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Abstract

This current dissertation deals with freight rate volatility in tankers' sector. This sector, like other sectors in shipping industry consists of four markets. Three of them refer to vessels and one refers to freight rates. Consequently, based on shipping industry circumstances and on general circumstances in economy, freight rates level is characterized by some volatility which varies according to vessels size and whether freight is traded on spot market or on time-charter market. This paper investigates the tanker sector and whether the volatility of freight differentiated between markets and between different ship sizes. Moreover, seasonality is studied together with the effect of the global economic crisis in the volatility of freight rates.

Keywords: Shipping, Freight Rates, Prices Volatility, Crisis effect, seasonality

1. Introduction

The tanker sector is about crude oil transportation, as well as all oil products in general. The transportation begins from the countries which manufacture these products to the rest of the world. It should be noted that, according to Stopford (1997), there are other products of liquid form as well, like chemicals, liquefied gas etc., which are also transported with the tanker fleet. However, their volume constitutes of a very small portion of the total transportation volume conducted through this specific tanker fleet.

Lyridis & Zacharioudakis (2012) claim that the tanker sector is a very important one in shipping, hence it is the highest in transporting volume compared to the other sectors of shipping transportation, reaching approximately one third of the global merchandise volume transported by the sea.

There are two kinds of tanker-type ships. The first type concerns the so-called "clean tankers" and the second type the so- called "dirty tankers". The first ones transport various oil products, like e.g. diesel oil, while the second ones transport exclusively crude oil. According to Grammenos (2010), the first ones are usually smaller in size in comparison with the second ones.

A tanker fleet usually consists of 6 main ship categories with the criteria of transportation dynamics. These categories are ULCCs, VLCCs, Suezmax, Aframax, Panamax and Handymax.

1.1 Shipping Cycles

As theories on financial or business cycles develop in the context of economy in general, we also meet equivalent theories in the shipping sector, which try to explain the long-term circular fluctuations of fare levels, depending on the situation prevailing in the sector.

Shipping cycles are considered rather as an indent of the general financial or business cycles under the logic that such circular fluctuations do not only occur on the financial level in general, but on the level of various sectors as well. So, in the shipping sector, this specific phenomenon of shipping cycles has been studied.

As it happens on the financial level or on every sector level, so in shipping as well, the study of the cycle phase helps the sector investors make investing and de-investing decisions e.g. regarding the fleet they own, both on quantity and quality level, as Stopford (1999) mentions relatively.

The decisions of shipping companies should be based both on the current cycle phase as well as the expectation there is about the future. An appropriate study of the shipping cycles can reduce the risk to a certain extent, and lead to safer relevant decisions.

Shipping is closely depending on the course of other sectors (derived demand), so the fluctuations on those also create fluctuations on the shipping sector. In an international environment, where the commerce volume is constantly changing while the change is strong in various other markets (oil, exchange, etc), intense fluctuations are naturally created in the shipping sector, too.

The shipping cycles' phases are 4:

1) Recession (excess supply, low freight rate levels, increased volume for demolition, more difficult access to finance, negative cash flow, decreased used vessels value)
2) Recovery (supply and demand in equilibrium, increased freight rate level, increased cash flows, business climate with uncertainty but with positive prospects, new vessels decision)
3) Peak (supply and demand in equilibrium, high level of freight rates, high profit margins, high cash flows, easy access to finance, increased value of used vessels, increased order of new vessels)
4) Collapse (excess optimism, excess order for new vessels, excess supply, decreasing freight rate level, decrease in cash flows, increased vessels demolition for decreasing supply so that equate with demand)

1.2 Shipping Risk

Shipping risk facing shipping companies are many and important and should be treated effectively. Actually, uncertainty and risk in shipping industry is on higher level compared to other industries. This happens because shipping companies operate in an international environment, where there are many risk factors which affect profitability and performance in general. These factors include international trade in many industries and sectors as well as financial markets and oil markets.

Shipping risks incorporated mainly freight rate risk which stems from volatility of freight rate level. As freight rate directly defines shipping companies' revenues, its volatility affects on a great extent their earnings volatility. Other shipping risks are operational risk, interest rate risk, foreign exchange risk and credit risk.

