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To What Extent the Fractal Behavior of a Financial Turbulence Can Help Greek Shipowners to Forecast Their Freight Rate Markets?

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Abstract

Mandelbrot & Hudson (2006) constructed bridges between Nature and Markets in a way making us to believe that forecasting of (freight rate) markets—i.e. the subject-dream of all maritime economists—at last, will become true. But it did not. Noah knew that after 100 years of building the Ark, the flood will terminate all lives found outside it. Humans also experienced the 1929-1936 Great Depression, (i.e. the 1st "Noah effect" in Economics), and maritime economists lived their 1918 1st "Noah effect". The end-2008 2nd Noah effect, however, reminded maritime economists of the freight rate indices, which increased gradually from 7,000 units to 19,000, within 7 years. Moreover, the frequent 7 yearly, or so, shipping cycles reminded researchers that the "Joseph biblical case" can re-happen. Economists tend to study events that are re-coming back from time to time, so they led them to the "Hurst exponent", indicating "long term memory in the data", and to alpha, showing fat tails. The computer program we used gave us H = 0.69 and alpha = 1.45, meaning that the Normal Distribution is a special case.

Keywords

Nature & Markets, The Global Financial Slump 2009, Predicting/Forecasting Shipping Chaotic Time Series, The Noah and Joseph Effects, The H and Alpha Exponents, Visioning versus Forecasting, The Lyapunov Exponent

1. Introduction

Forecasting, however, unlike visioning, is not one of the strong human abilities. Humans for centuries tried to derive laws from what they were observing. In fact, they derived laws even where no laws existed. Physics is, and always has been, a science in which laws exist and can be proved by experiment. Economists dreamed all along to be like the Physicists, and as a result called their conclusions "laws" where the human "Free Will", however, rejected them. The climatic destruction is a proof of the existence of the human free will.

Statisticians discovered the "law of the large numbers", where n has to tend to ∞. Let us have a set of *random* variables: can their sum and mean follow a *normal distribution*? The answer is yes, if the sample is *sufficiently* large. The "large sufficiency" was not rigorously defined as it should.

A normal distribution is a "*probability*" distribution (symmetric, bell-shaped, and simple) having (based on) only 2 parameters: the *mean* and the *variance*. Normal distribution is a mathematical relationship which gives the *probability* with which a Random variable takes on certain values, or falls between certain limits. No body, however, said that this is a special case.

2. The Purpose of This Work

The purpose of this work is to apply two prediction/forecasting[1] methods out of five, with the expectation that a better forecasting may protect the mankind in general, and the Greek shipowners, in particular, from such financial disasters as that experienced in 2009 and thereafter. The methods used here are the "Ordinary Least Squares" and the "Kernel density estimation" (Sugihara & May, 1990).

In the literature there are 5 computerized methods of predicting and forecasting, and five tests of them, i.e. inside and outside the sample. The tests usually ask for the number of last observations to be used and the number of the future steps to be forecast ahead. The program applies various combinations and calculates E: the error estimation: $E = \sqrt{\Sigma}\left(Xp - X\right)2 / \Sigma\left(Xa - X\right)2$, where Xp is the predicted value and Xa the average value. Certain of the methods require the size of the variance (PCR) to be taken into account, the "time delay", and "embedding dimension". As a result the method, or the methods, that have produced the lower E are used for forecasting inside and outside the sample.

3. The Structure of This Work

This work is cast in 5 parts, after a literature review, as follows: Part I, dealt with the interrelationship between Nature and Markets; Part II, dealt with a memoir of the Global financial crisis (2009-2018); Part III, dealt with the prediction/forecasting of chaotic shipping time series; Part IV, dealt with the "Noah" effect; Part V, dealt with the "Joseph" and the "Noah Effects" the way discovered by Mandelbrot. Finally, we concluded.

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[1] We use the term "prediction" for working inside the sample and the term "forecasting" for working outside the sample.

4. Data List

The original research (Psifia, 2006) used the “dry cargo tramp trip charter index” 1968-2003 (till August; 428 months). The present authors attempted to see what happened to their forecasting after the forecast period, by using the data provided by UNCTAD annual statistics after 2003 (August). In fact, we wanted to see whether the forecasting methods could forecast the Noah effect that we knew it have occurred in 2003-2008.

5. Literature Review

Feder (1988) argued that in a “fractional Brownian motion[2]” (FBM), we can generalize the H, (the Hurst exponent), so that to range from 0 to 1, instead from $0.50 < H < 1$. Let now a particle be in the position of a $B_H(t)$ in a FBM, where its variance of the changes in its position scales in time according to $V(t - to) \approx It - toI^{2H}$ (1) = ~131. The Variance found equal to 42.5 units (rounded) of the “dry cargo index due to Stopford (2009)” (i.e. the “Maritime Economics Freight Index”, 1741-2022). The variance is also governed by a power law equal to 2H (or by 1.38). This analysis is considered by the authors as the mathematical expression of the Noah effect. The time series are expected to change by a variance equal to 2H or by 1.38 = 131 index units.

