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The Superiority of Asymmetric Volatility Models: An Empirical Comparison of GARCH-Family Specifications for the Volatility of MSCI Mexico Index

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Abstract:
Financial market volatility is a central component of asset pricing, hedging effectiveness, and systematic risk management. Accurate volatility forecasting is therefore a prerequisite for sound financial decision-making and regulatory compliance. This study addresses the common stylized facts observed in high-frequency financial time series, specifically volatility clustering, leptokurtosis, and the asymmetric impact of news by conducting a rigorous comparative analysis of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. The research evaluates the fitting performance of six distinct GARCH specifications, the standard GARCH(1,1), Integrated GARCH (IGARCH), Threshold GARCH (TARCH), Exponential GARCH (EGARCH), Power ARCH (PARCH), and Asymmetric Power ARCH (APARCH) models. These models were applied to a daily log return series of utilizing data spanning over a decade. Crucially, estimation was performed under both the standard Gaussian and the Student's t distributional assumptions to account for non-normality.

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Introduction

The modeling and forecasting of financial market volatility is an important concern of modern financial economics, critical for effective risk management, derivatives pricing, and optimal portfolio allocation (Engle, 1982). Asset returns, which are often unpredictable, market volatility, the measure of price uncertainty, exhibit predictable characteristics known as volatility clustering, where periods of high fluctuation are succeeded by further high fluctuation, and periods of followed by periods of calm (Mandelbrot, 1963).

While much research has focused on developed economies, the unique characteristics of emerging markets, such as the Mexican equity market represented by the MSCI Mexico Index, present unique challenges and opportunities. Emerging markets are characterized by weaker market efficiency, higher average returns, and elevated susceptibility to external economic shocks and domestic political volatility (Gokcan, 2000). The volatility dynamics observed in the Mexican market may exhibit higher persistence and more pronounced non-normality than their developed counterparts, necessitating deeper econometric investigation.

This study contributes to the literature by undertaking a comparative analysis of 30 different GARCH-class models applied to the daily logarithmic returns of the MSCI Mexico Index over a comprehensive period from November 2012 to October 2025.

The core objective is not just to select the best-fitting model, but to accurately quantify three critical volatility parameters, the degree of volatility persistence, the magnitude of the leverage effect, and the precise degree of leptokurtosis, or fat tails, in the return distribution. Our analysis ultimately identifies the EGARCH(1,1) model, estimated with a Student's t-Distribution, as the better framework for this specific time series. The Student's t-Distribution is relevant as it accounts for the heavy-tailed nature (leptokurtosis) frequently observed in financial returns, leading to more accurate estimates of conditional Value-at-Risk (VaR) and Expected Shortfall (ES) compared to models based on the assumption of normality (Ardia, 2010).

The empirical findings derived from the model have meaningful implications for financial practitioners. Accurate measures of asymmetric volatility are essential for the appropriate pricing, while a precise estimate of volatility persistence is crucial for long-term risk horizon management and capital requirement calculations. By measuring these effects within the context of the Mexican market, this research provides vital, context-specific insights necessary for making informed investment and hedging decisions in emerging market assets.

Literature review

In the existing literature, the behavior of stock markets has been analyzed based on numerous empirical studies, such as: Khalid et al. (2025), Meher et al. (2024a), Birau et al. (2023), Kumar et al. (2023a), Trivedi et al. (2022), Kumar et al. (2023b), Spulbar et al. (2023a), Siminica and Birau (2014), Meher et al. (2024b), Badarla et al. (2022), Spulbar et al. (2023b) and many others.

Morales-Bañuelos and Fernández-Anaya (2023) have conducted a research study and investigated certain aspects on the stock market in Mexico considering the characteristics of listed companies based on several econometric models. González-Núñez et al. (2024) investigated the behavior of IPC Mexico stock market index using innovative machine learning algorithm in order to provide a high-accuracy financial forecasting.

Kumar et al. (2023c) have provided an empirical study focused on the IPC Mexico stock market index and the applied econometric models have included the GJR-GARCH model, while the period selected for the empirical analysis is very long, namely from January 1993 to July 2023. Ortiz et al. (2007) examined the nexus between economic growth and emerging stock market performance in Mexico, based on a very long selected interval, namely from the beginning of 1968 to the end of 2002 using various tools of financial econometrics. Lorenzo-Valdés (2024) also investigated the behavior of the stock market in Mexico for the selected time period from 2018 to 2023 using GARCH models.