Of course, each type of risk creates specific difficulties concerning effective operation of shipping companies and on cash flows generated as well as on financing decision on behalf of

several investors. Risk management has to do with effective treatment of those risks and not with their elimination, as this is not easy to happen. Actually, an effective management has to do with the decrease of the probability for adverse events to occur and which would have a negative effect on profitability and performance.

Concerning the quantitative measurement and risks evaluation, a very powerful and familiar methodology is the Value at Risk (VaR), which is used both in financial markets.

2. Research Methodology

In this paper, freight rate volatility is going to be studied both in spot market and in time-charter with relevant comparisons. Moreover, for each market, volatility for freight rates for different vessels' size will be studied. Volatility is measured on freight rate returns standard deviation.

Vessels sizes used in this paper is Handymax (small size with 35,000-50,000 DWT), Aframax (middle size with 80,000-120,000 DTW) and VLCC (large size with 180,000-320,000 DWT).

One research question of this paper is whether freight rate volatility is different among vessels sizes for each market separately (spot and time-charter). A second research question is whether freight volatility is different between spot market and time-charter for each size separately (Handymax, Aframax και VLCC).

A third research question of this paper is whether financial crisis matters for freight rate volatility. More particularly, we will examine whether freight rate volatility is different before and during financial crisis period for each market (spot and time charter) and for each size (Handymax, Aframax και VLCC). With the term "financial crisis" is meant global financial crisis and not some regional crisis (i.e. financial crisis in European Union). The rationale is that freight market, especially in Tanker sector, has global dynamics and the point is to examine global phenomena how to affect freight rate volatility. Global financial crisis includes the time period between 2007 August and 2009 Mars.

Finally, a fourth research question of this paper is whether seasonality matters in freight rate volatility. That is, we will examine whether volatility is different among quarters of each years. This comparison will be conducted for each market (spot and time charter) and for each size (Handymax, Aframax και VLCC).

For this paper, data used measure freight rate for spot market and time-charter for three vessels sizes. Data were collected since 2001 until 2015 on a monthly basis and are measured on dollars per day. Time-charter has 1 year maturity.

For VLCC and Aframax freight rates were collected from relevant index Baltic Dirty Tanker Index (BDTI), while for Handymax freight rate were collected from relevant index Baltic Clean Tanker Index (BCTI). It is worthwhile to mention that for each vessel size there are freight rate for several routes and as the final freight rate their average is taken. For Aframax vessels 7 routes are taken, while for Handymax size 9 routes exist.

Concerning data, it should be mentioned that data base used for data collection was the familiar Clarkson Research Services Ltd.

Concerning statistical measurement, volatility is a measure of dispersion. Using data for freight rate in each vessel size and in each market, volatility comparisons were made under certain statistical hypotheses. Using standard deviation, as a measure of volatility, a proper statistical test concerning standard deviation comparisons is going to be used. More particularly, Levene statistics will be used. For seasonality effect on freight rate volatility,

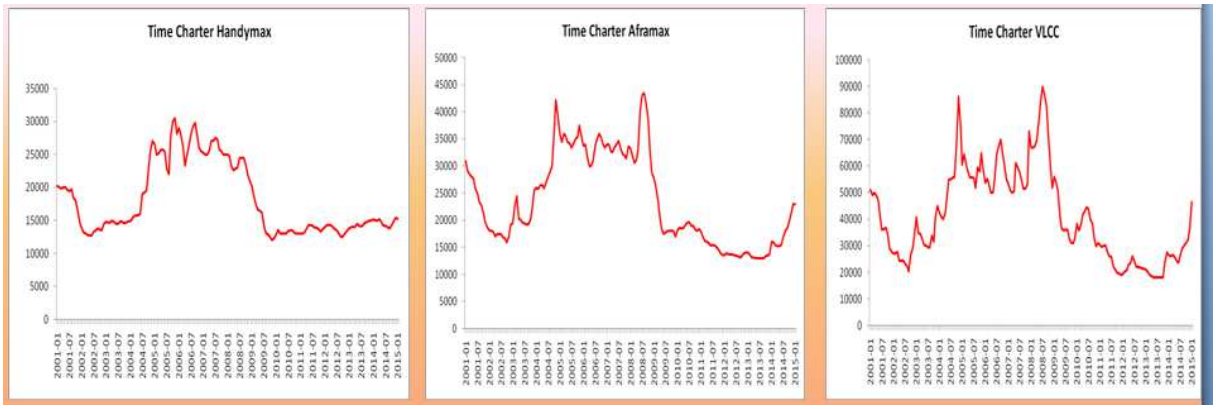
variances comparisons among quarters will be done. For theses comparison, Bartlett test will be used with the following statistic:

$$X^2 = \frac{(T-k)\ln(SD_P^2) - \sum(T_i - 1)\ln(SD_i^2)}{1 + \frac{1}{3(k-1)}\left(\sum\left(\frac{1}{T_i - 1}\right) - \frac{1}{T-k}\right)} \sim X^2{}_{k-1} \quad \textbf{(1)}$$

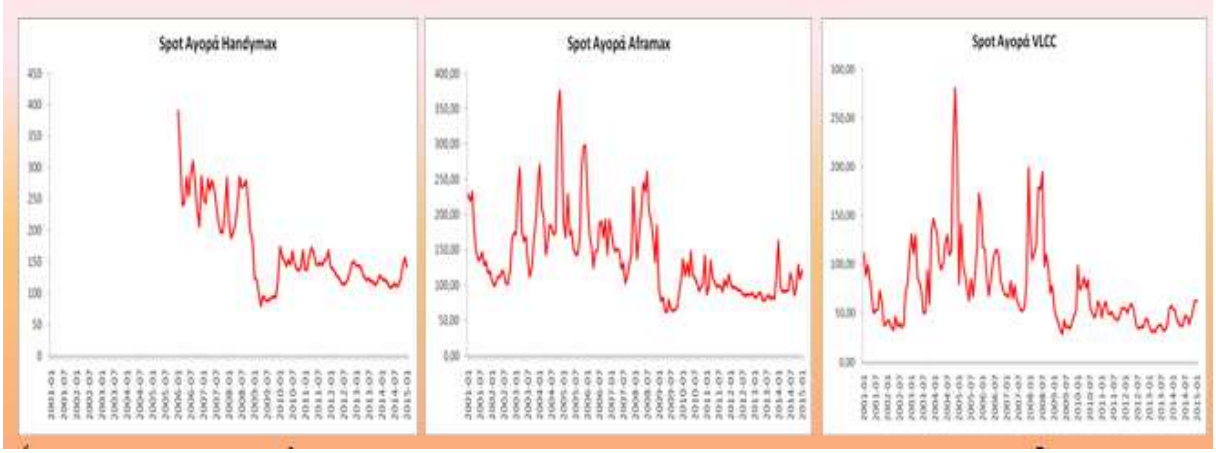
3. Results

In graph (3.1) it can be observed that time-charter freight rate don't perform so much volatility in each vessel size. Moreover, it seems that as vessels size increases, volatility also increases. Finally, it also seems that volatility during global financial crisis is higher for each vessels size.

In graph (3.2), it can be observed that freight rate perform some volatility, compared to volatility in time-charter market for each vessel size. Moreover, volatility seems to be increased as vessel size is increased. Finally, freight rate volatility in spot market seems to be higher during global financial crisis for each vessel size.



Graph 3.1 *Freight Rate in Time-Charter Market for Vessels Sizes Handymax, Aframax & VLCC*



Graph 3.2 *Freight Rate in Spot Market for Vessels Sizes Handymax, Aframax & VLCC*

Generally speaking and based on graphs (3.1) and (3.2), one can argue that freight rate volatility, in spot market especially, is higher as size is increased. Moreover, one can argue that freight rate volatility in spot market is higher compared to volatility in time-charter for each vessel size. These graphs may provide some first evidence concerning research hypotheses. However, more powerful evidence should be provided though formal inferential statistical analysis.

First, volatility comparisons are presented among vessels sizes separately for spot market and time-charter. Relevant results are presented in the tables (3.1) and (3.2) below.

From tables (3.1) and (3.2) it is inferred that as vessels size is increased, freight rates volatility is also increased, implying a positive relationship between vessels size and freight rate volatility, for both time-charter and spot market.

Then, it is examined whether freight rate volatility is different between spot and time charter market. This is examined separately for each vessel seize. Results are presented in table (3.3) below.