Schroeder (1991) proposed this formula: $X_{n+1} = \rho. Xn + \surd 1 - \rho^{2}. r_n$ (2), where $X_0 = 0$, r is a (uniform) random number and ρ is the (desired) correlation, time related to the “relaxation time t”, where $\rho = \exp(-1/t)$ (3). A relaxation process is a form of a *dynamic equilibrium* (Peters, 1994: p. 172). According to (3) $\sigma = t^{H}$, i.e. the standard deviation increases at a rate equal to H, or $3^{0.69} = 2.134$ (rounded.) at a 99.75% probability.

Priesmeyer (1992) argued that the chaos theory suggests *visioning* (pp. 173-191) so that to replace the “impossible” forecasting. Visioning is a specific procedure with important implications for planning inside the Enterprises. Managers, however, have a free will, which allows them to decide whether or not to take action and what kind of action to take. Whoever could forecast the million decisions taken by global managers?

Managers should have a vision of how they want their company’s future to be. The enterprises, however, have *structural characteristics*, which define their patterns of performance (**Table 1**). These characteristics distinguish one enterprise from the others and one manager from the rest. In fact, Enterprises try to *reduce* the Chaos that appears in their industries.

Table 1. The five structural characteristics which define the patterns of the performance of the Enterprises.

In Purchasing	*In Producing*	*In Marketing*	*In Financing*
In the nature of contracts with Suppliers & Customers (*Charterers*)			

Source: author; inspired by Priesmeyer (1992).

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[2] A “biased” random walk.

The above 5 structural characteristics define the Enterprises. The Managers are those who determine the above, and make their enterprises: adaptive or *responsive*, *resilient* or *rigid*.

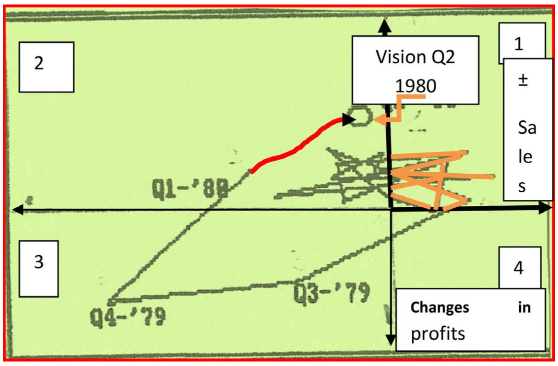
Priesmeyer defined forecasting as a "process of predicting, projecting or calculating an estimation of the future conditions". Humans frequently extend the past into the future. We are using certain statistical tools like the "regression analysis", the "time series analysis", the "moving averages", the "exponential smoothing" etc., so that to be able to forecast future.

But visioning is not frequently used by the Enterprises, if at all, being a synonymous with a number of concepts like: d*iscernment*, *foresight*, *insight*, *imagination* and *dreaming*. Five terms, which make management more effective. Management often adopts a "Vision" and defines managers as those who make things to happen.

Keynes (1936: pp. 161-162) believed that Managers possess what he called "animal spirits", meaning that we expect from them action instead of inaction. These make the wheels of the world economy to turn around.

The "TORO" Company e.g. found itself in a bad economic situation during the 4th quarter of 1979 (**Graph 1**), due to a season "of no snow" (3-4 Qs 1979) for company's main product (the "snow throwers"). The company, before 1979, saw its sales and earnings to increase 3 times, up to $358 m. Company's vision, after its "sock", required for company's sales to be increased by $21.35m and the earnings per share to be increased by $.46.

Of course, the above "vision" can be realized if it could be partly helped by the weather. The movement of the trajectories towards quadrant 1, in a sense, guaranteed that the vision can be realized, weather permitting. The company indeed realized[3] increased sales and profits in 1980-1987. Eight years when snow was abundant.



Source: author; modified from that in Priesmeyer (1992: pp. 54-56).

Graph 1. The phase plane of the toro manufacturing company of USA, 1979-1980, per quarter, & its Vision.

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[3] It seems however that Toro company's vision had to be supplemented by the resignation of one chairman, the firing of one President, and the dismissal of 125 other managers; cutting the workforce by 50%, reducing administration costs by 23% and carrying production in 5 plants instead of 8. The "snow thrower's" production suspended for 2 years. This case-study showed that weather for two years ahead is impossible to be forecast.

Similarly, Greek shipowners when they found themselves in hard, and cyclical, situations, tried to invest in markets, which destined to prosper, i.e. when certain shipping markets destined to suffer. During the 1981-1987 depression tankers entered into a crisis first, and then followed, after a year, by the dry cargoes—providing limited time to shipowners to be prepared. Greeks were, however, lucky as the majority of their tonnage was in dry cargoes, as this happens even nowadays. As Stopford (2009) argued, at those times, oil trade and dry cargo trade moved together, so Greek shipowners were unable to avoid the coming depression.

Greek shipowners invest heavy amounts in real property considering it as a stable and gradually increasing—in value—industry. They also speculate and/or invest in Gold. Greek shipowners usually have lost money in trying to profit from buying and selling shares and foreign currencies. They were also conservative in investing in all kinds of derivatives, if at all.

Lane and Maxfield argued (1995) that when the *foresight horizon* is clear, it may be possible to anticipate all the consequences of any course of action, including the responses of all other relevant agents, and to chart-out a best course which takes account of all possible contingencies (italics added).

