dashed line). The indices show similar trends, though the variability of index TD3 is not so pronounced. Higher values are expected in the month of September for TD3 and in the month of July for TD5. Accordingly, lower values are shown in the month of February for both TD3 and TD5. The agreement between the variability trends of TD7 and TD9 is even better; see Figure 6a. Here, maximum and minimum values are shown for both indices in the same months (March and September, respectively). Finally, the comparison between the indices TC2 and TC3 gives the better result among the three cases; see Figure 7a.

b) Seasonal standard deviation:

In Figure 5b, the seasonal standard deviation of TD3 (red continuous line) is compared with the corresponding one of the TD5 (blue dashed line), showing similar trends, and in some cases, complete coincidence of their values. In the sequel, the variability of TD7 seems to be more pronounced than the one of TD9; see Figure 6b. Finally, the comparison between the indices TC2 and TC3 shows that a direct comparison is not feasible; see Figure 7b.

c) Relative Difference

The relative difference, as defined in (6), shows the difference between the variability of seasonal mean value (and/or of the standard deviation) of two indices as percentage of the values of one of the two mean values (namely of TD5, TD9 and TC3). In Figures 8a-c, the relative difference of both seasonal mean value (green lines) and standard deviation (magenta lines) are depicted for the three pair of indices (TD3 vs. TD5, TD7 vs. TD9, TC2 vs. TC3).

Concerning the mean value, this relative difference is found to be almost constant, taking values 40% of TD5 (Figure 8a), 25% of TD9 (Figure 8b), and 2% of TC3 (Figure 8c) for the three comparison cases. In the case of the standard deviation, the situation is different: the relative difference exhibits its own variability, ranging from -50% to 50% of the actual values. In two (out of three) cases, the exhibiting variability seems to have a periodic character.

ACKNOWLEDGMENTS

The author is grateful to Mr. Lambros Papaeconomou of Nyfex & Company LLC for providing with the daily time series of the tanker freight rate indices.

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