Table 3.1: *Freight Rate Volatility Comparison Among Vessels Size – Time Charter*

Pair	*Handymax vs Aframax*	*Handymax vs VLCC*	*Aframax vs VLCC*
Statistic	0.669*	0.237*	0.354*
Result	H < A	H < V	A < V

Notes:

5% lower and upper critical values for F(168, 169) are 0.738 and 1.355 αντιστοίχως

* Statistical significant in 5% level

5% lower and upper critical values for F(168, 168) are 0.738 and 1.355

* Statistical significant in 5% level

Table 3.2 : *Freight Rate Volatility Comparison Among Vessels Size – Spot Market*

Pair	*Handymax vs Aframax*	*Handymax vs VLCC*	*Aframax vs VLCC*
Statistic	0.391*	0.236*	0.603*
Result	H < A	H < V	A < V

Notes:

5% lower and upper critical values for F(108, 168) are 0.705 and 1.401

5% lower and upper critical values for F(168, 168) are 0.738 and 1.355

* Statistical significant in 5% level

From table (3.3), it is inferred that freight rate volatility in spot market is statistically higher compared to volatility in time-charter for each vessel.

Table 3.3: *Freight Rate Volatility Comparison Between Time-Charter and Spot Market for Each Vessel Size*

Vessel's Size	*Handymax*	*Aframax*	*VLCC*
Statistic	0.139*	0.082*	0.139*
Results	TC < SM	TC < SM	TC < SM

Notes:

5% lower and upper critical values for F(168, 108) are 0.714 and 1.419

5% lower and upper critical values for F(168, 168) are 0.738 and 1.355

* Statistical significant in 5% level

Then, test results concerning global financial crisis effect are presented for each market and for each vessel size. Relevant results are presented in tables (3.4) and (3.5) below.

Table 3.4*: Freight Rate Volatility Comparison in Time-Charter Between Crisis and Before Crisis Period for each Vessel Size*

Vessel's Size	*Handymax*	*Aframax*	*VLCC*
Statistic	1.686*	2.317**	1.444
Results	Crisis < No-Crisis	Crisis > No-Crisis	Crisis = No-Crisis

Notes:

10% lower and upper critical values for F(19, 148) are 0.52 and 1.657

5% lower and upper critical values for F(148, 19) are 0.549 and 2.190

* Statistical significant in 10% level ** Statistical significant in 5% level

Results are really different for each vessels size, implying that there is an interaction effect between global financial crisis and vessels' size on freight rate volatility in time-charter market.

More particularly, for Handymax size, freight rate volatility is found to be different in 5% level between crisis and before crisis period. Surprisingly it was found that volatility for this size in time-charter is lower during crisis period.

For Aframax size, freight rate volatility is found to be different in 5% between crisis and before crisis period. Not surprisingly it was found that volatility for this size in time-charter is higher during crisis period.

Finally, for VLCC size, freight rate volatility is not found to be different in 5% between crisis and before crisis period. Surprisingly, it was found that freight rate volatility for this size in time charter is not higher during crisis period.

Results show that only for middle size vessels (Aframax) global financial crisis has an expect effect, increasing freight rate volatility in time-charter market. For small size vessels (Handymax), crisis has a reverse effect, decreasing freight rate volatility in this market, while for large vessels (VLCC), crisis has not any significant effect at all in freight rate volatility.

Table 3.5: *Freight Rate Volatility Comparison in Spot Market Between Crisis and Before Crisis Period for each Vessel Size*

Vessel's Size	*Handymax*	*Aframax*	*VLCC*
Statistic	2.075*	2.182*	1.994*
Results	Crisis > No-Crisis	Crisis > No-Crisis	Crisis > No-Crisis

Notes:

10% lower and upper critical values for F(88, 19) are 0.586 and 1.948

10% lower and upper critical values for F(148, 19) are 0.603 and 1.921

* Statistical significant in 10% level

Volatility comparisons between crisis and before crisis periods, in spot market, were conducted for each vessel size. Results are almost identical for each vessel size, implying that no interaction effect exists between crisis and vessel size on freight rate volatility in spot market.

More particularly, for each vessel size, freight rate volatility is found to be different statistically in 10% level between crisis and before crisis period. Not surprisingly it is found that volatility, for each vessel size, is higher during crisis period.

Finally, it is examined whether freight rate volatility is different for each quarter in each year. This is examined for each vessel size and for each market. Results are presented in the table (3.6) and (3.7) below.