Lorange (2009: p. 35) argued that with a better understanding of the crucial underlying factors, managers should be able to forecast more accurately those, which really matter for their company and thus be in a better position to manage the risks and reduce the cost of capital. He also argued that tanker freight rates showed higher volatility (Adland & Stradenes, 2007), while port congestions are relatively more important for the dry bulk carriers (ibid). He argued that shipowners try always to buy and sell ships low and high. This asset play strategy requires when to buy and sell to buy and sell in time and better is to have the lowest operating cost.

Our opinion is, however, to try both in a perfect timing strategy. Long-term financing proved to be very important. Market forecasting has an important role to play given that shipping companies do not have strategies to face a 50% fall in freight rates and ship prices. Several national forecasters, however, proved to be wrong. The key to success for shipowners operating in the class atomistic shipping markets is to understand better the importance of timing in their decisions and above all to learn to anticipate the turning points in the freight rate market.

6. Part I: The Interrelationship between Nature and Markets

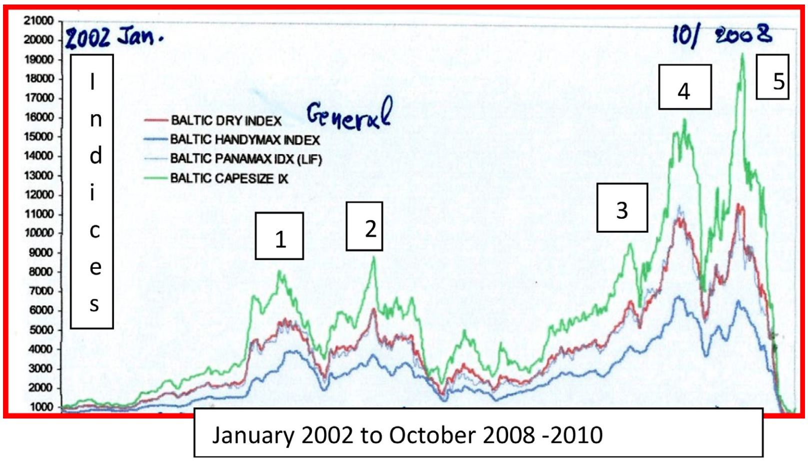
Mandelbrot & Hudson (2006) built bridges between Nature and Markets. This is a methodology followed all along since Man's first appearance on Earth, i.e. to simulate economy as if it obeys to a natural order. Three states of Matter exist in Nature: Solid, Liquid & Gas. Three states of "randomness" exist also in Markets: Mild, Slow & Wild. In the Human Social Life, we are all aware of the "Noah's Flood", followed by the appearance of the "Rainbow", and in economic life, we are all aware of the 1929-1936 Great Crisis. The experience of most of us admits that this is economic life, i.e. first it creates frequent say 7 yearly cycles and then it creates rare catastrophes, one every 45 years.

The above 3 states can also be expressed by the so called mathematics of the "Fractal Geometry". Fractal means the reality, which is expressed by fractals, i.e. by non-integer numbers. This is a non-Euclidean world. This is the world of Nature, or rather the "Geometry of Nature".

Here the initial conditions count, as there is sensitivity of the system to them, and the parts are similar to the whole adopting different however size/scale. People wrongly believe, perhaps misled by the Greek poet Hesiod (8th c. B.C.) arguing that at the beginning of the creation of Earth there was chaos before, while chaos is now recognized as having order in what otherwise appears random.

Despite the three worlds underlined above, the "conventional financial theory" assumes a world of "mild randomness" only in which the variation of the Prices can be modeled by a "Random Process", which follows the simplest "mild" pattern, where each up-stick or down-stick is determined by the toss of a coin. Global financial crises have, however, rejected this pattern.

Real Prices "misbehave". There is a strong opinion that the "fractally wild randomness" producing diverse phenomena like: turbulent flows, tracking a stock or a bond price, and give the high odds for catastrophic price changes, are the alter-ego of the "freight rate markets" (Graph 2). This is why we decided to present this (wild) randomness and also apply it to Shipping industry.

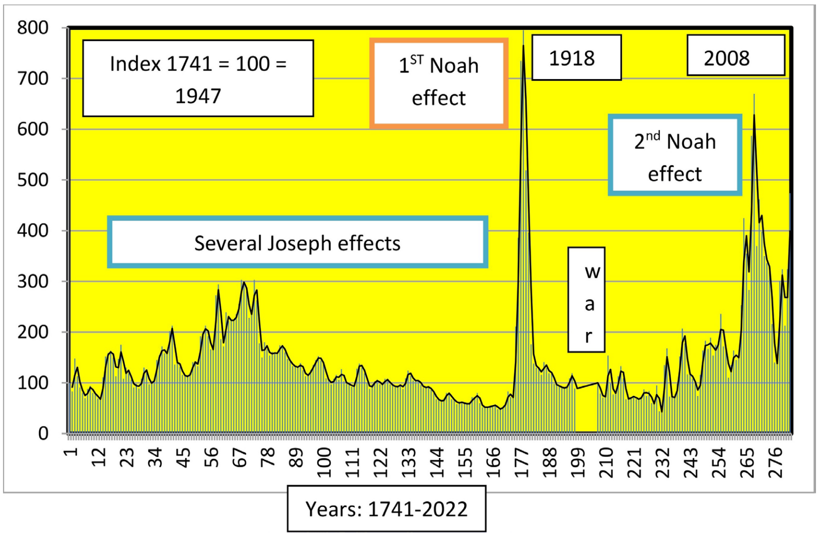


Source: author's archives.

