

**VOLATILITY DYNAMICS IN THE CAC 40 STOCK MARKET INDEX: EVIDENCE
FROM GARCH-FAMILY MODELS WITH ASYMMETRIC EFFECTS**

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Abstract

The study analyses the volatility behaviour of the CAC 40 index using daily stock market data from January 25th, 2007, to 24th April 24th, 2026. The main purpose of the research is to examine market volatility and identify the most suitable GARCH family models for volatility estimation and forecasting. Daily closing prices were converted to log returns, and various statistical and econometric techniques, including graphical analysis, the Augmented Dickey–Fuller (ADF) test, and the Ljung–Box test, were applied to examine the series' behaviour.

The results indicate volatility clustering, volatility persistence, and asymmetric effects in the CAC 40 return series. The ADF test confirmed that the log-return series is stationary, while the Ljung–Box test indicated significant autocorrelation in the data, supporting the use of GARCH-family models. Different models, including GARCH, EGARCH, GJR-GARCH, T-GARCH, and APARCH models with various distributions, were estimated and compared using Log-Likelihood, AIC, and BIC values. Among all the models, the T-GARCH model with skewed Student's t-distribution was found to be the most suitable for the study.

The findings further reveal that negative market news has a stronger effect on volatility than positive news and that market shocks remain for a longer period. The conditional volatility analysis also highlighted major spikes during the 2008 financial crisis and the COVID-19 pandemic. Overall, the study concludes that the selected T-GARCH model effectively captures the volatility behaviour of the CAC 40 Index and can be useful for investors, researchers, and policymakers in understanding market risk and making informed financial decisions.

Keywords: CAC 40 index, volatility forecasting, T-GARCH model, Skewed Student's t-distribution, leverage effects

Classification JEL: C22, C53, G15, G17

Introduction

Stock markets play an important role in an economy's growth and development by providing opportunities for investment, capital formation, and wealth creation. However, stock markets are highly sensitive to economic conditions, political events, global uncertainties, and investor behaviour, leading to fluctuations in stock prices. These fluctuations create market volatility, and understanding this volatility has become an important area of research in financial economics. Volatility reflects the level of risk and uncertainty present in the market and directly influences investment decisions, portfolio management, and financial planning.

In recent years, global financial markets have experienced several major economic disturbances, including the 2008 global financial crisis, the European debt crisis, and the COVID-19 pandemic. These events significantly affected stock market performance across countries and increased uncertainty in financial markets. The French stock market, represented by the CAC 40, also witnessed substantial fluctuations during these periods. As one of the major stock market indices in Europe, such as the CAC 40 index which reflects the performance of leading French companies and provides important information regarding the behaviour of the French financial market.

The present study focuses on analysing the volatility behaviour of the CAC 40 Index using daily stock market data from January 25th, 2007, to 24th April 24th, 2026. The study applies GARCH-family models to identify the most suitable model for volatility estimation and forecasting. By examining the behaviour of market returns, volatility persistence, and asymmetric effects, the research aims to provide a better understanding of volatility's changing nature in the French stock market. The study's findings may be useful to investors, researchers, policymakers, and financial analysts in understanding market risk and making informed financial decisions.

Literature Review

In the literature there are numerous empirical studies which used econometric models based on emerging countries like India, such as Meher et al. (2023), Kumar et al. (2021), Kumar et al. (2023), Birau et al. (2021), Shreevastava et al. (2024), Bai et al. (2024), Raza et al. (2024) and many others. Anand et al. (2023) conducted an empirical study on the behavior of the Portuguese stock market using econometric FIGARCH models. Aman et al. (2024) investigated the behavioral dynamics of the emerging stock market in Hungary based on GARCH family models.

Volatility in stock returns generally does not remain constant over time. Financial markets often exhibit periods of calmness followed by periods of extreme volatility, a phenomenon known as volatility clustering. Traditional statistical models are often unable to properly capture such changing volatility behaviour. Therefore, researchers and financial analysts widely use GARCH-family models because they are more effective at measuring time-varying volatility, the persistence of shocks, and asymmetric market behaviour.