Table 3.6: *Freight Rate Volatility Comparison in Time-Charter Among Quarters for each Vessel Size*

Vessel Size	*Handymax*	*Aframax*	*VLCC*
Bartlett Statistic	26.151*	21.682*	22.158*
Seasonality Effect	YES	YES	YES
Quarter 1	0.0326	0.0508	0.0783
Quarter 2	**0.0307**	0.0567	0.0811
Quarter 3	**0.0595**	**0.0344**	**0.0690**
Quarter 4	0.0524	**0.0729**	**0.1317**
Total	0.0453	0.0554	0.0930

Notes:

5% critical value for $X^2(3)$ is 7.815

1% critical value for $X^2(3)$ is 11.345

* Statistical significant in 5% level

** Statistical significant in 1% level

Volatilities in bold are lower and upper correspondingly

For time-charter market, it is inferred that there is a seasonality effect, according to Bartlett statistic, in 5% level, for each vessel size, as statistic value is inside critical area, implying rejection of null hypothesis for variances equality among quarters.

More particularly, for Handymax vessels, freight rate volatility is lower in each second quarter (3.07%), while is higher, almost double, in each third quarter (5.95%). Generally, for these vessels, volatility in time-charter is higher in first semester compared to first semester.

For Aframax vessels, freight rate volatility is lower in each third quarter (3.44%), while is higher, over than double, in each fourth quarter (7.29%). Generally, for these vessels, volatility in time-charter is much higher in each fourth quarter, compared to middle level volatility in each first and second quartet, and to low level in each third quarter.

Finally, for VLCC, freight rate volatility is lower in each third quarter (6.90%), while is higher, almost double, in each fourth quarter (13.17%). Generally, for these vessels, volatility in time-charter is much higher in each fourth quarter, compared to middle level volatility in each first and second quartet, and to low level in each third quarter. Actually, it seems that seasonality pattern of VLCC is similar with that of Aframax.

Table 3.7: *Freight Rate Volatility Comparison in Spot Market Among Quarters for each Vessel Size*

Vessel Size	*FR Handymax*	*FR Aframax*	*FR VLCC*
Bartlett Statistic	16.760**	21.879**	9.067*
Seasonality Effect	YES	YES	YES
Quarter 1	**0.1525**	**0.2346**	0.2618
Quarter 2	0.0947	0.1556	**0.1912**
Quarter 3	**0.0699**	**0.1148**	0.2091
Quarter 4	0.1273	0.1997	**0.2905**
Total	0.1212	0.1938	0.2497

Σημειώσεις:

5% critical value for $X^2(3)$ is 7.815

1% critical value for $X^2(3)$ is 11.345

* Statistical significant in 5%

** Statistical significant in 1%

Volatilities in bold are lower and upper correspondingly

Both in spot market, seasonality effect is statistically significant, according to Bartlett statistic, in 5% level, for each vessel size, as statistic value is inside critical value, implying rejection of null hypothesis of equal variances among quarters.

More particularly, for Handymax vessels, freight rate volatility is lower in each third quarter (6.99%), while is higher, almost triple, in each first quarter (15.25%). Generally, for these vessels, volatility in spot market is much higher in each first and fourth quarter compared to second and third.

For Aframax vessels, freight rate volatility is lower in each third quarter (11.48%), while is higher, over than double, in each first quarter (23.46%). Generally, for these vessels, volatility in spot market is much higher in each fourth quarter, compared to middle level volatility in each first and second quartet, and to low level in each third quarter. Actually, there is a similar seasonality pattern with Handymax vessels.

Finally, for VLCC, freight rate volatility is lower in each second quarter (19.12%), while is higher in each fourth quarter (29.05%). Generally, for these vessels, volatility in spot market is much higher in each fourth quarter, compared to middle level volatility in each first and second quartet, and to low level in each third quarter. Actually, there is a similar seasonality pattern with the other two sizes.

4. Conclusions and suggestions for future research

Empirical research results of this paper showed that indeed there is freight rates volatility differentiation both with respect to vessels size and with respect to market (time-charter or spot).