Graph 2. Four Baltic shipping indices, from 2002 to 2009-10.

As shown, 4 shipping markets experienced, in 7 years, five increases in their level of the freight rates indices. This is a phenomenon which occurred in end-2008, but it has occurred also in 1918 (Graph 3). For the shipping industry this is equivalent with a "Noah Flood", explained below in more detail.

As shown, the "maritime economics freight index" from 1741 to 2022 indicates several "Joseph" effects over these 274 years and two "Noah effects" in 1918 and in 2008; i.e. two Noah effects in 90 years. The average index was 146.94 units and its variance was 42.5104.



Source: author; data from Stopford (2009) up to 2007; from other sources for 2008-2022; no figures for 1939-1946 due to 2nd W War.

Graph 3. The dry cargo freight rate index, 1741-2022.

7. Part II: The Global Financial Crisis, 2009-2018

The worldwide markets crashed in end-2008, caused by: greedy bankers, lax regulations, gullible investors and by the all-too-limited understanding of humans: of how markets work, how prices move, how risks evolve and how one should not be over-optimistic. Markets are complex and treacherous. Obviously, the humans were responsible for their financial catastrophes.

The bone-chilling market e.g., which fell in 29/09/2008 by a 7%, a 777-point plunge in the "Dow Jones Industrial Average", was, in historical terms, just a *particularly dramatic demonstration*—in few hours more than $1.6tr was wiped-off the value of USA industry. The world, however, paid 3 times more than USA, i.e. $5tr.

The subprime mortgages, which undermined the USA banks, were written on the false assumption that "the past will continue into the future" and that the house prices will keep rising, the default rates will stay within the forecast range, and the hedging strategies will be still working.

Sometimes history indeed has taught us, given that the above same assumptions have led to every financial bubble we know so far. From the case of the "tulips", in Holland (early-mid 1600), to the "dot-com" in USA (2001). Humans, however, tend to forget all unpleasant events and especially those where they have committed one or more mistakes. This is a human mechanism for humans not to admit their shortcomings.

It is delivered from the above at least one lesson, i.e. from the 2008 crash, which is: the over-confidence created *by the supposed human understanding of the markets as reflected in industry's—increasingly sophisticated—computer models* (Bookstaber, 2007). Something, which is expected to re-happen, by the use of the AI, sooner or later. For a manager to be aware of what he/she able to do and what he/she is not able to do, perhaps this is an action of wisdom. Humans believe that if AI makes them un-competitive, especially in memory and in combining data etc., then markets will be a place for humans to dominate.

Let describe now the methodology we are going to use in predicting and forecasting the freight rates.

8. Part III: Predicting Chaotic Time Series

Methodology: Let the last point of a time series be x_T, and let its last observation be: $x_T + (m - 1)\cdot T$; this is equal to x_n (by identity). Let the nearest neighbors be x_j j = 1(1)k. Let us next construct a linear system of k equations with m unknowns. The lines of the table of the components of the variables, i.e. the **A**, are the x_j. The vector of the results **b** is the component m of the vector $\mathbf{x}_{j+1}$. We solve the linear system: **Ac = b,** using the SVD[4] and the OLS—"ordinary least squares" (Press et al., 1996). The columns of **A** and **b** have 0 averages. The forecast value is given by: X_{N+1} = b dash + $\sum_{i=1}^{m} Ci\left(Xi - Xidash\right)$ (i), where m stands for the embedding dimension (which has to be large). The number of the nearest neighbors must be k ≥ m + 1 (Casdagli, 1989). Takens (1981) required, however, m ≥ 2D + 1, where D stands for the system's capacity dimension.

We will use the "tramp trip charter dry cargo index" from Jan. 1968 to August 2003 (428 months). If this time series is chaotic, then we need quite a number of observations, where 250 observations are not considered adequate, although models have been constructed proved to be effective also with small samples.

We shall use one of the simplest methods, i.e. the one due to Farmer & Sidorowich (1987), described already in the methodology. This method takes into account the movement of the nearest neighbor of a point, and the movement of the whole neighborhood of the point, which we want to forecast.

The above method is considered quite successful even with small samples[5]. Our forecast target is the 11 monthly last values of the above mentioned index using the 417 previous ones (out of 428, as mentioned); first inside the sample. Then we will predict the values of the 11 months outside the sample.

The OLS and KDE prediction methods are applied. KDE stands for the Kernel density estimation method (Sugihara & May, 1990). This method is simpler than the others, being really a weighted average method having the restriction, however, that k = m + 1, and also that the $\mathbf{x}_j$ includes $\mathbf{x}_\tau$ (bolds indicate vectors).

Table 2 below shows the predicted values of the index (1965 = 100, 1966 = 100), (1985 = 100), its actual values and the % deviations of the actual values from the

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[4] Press et al. (1996). The "singular value decomposition" is a method used to reconstruct attractor's phase space, to reduce noise and to identify governing equations from data. Since our bibliography stops in 2000 as far as nonlinear time series analysis is concerned, reader is recommended to consult the very rich literature that has appeared since then of about 260 papers…

[5] Vautard, Yiou, & Ghil (1992). Singular-spectrum analysis: a toolkit for short, noisy chaotic signals, Physica D 58, pp. 95-126; these authors used *only 250* observations with the "Principal components analysis" method.

predicted ones for each of the two methods, which have been selected (inside the sample). There are 2 × 5 prediction methods[6] and thus the selection of one or two of them implies a "risk" taken by the author.