Mehanaoui (2017) investigated the relevant issues of financial integration and volatility in the case of stock market in France. Helhel (2026) discussed the importance of stock markets considering long-term economic growth. Duttilo et al. (2021) have conducted an empirical study on European stock markets in the eurozone considering the impact of COVID-19 pandemic.

Spulbar et al. (2023) examined volatility spillovers in the case of certain developed European stock markets, such as Germany, Austria, France, but also Spain also applying the methodology of GARCH econometric models. On the other hand, Spulbar et al. (2019) investigated the volatility patterns in the case of a cluster of developed markets on two continents Europe and North America, which includes the following France and UK, USA and Canada, based on certain statistical tests and econometric models, such as VAR model, Granger causality and GARCH (1, 1) model.

Research Gap

Several studies have already been conducted on the volatility behaviour of the CAC 40 index in France using models such as GARCH and other related econometric techniques. However, most of these studies were conducted over specific time periods or during major financial crises. Many researchers mainly focused on predicting volatility rather than understanding how market behaviour changes over time.

In addition, earlier studies often used older datasets that may not accurately reflect current conditions in the French stock market. In recent years, global economic uncertainty, technological developments, and post-pandemic financial changes have significantly affected stock market movements. Despite these changes, limited research has been conducted using recent daily data of the CAC 40 index.

Another important issue is that only a few studies have compared different volatility models to examine which model better explains market fluctuations, volatility persistence, and sudden market shocks in the CAC 40 index. Therefore, there is still a need for updated research based on daily stock market data to better understand the current volatility pattern of the French market. The present study attempts to address this gap by analysing the volatility behaviour of the CAC 40 index using daily data and suitable econometric models.

Objective of the study

The main objective of this study is to examine the volatility behaviour of the CAC 40 Index in France using daily stock market data for the study period and to apply different GARCH-family models to identify a suitable model for measuring and forecasting volatility in the CAC 40 Index. This paper aims to understand how market volatility changes over time and how different economic and financial conditions influence stock market movements, and to analyse market fluctuations and identify volatility in the French stock market.

By examining these volatility patterns, the study also aims to provide useful insights for investors, policymakers, and the government to better understand market risk and make more informed financial and investment decisions.

Research Methodology

The research is quantitative and exploratory, and an appropriate econometric tool is utilised to predict price movements. Pourmansouri and Birau (2024) provided an extensive and complex

framework regarding financial econometrics. There are a total of 4926 data points for the CAC 40, Euronext Paris. Covering the period from January 25th, 2007, to 24th April 24th, 2026. The idea was to capture the volatility of the index using an appropriate Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model with the relevant distribution. Firstly, the Stationarity of the data was evaluated by using the Augmented Dickey-Fuller (ADF) statistic test. After evaluating stationarity, the ARCH Lagrange Multiplier (LM) test was applied to assess heteroscedasticity in the returns' residual series. Various models from the GARCH family were employed (GARCH, TGARCH, IGARCH, EGARCH, PARCH, APARCH) across various distributions (Normal, Gaussian Distribution, Student's t-distribution, Generalised Error Distribution (GED), with fixed parameter and GED with fixed parameter) for volatility analysis. The software package used for analysis was EViews 10.

Significance of the Study

This study is important because it helps in understanding the volatility behaviour of the CAC 40 index using daily stock market data. As observed, stock prices do not remain stable; their movements are affected by various economic, political, and global events. By studying these fluctuations, the research provides a better understanding of how the French stock market behaves under different market conditions. The study also helps identify whether market shocks have short- or long-term effects on stock market returns.

Another important aspect of this research is the use of different GARCH family models to analyse and predict market volatility. Choosing an appropriate volatility model can improve forecasting accuracy and clarify market risk. The study's findings may be useful to investors, researchers, analysts, and policymakers.

Limitations of the Study

Although the study uses daily price data for detailed volatility analysis, it is statistical and may not fully capture the complexities of the real market. Since the main focus is on estimating the conditional variance of returns, the framework is more theoretical and may not clearly explain every market situation.