It was found that the larger the size is, the higher the freight rate volatility is in both markets. This finding can be explained because larger vessels are assigned longer routes which involve higher risk and higher uncertainty reflected to higher volatility. Moreover, larger vessels face more restrictions in approaching certain ports. Therefore, it is less probable to be assigned transportation, which increase risk in those vessels. Freight rate volatility in spot market was found higher enough compared to time-charter for all vessels' sizes. This finding can be explained due to the fact that freight rates on spot markets are traded more frequently, on a daily basis, involving higher uncertainty and higher risk resulting in higher volatility. These results, concerning size and market effect on volatility, are really expected and they are confirmed with this empirical research.

Concerning global crisis effect, it was found a statistically significant effect of crisis on freight rate volatility. More particularly, in time-charter market, crisis effect was not uniform across vessels size. Actually in some cases results are not expected. Only for middle sized vessels (Aframax) results were expected, where freight rate volatility in time-charter was higher during crisis period, in a sense that during a financial crisis uncertainty and risk is increased and this is reflected in higher volatility.

On the contrary, for small sized vessels (Handymax), global financial crisis had a reverse effect, where during crisis period, volatility was statistically lower compared to crisis period. A possible explanation for this non-expected finding is that during crisis period, small sized vessels, which are assigned for shorter routes, faced more stable and higher demand in the context of meeting high uncertainty and high risk generated in many markets. Moreover, these vessels can carry lower quantities and are consistent to a trade with lower volume, as it typically happens during such periods. Of course this demand has to do only with time-charter

market, as during crisis periods, there is increased need to close certain freight rate in advance using time-charter market in order to fight increased uncertainty.

For larger vessels (VLCC), crisis was not found to have some impact on freight rate volatility in time-charter market. For this non-expected finding, a possible explanation is that larger vessels, which are assigned longer routes, have a constant demand irrespectively any crisis period, in a sense that time-charter for such routes are closed in advance independently of any crisis existence.

In spot market, global financial crisis was found to have a uniform expected effect for each vessel size. More particularly, it was found that freight rate volatility is higher during crisis period. This finding can be explained due to the fact that freight rate in spot market are frequently traded and, thus, increased uncertainty incorporates in higher risk and higher volatility in such prices, as it happens in most traded markets.

Concerning seasonality, some particular pattern was found both in time-charter and in spot market. More particularly, in time-charter, small sized vessels had higher freight rate volatility in each second semester, while for middle-sized and large vessels volatility was higher in each fourth quarter and lower in each third.

In spot market, for all sizes freight rate volatility was higher in each first and fourth quarter and lower in each second and third.

A general finding for all sizes and across both markets is that freight rate volatility tends to be higher in each fourth quarter, that is during the end of each year, while it tends to be lower in each third quarter. During fourth and first quarter it is winter in north hemisphere, which means worse weather conditions involving higher risk in routes which is reflected to higher freight rate volatility. On the contrary, each second and third quarter it is spring or summer with better weather conditions involving lower risk in voyage which is reflected with lower freight rate volatility.

An interesting implication for investors in shipping is to explore high volatility existence in freight rate, in a sense that such high volatility will lead to high volatility in earnings of shipping companies and, in turn, high volatility in stock prices. Therefore, risk-averters should prefer stocks of shipping companies with many small vessels, depending heavily on time-charter and holding them in each second and third quarter, while selling them each first and fourth quarter. On the contrary, risk-lovers should prefer stock of shipping companies with many large vessels, depending heavily on spot market and holding these stocks in each first and fourth quarter.

Another implication is when market increase is expected, investors should prefer buying stock with higher volatility, meaning stock of shipping companies with larger vessels depending more on spot market. On the contrary, when market decrease is expected, investors should prefer buying lower volatility stocks, meaning stock of shipping companies with smaller vessels depending more on time-charter market.

Based on this analysis, it would be interesting a similar study in both spot market and time-charter for bulk and combined transportation sectors. More particularly, for bulk carrier there are vessels carrying homogenous transport including, for example, sugar, coal etc.). For combined transportations, LNG vessels could be examined (vessels carrying liquidated gas) as well as LPG vessels (carrying liquidated oil gas). Moreover, containership can be also studied along with Roll-On/Roll-Off vessels (vessels carrying vehicles).

Taking into consideration, freight rate from so many vessels categories, it would be attractive enough to examine similar hypotheses and to provide evidence whether results are similar to tanker sector, as it was studied in this paper.

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