Table 2. The 11 monthly predicted values of the dry cargo trip tramp index (1965 = 1966 = 100), (1985 = 100), its actual values and the % deviations of the actual values from the predicted ones for OLS and KDE (inside the sample).

Oct. 2002	204 (actual)	203 forecast OLS (rounded)	Deviation −0.49%	KDE forecast 204	0% dev. (rounded)
Nov.	215	204	−5.39 (*)	206	−4.35
Dec.	215	214.5	−0.2	204	−5.4 (*)
Jan. 2003	216	221	2.3	215	−0.5
Feb.	216	215	−0.5	219	1.4
March	216	212	−1.9	218	0.92
April	226	208	−8.7 (*)	215	−5.2
May	235	230	−2.2	223	− 5.4 (*)
June	230	233	1.3	233	1.3
July	230	233	1.3	232	0.9
August	229	228	−0.2	235	2.6

Source: Psifia (2006) doctoral thesis; (*) larger deviations; using the NLTSA[7] computer program.

As shown in Table 2, the KDE method gave results having smaller deviations (≤5.4%) than the OLS method (≤8.7%) (where: m = 6, i.e. the embedding dimension; $\tau = 1$: the time delay[8]; k = 7, i.e. the number of the nearest neighbors and the error E = 0.132). Worth noting is that here we have: k = m + 1[9].

Of course, predicting the values of a time series within the sample is not at all helpful. The predicted index has showed greater deviations (outside the sample) than those of inside the sample, as this was expected (Table 3).

Table 3. The forecast index outside the sample using OLS & KDE, 2003 Sept.-2004 (July).

Sept. 2003	OLS rounded 221 (forecast)	KDE rounded 230 (forecast)	(1985 = 100) 294 actual	27.83% vis-à-vis KDE (deviation)
Oct.	221	229	337	47.16
Nov.	213	221	309	39.8
Dec.	218	222	360	62.2
Jan. 2004	208	222.5	553 (**)	248.54

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[6] OLS, Principal components analysis, Ridge lines, Radial basis functions and KD Estimation.

[7] This runs in MS-DOS, with a code written in language C/C++, with a compiler GNU CC 2.8.0 (updated 07/01/98) in the RHIDE 1.4 environment, of 3.8 MB, with max. 16,384 observations.

[8] The theory suggests a time delay equal to 1.

[9] The values of the m, τ, k suggested by the NLTSA *may not contribute* so that the construction of a rebuilt phase space to be equivalent with the original one if m < 2D+1.

Continued

Feb.	208	220.5	613	278(**)
March	195	219.5	451	205.47
April	198	222.5	558	250.79
May	197	224	533	237.95
June	195	224	401	179
July	202.5	224	478	213.39

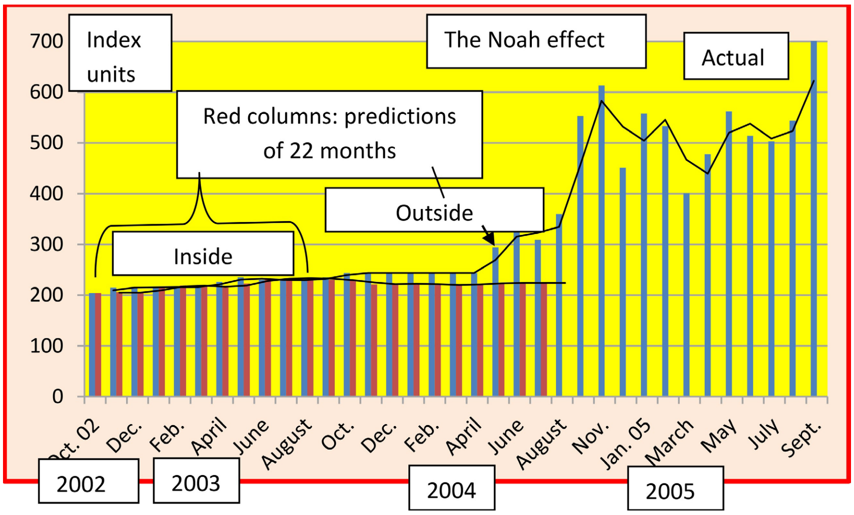
Source: author; data from UNCTAD; (*) the index basis changed in 1985 = 100 vis-à-vis 1965 July-1966 June = 100; (**) max. % deviation.

As shown in Table 3, the forecasting effort, after Jan. 2004, was a complete failure. The actual values increased almost three times vis-à-vis the forecast ones (278%). This outcome is due to the *inability* of the two forecasting methods to capture the great change caused mainly by the rise in demand of the dry cargo products transported by the tramp vessels in trips and to a lesser degree to the change of the index of its 100 basis-year. The above analysis demonstrated that a Noah effect had to be forecast. We turn now to this Noah effect.

The reader must be informed that our attention is turned from the Joseph effect to the Noah effect, because we believe that cycles are easier to be forecast than the floods.

9. Part IV: The Noah Effect

The index concerning "the dry cargo tramp trip charter" market between 2003 and 2005 experienced a historic boom, driven by China's demand for raw materials (Diagram 1).