- Limited availability of detailed data is another limitation of the research. The study uses secondary data from publicly available sources and, due to limited resources, the analysis follows a broad market approach rather than examining firm- or micro-level variations in detail, making it a generalised piece of work.
- Although GARCH family models are flexible and widely used for volatility forecasting, they may not completely capture all aspects of complex market behaviour.
- The findings of the study are limited to the selected study period and the CAC 40 Index only. Therefore, the results may vary for other stock markets or different time periods.

Given the strengths and limitations of the TGARCH-skewed Student and GARCH models, the study will proceed with the analysis and estimation. The study will now proceed with the analysis and estimation process.

Analysis, Estimation, and Results

To better understand price movements, it is important to examine them visually. The graphical representation of the actual prices is shown below.



Figure 1. Daily Closing Price of Index
Source: Authors' own formulation using Python Software

The above is a graphical representation of the volatility of the CAC 40 index, based on data spanning almost two decades. And from the above representation, it can be observed that the price was never stagnant, and in 2012, the price was slightly going upward with a minimum dip and spike until 2020. After 2020, it can be observed that there were huge fluctuations until 2023 due to the pandemic and macroeconomic effects, such as various systematic and unsystematic reasons.

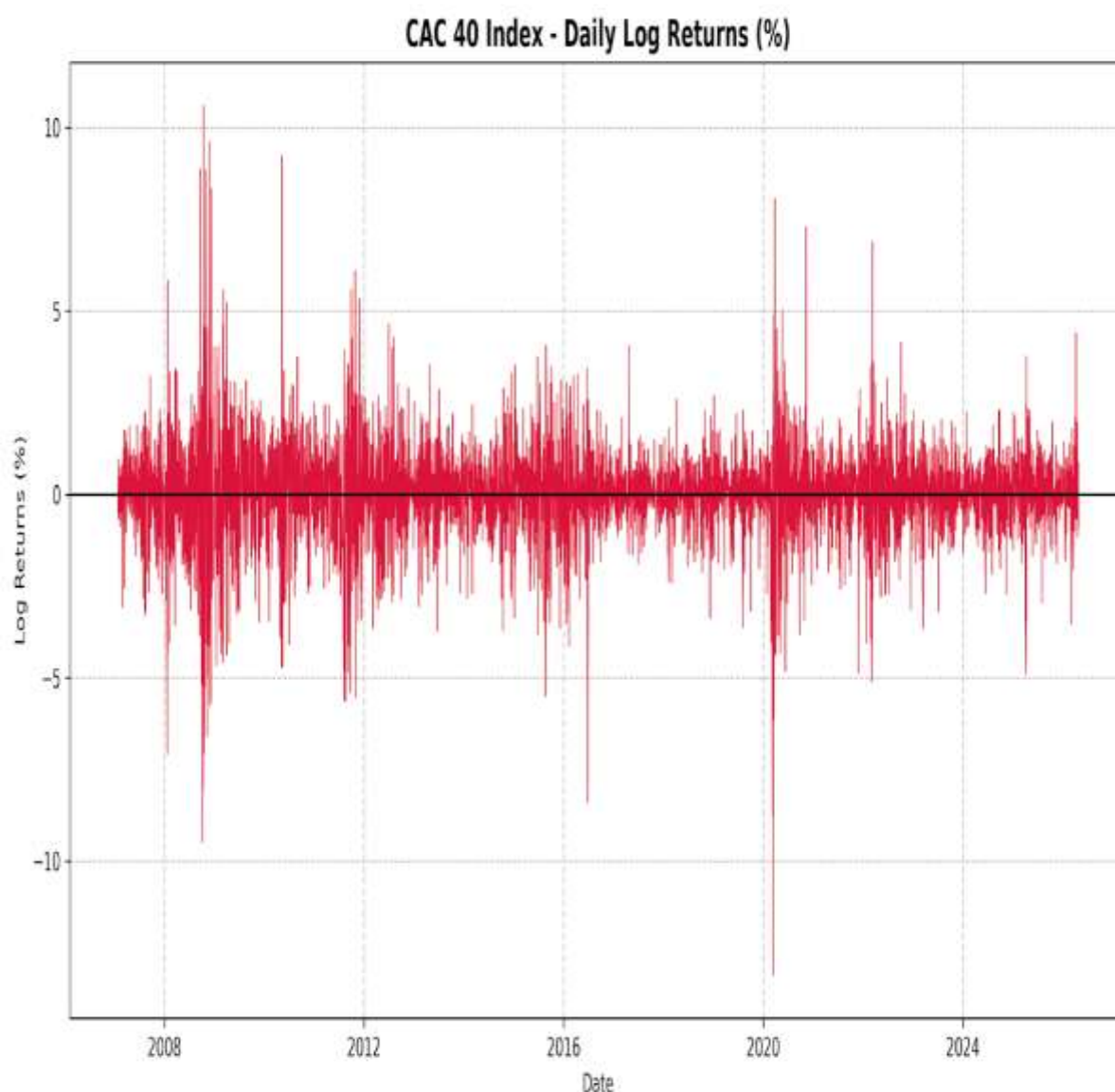


Figure 2. Log Returns Graph
Source: Authors' own formulation using Python Software

The log returns have been calculated to make the returns stationary. The above graphical representation of the CAC 40's log returns shows that the market experiences frequent fluctuations throughout the period. The graph clearly indicates volatility clustering, where periods of high volatility are followed by periods of high volatility, and periods of low volatility are followed by periods of low volatility. Major positive and negative spikes can also be observed during financial and economic events, particularly during the 2008 financial crisis and the COVID-19 pandemic period in 2020.

The test of stationarity is essential, as the data visually appear to exhibit heteroscedasticity.

Metric	Original Prices	Log Returns
Test Statistic	-0.55282	-12.8099
p-value	0.881291	6.48E-24

1% Critical Value	-3.43169	-3.43169
5% Critical Value	-2.86213	-2.86213

Table 1: Augmented Dickey-Fuller test
Source: authors' tabulation using MS Office