Source: author; data from UNCTAD and Psifia's doctoral thesis (2006).

Diagram 1. The dry cargo tramp trip charter market index from October 2002 to September 2005, with the predicted values from Oct. 2002 to July 2004 (red columns); 1965-1966 = 100.

The freight rates surged, so that this index to exceed 700 (701) units by end 2005 or ~2.9 times higher. This means that the extreme events that occur twice in 90 years are not predictable even using chaotic methods. The index increased by 154% in early 2005 from 360 units to 553 units and then to 701 units.

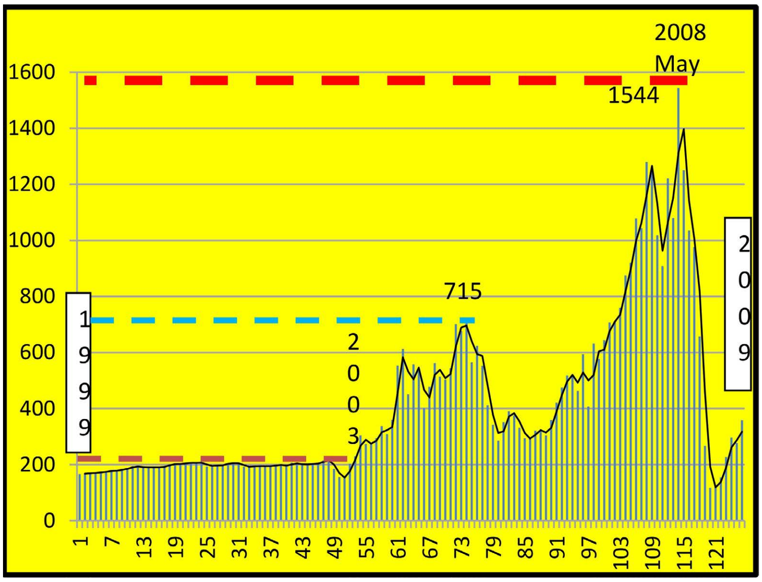
As shown, there are 22 months which are predicted by the KDE method: 11 months inside the sample and 11 months outside it. The predicted values inside the sample are closer to actual, while those outside the sample are less accurate, as this was expected. From Nov. 2003, the deviations between actual and those predicted increased fast to top-up in 2005 (Sept.).

One, however, may ask why we have predicted only 11 months? This is the predictive range allowed to us by the "Lyapunov's exponent". This exponent measures the system's sensitivity to its initial conditions. If the maximum Lyapunov exponent is positive, >0, then the system is chaotic, as in this case-study.

The method used is that of Kantz (1994), so that to find-out the Lyapunov exponent. The max. Lyapunov exponent is given by the equation: $\lambda_1(\alpha) = S(\alpha + 1) - S(\alpha)$ (6), where the slope λ_1 of the regression is given by: $S(\alpha) = \lambda_1 . \alpha + c$ (7), where c is a constant. For $\tau = 1$, embedding dimension $m = 10$ and D attractor's dimension $> 4 = 5$, the λ_1 is > 0 and $= 0.094$. And $(\lambda_1)^{-1} = 1/0.094 = 10.64$ or 11 months rounded. Forecasting even 11 months ahead may be very helpful for the shipping enterprises and we may suggest repeating forecasting using many 11 months intervals at the end of each eleven-month period.

We will next represent the most interesting ten-yearly history of the index, i.e. from 1999 to 2009. The Noah effect and the Joseph effect are also shown after 4 years of stability (1999-2003).

As shown in **Diagram 2**, the index showed two substantial changes-up in its



Source: author, data from UNCTAD various years.

Diagram 2. The trip tramp dry cargo Index from 1999 Jan. to 2009 May, 126 monthly observations.

level, first from about 200 units to 715 and then from 715 to 1544 (1999-2005 Feb. and from March 2005 to 2008 May), i.e. ~3.6 times and ~2.16 times respectively. Can this behavior be explained by a change in the scale of the distribution of the index? Or this is due to a change in the standard deviation of the distribution or in its Variance?

10. Part V: The Joseph and the Noah Effects as Discovered by Mandelbrot

Mandelbrot-M thereafter, (p. 200), in his book with Hudson (2006), wrote that it occurred to him that markets' first wild trait, abrupt change or discontinuity, preexisted in the Bible, and in particular in the tale about Noah. As this is known to Orthodox Christians, Noah was building, during 100 years, a ship to face a serious coming flood so that to save his 7-persons-family (3 couples plus his wife). Greeks gave to Noah the Greek name "Deucalion". Thus, Noah was the first shipbuilder and passenger shipowner transporting also livestock. God, of course, was the naval architecture.

M wrote that the >29% collapse of Oct. 19, 1987, was a 2nd "Noah" event. He failed to mention the 1929-1936 one. This, however, arrived without warning or convincing reason, and at the time it seemed like the end of the financial world, the same way that the "Noah Flood" brought the end of the pre-Noah "wicked" world till the coming of the Rainbow. The 3rd Noah event or 4th was the, 2009 starting, "Global financial Crisis", described also above.

Moreover, Market's 2nd wild trait—the cyclical one—is again prefigured in Bible's story of "Joseph" 7-yearly cycles of prosperity were then destined to be followed by 7 years of famine. Are thus the markets destined to show a series of frequent cyclical events of a number of years, perhaps 7, and to show, less frequent, catastrophic events, let us say twice in 90 years, in an exact simulation of Noah's Flood?