The Augmented Dickey–Fuller (ADF) test results show that the original price series of the CAC 40 is non-stationary. This is because the test statistic exceeds the critical value and the p-value exceeds the 5% significance level. It means that the original price data exhibit a unit root, and that their mean and variance change over time.

After converting the prices into log returns, the series becomes stationary. The test statistic for the log return series is below the critical value, and the p-value is much smaller than 0.05. Therefore, the null hypothesis of the presence of a unit root is rejected. This indicates that the log-return series is stable over time and can be used for further volatility analysis using GARCH-family models.

Lag	LB Statistics	LB p-value
10	2127.254	0
20	3061.299	0

Table 2: Ljung–Box test
Source: authors' tabulation using MS Office

The Ljung–Box test results for the return series show very high statistics with p-values of 0 at both lag 10 and lag 20. This indicates significant autocorrelation in the CAC 40 index return series. The results suggest that the series is not completely random and contains volatility dependence over time. Therefore, the data are suitable for further volatility modelling using GARCH-family models.

Model	Distribution	Log-Likelihood	AIC	BIC (SIC)
T-GARCH	Skewstudent	-7294.7	14603.4	14648.9
APARCH	Skewstudent	-7294	14603.9	14656
EGARCH	Skewstudent	-7298.8	14611.6	14657.1
T-GARCH	T	-7318.3	14648.5	14687.5
APARCH	T	-7317.8	14649.7	14695.2
EGARCH	T	-7323.9	14659.8	14698.8
GJR-GARCH	Skewstudent	-7333.8	14681.5	14727
T-GARCH	GED	-7342.7	14697.5	14736.5
APARCH	GED	-7342.4	14698.9	14744.4
EGARCH	GED	-7351.6	14715.3	14754.3
GJR-GARCH	T	-7354.3	14720.6	14759.6
GJR-GARCH	GED	-7375.6	14763.2	14802.2
T-GARCH	Normal	-7442.1	14894.3	14926.8
APARCH	Normal	-7442.3	14896.6	14935.6
GARCH	Skewstudent	-7442.7	14897.3	14936.3
GARCH	T	-7455	14920	14952.6
EGARCH	Normal	-7460.5	14930.9	14963.4
GARCH	GED	-7465.9	14941.7	14974.2
GJR-GARCH	Normal	-7482.2	14974.3	15006.8
GARCH	Normal	-7594.2	15196.5	15222.5

Table 3: Decision table

Source: authors' tabulation using MS Office

After implementing GARCH, TARCH, EGARCH, IGARCH, PARCH, APARCH, GJR - GSRCH, T-GARCH models across the Gaussian Normal Distribution, Student's t distribution, Generalised Error Distribution (GED), t distribution with fixed parameter and GED with fixed parameter, from the above table, we can conclude that T-GARCH model at the skewed student distribution is an appropriate model due to the lowest Akaike info criterion (14603.4), comparatively lowest Schwarz criterion (14648.9) and the highest Log Likelihood (-7294.7).