The above Joseph's pattern it has been rediscovered by Hurst[10] before M. Hurst worked on the prediction of Nile's waters. The "Hurst effect", like the "Joseph effect", led M to see a similarity of these two effects with markets' effects. M concluded that there must be a "long-term memory" through which the *past* continues to influence the random fluctuations of the *present* (2006: p. 201).

M, (who passed-away in end 2010), as a mathematician, developed 2 new statistical tools: first H. The H is the coefficient, named after Hurst, for the "long term dependence" in data, mentioned above. $H > 0.5$ shows a persistent data with trend towards the same direction; H therefore can also measure the dependence of the freight rate changes upon their past changes.

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[10] H E Hurst (a hydrologist) was born in 1880 in England. In Egypt, however, he found his future. Nile was a river of 4,160 miles long and a dam was the obvious suggestion given its serious volatility of its waters from 151b cm to 42, p.a. A helpful periodicity was absent. The range widened at 0.73 power law not 1/2. He used this equation: $\log(R/\sigma) = H \log(N/2)$ where $H = 0.73$ and $\sigma = 0.09$, where R = the range between the highest observation and the lowest one.

$H = \log(R/S)/\log(N/2) \rightarrow \log R/S = H \log N/2$ (4) where R/S stands for the rescaled Range i.e. the Range divided[11] by the standard deviation σ or S and $C = 2^{(2H-1)} - 1$ (5), where C is a correlation measure; $R/S = c \cdot N^H$ (6), where c is a constant,

$\log(R/S)n = \log c + H \log(n)$ (7), equation which gives H.

The 2nd one is alpha, or volatility coefficient, met in every kind of risk calculations. Alpha is the exponent, which measures how wildly prices vary or how "fat" the tails of the price change curve are (p. 262). When α < 2, as here, the population variance is undefined, or ∞. Alpha determines the peakedness at δ and takes the values 0 < α ≤ 2. When alpha > 1 < 2 the population mean exists. *Here alpha found equal to* 1.45.

The characteristic function of a stable L formula is:

$$Logf(t) = i\delta t - \gamma |t|^{\alpha} \left[1 + i\beta\left(t/|t|\right)\tan(\alpha\pi/2)\right. \quad (8)$$

As shown the L-stable probability distribution has 4 parameters, which are the key variables which determine the final shape of the curve: δ gives the location; γ gives the scale (i.e. the magnitude of the probabilities); β gives the skewness (if = 0 we have symmetry); and α, determines the fatness of the tails.

Applying the above methodology to data of the index of the trip charter tramp, 1968-2003, and after making the data stationary—a very delicate task, by using the 1st logarithmic differences—we can calculate H. This found to vary from 0.61 to 0.69, but according to theory we select the max. H = 0.69 for n = 70 months.

These 70 months is the time by which the memory of the past stays into the present, i.e. almost 6 years, within the memory of the present. The c is ≠ 0 and equal to 0.30556, indicating persistence and a long-term memory. More important, however, is the relationship between alpha and H: α is equal to 1/H (9)[12] = 1.43 < 2 or 1.46 < 2.

Using the data from Stopford (2009) for 1741 to 2022 (presented in **Graph 3**) and for n = 10 years, the H = 0.686717 (or 0.69 rounded) and alpha = 1.456204 (or 1.46 rounded). This means that going from the 428 months data to 274 years, the H stayed the same, the alpha gained 0.03% points and the memory almost doubled from 6 years to 10 years.

As a result, we recommend to Greek shipowners to forecast the alphas concerning the time series of their freight rates indices, so that to derive useful future insights, as we did, by predicting the alphas for the dry cargo ships for the years to come. We did it for 2026 to 2035 as follows (**Table 4**):

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[11] This was the brilliant action of Hurst making the data comparable over time/centuries. This is why the method is called a normalized volatility method.

[12] Let a sum Rn (of a stable variable) = R1 (its initial value) + $n^{1/\alpha}$ (where n = an interval). Taking logs: logRn = logR1 + 1/α log n and -1/αlogn = log R1 − logRn and 1/αlog n = -logR1 + logRn and 1/α = logRn − logR1/logn and alpha = logn/logn-logR1. H = logR/S/logn and alpha = 1/H, where log(Rn-logR1)/logn = log R/S/logn. Peters (1994: pp. 212-213).

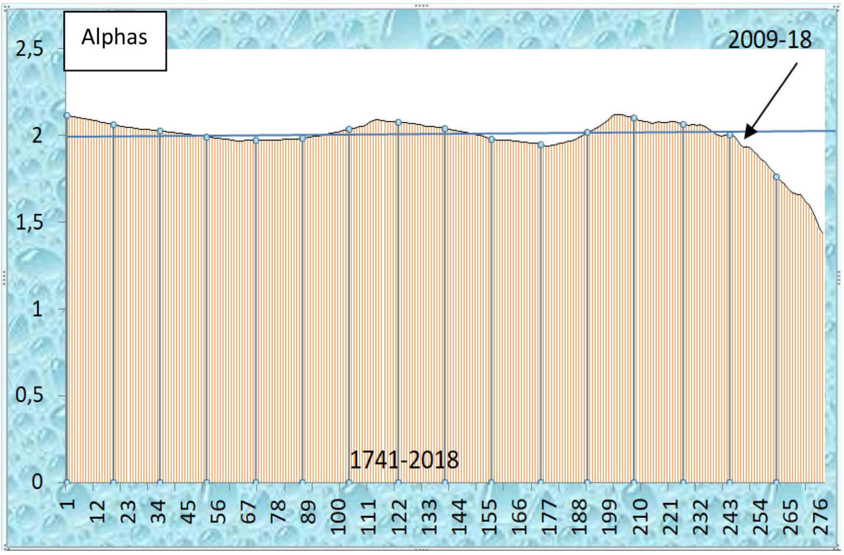
Table 4. The Predicted alphas, 2026-2035 (rounded).