Constant Mean - TARCH/ZARCH Model Results					
=====					
=====					
Dep. Variable:	CAC40 index log returns			R-squared:	0.000
Mean Model:	ConstantMean			Adj. R-squared:	0.000
Vol Model:	TARCH/ZARCH			Log-Likelihood:	-7294.71
Distribution:	Standardised Skew Student's t			AIC:	14603.4
Method:	Maximum Likelihood			BIC:	14648.9
				No. Observations:	4925
Date:	Fri, May 15 2026			Df Residuals:	4924
Time:	01:16:46			Df Model:	1
Mean Model					
=====					
	coef	std err	t	P> t	95.0% Conf. Int.

mu	3.4618e-03	1.303e-02	0.266	0.791	[-2.209e-02,2.901e-02]
Volatility Model					
=====					
	Coef	std err	t	P> t	95.0% Conf. Int.

omega	0.0323	5.483e-03	5.889	3.891e-09	[2.154e-02,4.303e-02]
alpha[1]	0.0000	9.709e-03	0.000	1.000	[-1.903e-02,1.903e-02]
gamma[1]	0.1894	1.525e-02	12.422	1.984e-35	[0.160, 0.219]
beta[1]	0.9019	1.171e-02	77.005	0.000	[0.879, 0.925]
Distribution					
=====					
	coef	std err	t	P> t	95.0% Conf. Int.

eta	6.9971	0.671	10.429	1.828e-25	[5.682, 8.312]
lambda	-0.1395	2.037e-02	-6.846	7.587e-12	[-0.179,-9.953e-02]
=====					
Covariance estimator: robust					

Table 4: TARCH/ZARCH Model Results
Source: Authors' own formulation using Python Software

The findings from the TARCH/ZARCH models with a skewed Student's t-distribution help better understand the volatility behaviour of the CAC 40. The coefficient of the mean equation (μ) is not statistically significant because its p-value is greater than 0.05, indicating that the market's average return is very low and does not play a major role in explaining market volatility.

The volatility equation indicates that ω is positive and significant, confirming the presence of market volatility. The β coefficient is quite high and statistically significant, indicating that volatility shocks persist in the market for a longer period. The γ coefficient is also positive and highly significant, indicating asymmetric volatility in the market. This suggests that negative news has a stronger effect on market volatility than positive news.

The distribution results further reveal that the return series is not normally distributed, exhibiting asymmetry and fat tails. The negative and significant λ value indicates negative skewness in the return distribution. Overall, the results suggest that the TARCH/ZARCH model effectively captures volatility clustering, persistence, and asymmetric movements in the CAC 40 return series.

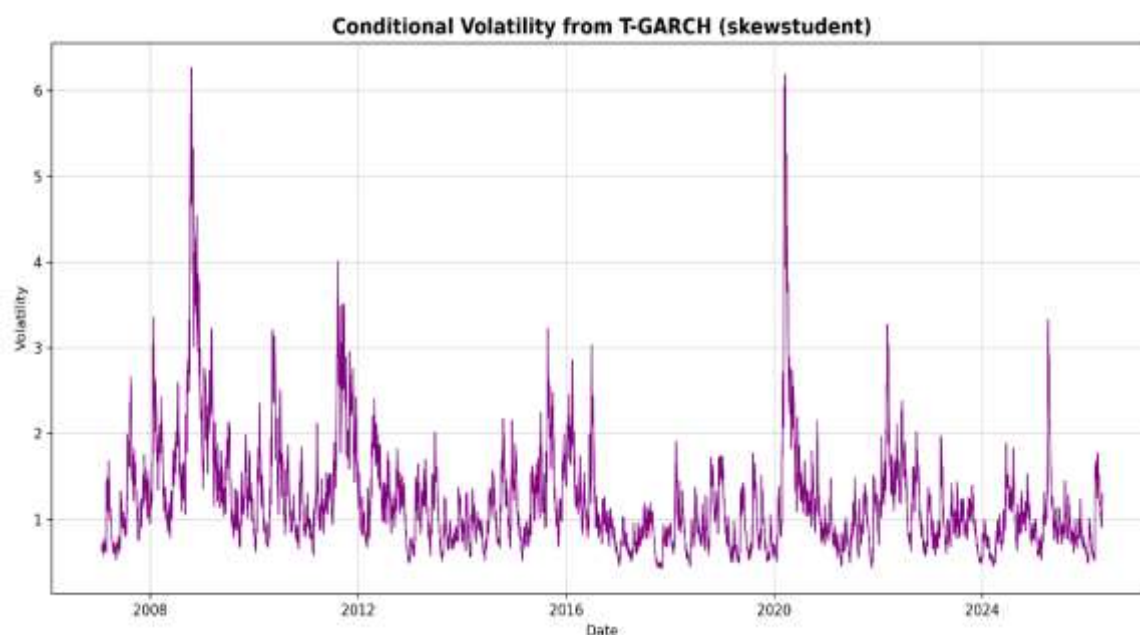


Figure 3: conditional volatility
Source: Authors' own formulation using Python Software

The conditional volatility graph from the T-GARCH model shows that the volatility of the CAC 40 did not remain stable during the study period. The market experienced several periods of high and low volatility, which indicates continuous changes in market risk and investors' behaviour over time. The graph shows several sharp spikes, indicating sudden increases in volatility during periods of economic and financial uncertainty.

A major rise in volatility occurred during the 2008 financial crisis and again around 2020 during the COVID-19 pandemic. These spikes suggest that negative market events elicited strong reactions and increased uncertainty among investors. The graph also shows volatility clustering, with periods of high volatility lasting for some time before returning to normal levels.

Overall, the graph indicates that the CAC 40 market was highly sensitive to major global events and economic shocks during the selected period. The T-GARCH model effectively captured these changing volatility patterns, making it suitable for analysing and forecasting market volatility.

Metric	Original Prices	Log Returns
Test Statistic	-0.55282	-12.8099
p-value	0.881291	6.48E-24
1% Critical Value	-3.43169	-3.43169
5% Critical Value	-2.86213	-2.86213

Table 5: Standardised Residual Test
Source: authors' tabulation using MS Office

The Ljung–Box test results for the standardised residuals indicate that the p-values for lags 10 and 20 exceed the 5% significance level. This means that there is no meaningful autocorrelation left in the residual series after fitting the GARCH model. In other words, the model has effectively explained the volatility pattern in the return series, indicating that the model is reliable and suitable for volatility estimation and forecasting.

Conclusion and Recommendations

The findings showed that the market experienced continuous fluctuations during the study period, with clear evidence of volatility clustering and changing market risk over time. Major spikes in volatility were observed during major global events, such as the 2008 financial crisis and the COVID-19 pandemic, indicating that the French stock market was highly sensitive to economic and financial uncertainty. The ADF test confirmed that the log-return series was stationary, while the Ljung–Box test indicated autocorrelation in the return series, supporting the use of GARCH-family models for volatility analysis. After comparing different models on the basis of Log-Likelihood, AIC, and BIC values, the T-GARCH model with skewed Student's t-distribution was found to be the most suitable model for analysing volatility in the CAC 40 return series.

The results further showed strong volatility persistence and asymmetric effects, suggesting that negative market news had a stronger impact on volatility than positive news. Diagnostic checks of standardised residuals also confirmed that the selected model successfully captured the volatility behaviour of the series and was appropriate for forecasting market volatility. Based on these findings, investors and portfolio managers should carefully monitor market volatility before making investment decisions, especially during periods of economic uncertainty. Policymakers and financial institutions should also take timely measures to reduce market instability during financial crises. In addition, future researchers may extend this study by including other stock markets, macroeconomic variables, or different time frequencies to develop a broader understanding of stock market volatility behaviour.

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