2026	1.94	2027	1.95
2028	1.95	2029	1.96
2030	1.96	2031	1.96
2032	1.97	2033	1.97
2034	1.98	2035	1.98

Source: author; using the NLTSA computer program; data of 277(*) years, where n is suggested to start from 10 years on; (*) 1741-2018.

As shown, the predicted alphas are all equal or below 1.98. In n = 10 the max. Alpha = 1.431629. Worth noting is the fact that since 2009, the alphas started to deviate from its value round 2 (normal distribution) and gradually to fall to 1.43 (rounded) (Graph 4). This means that alpha prefigured the coming of the 2009-2018 global financial crisis producing a more peaky probability density function. For a fractal, or Pareto, distributions, alpha > 1 and < 2. Graph 4 confirms this. Also alpha = 1/H and H = 0.70 for persistent series (0.50 < H < 1).

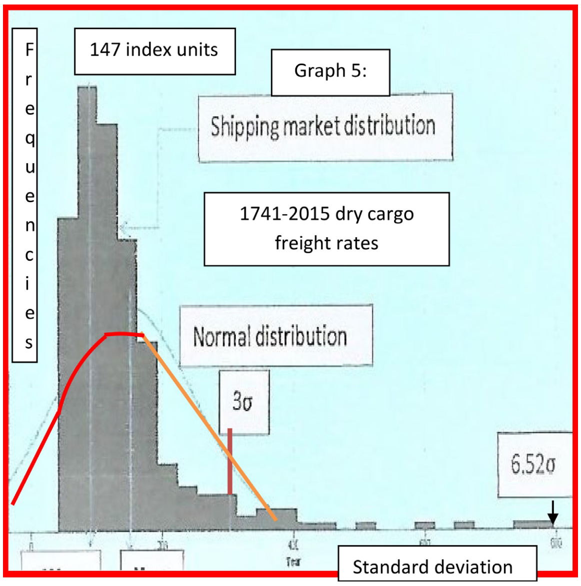
The good news are, however, that the alphas for the period 2026-2035 do not predict fat tails similar to that of 2009-2018, because all are >1.43 and near 2.



Source: author; data for 277 years from Stopford for the dry cargo index 1741-2018. Using the NLTSA computer program for "Non Linear Time Series Analysis".

Graph 4. Alphas 1741-2018.

Though we saw (in Graph 4) that the alphas regressed round 1.94-1.98, indicating a nearness to a "bell curve distribution", except for the period of the global financial crisis, 2009-2018, we have calculated the deviations of the distribution's standard deviation away from 3σ (as in Graph 5): the σs of the trip tramp period dry cargo index showed in October 1973 4.8σ; in August 1998 3.2σ; in November 2002 3.4σ and in November 1973 7.6σ. In 1741-2015, the dry cargo secular index had 6.52σ and the r.h.s. tail was fat (**Graph 5**). Moreover, the $1/2 < H < 1$ indicates catastrophes and discontinuities up or down, with high peak in the mean and fat tails (as in **Graph 5**).



Source: author; data from Stopford (2009) etc.; the distribution has a r.h.s fat tail; a leptokurtic curve; its mean is equal to 147 units, taller than normal.

Graph 5. Catastrophes and discontinuities.

11. Conclusions

The sample used was "comparatively" large as having 428 monthly observations and by using also a suitable methodology for small samples for chaotic models, the Lyapunov exponent did not allow us to predict beyond almost one year ahead (i.e. 11 months) (outside the sample).

We saw, however, that when freight markets assumed a substantial rise, like in 2003 (May) and thereafter, the two forecasting methods used, were unable to follow. In fact, we saw the system to generate 3 characteristics: *fat tails*, *persistence* and *unstable variance*. Thus, a more effective forecasting model is the one accommodating all these three properties.

We showed that fat tails via alphas can be forecast and persistence via a predicted H can be calculated. We showed that the FBM has a variance that scales at a factor faster than the square root of time following Schroeder, or at t^H or at $t^{0.69}$.

As far as "persistence" is concerned, the term "black noise" has been also used for it. Moreover, black noise has been used to model also the abrupt collapses. In addition, there is a relationship between the Hurst exponent H and the "spectral exponent" b: $b = 2H + 1$ or $2 \times 0.68672 + 1 = 2.37344$ (9) indicating black noise, i.e. $b > 2$, where $b > 2 \leq 4$ and $H > 0.50$. A persistent (black noise) process will create a variance, which will behave much like the scaling of the capital markets (or at a slightly faster H according to Peters, 1994: p. 184).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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