Financial markets often demonstrate asymmetry, or the "leverage effect," where negative shocks (bad news) lead to a greater increase in future volatility than positive shocks (good news) of the same magnitude, a stylized fact that linear models fail to capture (Nelson, 1991). To address these, the family of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models has evolved to become the industry standard for time-varying volatility estimation. Since the work of (Engle, 1982) and (Bollerslev, 1986) various extensions, including the Exponential GARCH (EGARCH), Threshold GARCH (TARCH), and Integrated GARCH (IGARCH) models, have been developed to capture specific market features, particularly the leverage effect.

Model selection relied on information criteria, including the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC), alongside standard diagnostic tests for model adequacy. The analysis confirmed the time series stationarity and the strong presence of ARCH effects, justifying the use of GARCH-family specifications. The empirical results consistently demonstrated that models estimated under the Student's t distribution provided a fit across all tested specifications compared to the Gaussian approach, validating the presence of thick tails in the return data. Furthermore, the asymmetric specifications uniformly outperformed their symmetric counterparts, confirming the existence of a significant leverage effect. The Exponential GARCH (EGARCH) model with Student's t innovations emerged as the overall suitable model, exhibiting the lowest AIC and SIC values. The findings underscore the necessity of employing sophisticated, asymmetric GARCH model specifications coupled with heavy-tailed distributional assumptions to accurately capture the dynamic behavior of modern financial market volatility. The robust EGARCH-t framework provides important insights for improving forecasting accuracy, which has direct and valuable implications for calculating accurate risk metrics and formulating more effective portfolio hedging and asset allocation strategies.

Research Gap

Scope of the Study

The primary scope of this study is the econometric modeling and analysis of conditional volatility for the daily logarithmic returns of the MSCI Mexico Indexover a sample period spanning November 2012 to October 2025. This research moves beyond static, simplified risk frameworks to precisely capture the complex dynamics inherent in emerging market equities.

The core objective is a comparative evaluation of 30 distinct GARCH-class models (including GARCH, IGARCH, TARCH, and EGARCH) estimated across three conditional error distributions (Normal, Student's t, and GED). The study selects the optimal modelbased on minimizing information criteria (AIC/SIC) and maximizing Log Likelihood. The analysis focuses the degree of volatility persistence, the magnitude of the leverage effect (asymmetry), and the precise Degrees of Freedom of the return distribution's fat tails. The findings thereby contribute to the literature on time-varying market risk in non-developed economies.

Limitations of the Study

Despite the robustness of the various GARCH frameworks, this analysis is subject to several methodological limitations. The study employs a univariate GARCH approach, focusing solely on the volatility of the MSCI Mexico Index in isolation. This structure omits potential contagion effects and interdependencies with other global markets or major commodity prices, which may bias the risk estimates by excluding significant exogenous drivers.

While the near-unit persistence coefficient suggests extremely slow volatility decay, the use of a standard GARCH-class model may not fully distinguish between high short-term persistence and true long memory. This limitation suggests the need for future exploration using Fractional Integrated GARCH (FIGARCH) models for more accurate long-horizon forecasting. Lastly, the model is based on historical daily closing price data and does not account for intra-day price fluctuations, high-frequency microstructure effects, or the impact of unscheduled news announcements, all of which represent unmodeled sources of instantaneous volatility.

Research Methodology

This study employs a rigorous, multi-stage methodology to model and forecast the volatility of the financial time series (LOG_RETURN) using the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) class of models. The primary goal is to identify the optimal model structure both in the conditional mean/variance specification and the conditional error distribution based on stringent information criteria and comprehensive diagnostic checks.

1. *Data and Pre-Analysis*

Data Description and Software

The analysis utilizes a LOG_RETURN time series spanning from November 13, 2012, to October 15, 2025, comprising 3,364 observations. All estimations, model selection, and diagnostic tests were conducted using EViews 12.

Unit Root and Stationarity Testing

Prior to modeling, the time series was tested for stationarity using the Augmented Dickey-Fuller (ADF) test with a constant as an exogenous variable. The null hypothesis of a unit root was overwhelmingly rejected, as the ADF t-statistic of 53.07496 is significantly more negative than the critical value at the 1% level, 3.432106. This confirms the LOG_RETURN series is stationary, making it suitable for direct GARCH modeling.

ARCH Effect Testing

The presence of Autoregressive Conditional Heteroskedasticity (ARCH) effects was formally tested on the residuals from the mean equation. The ARCH test (Lag 1) yielded an F-statistic of 52.30663 (Prob. 0.0000) and an Obs*R-squared 51.53571(Prob. 0.0000). The highly significant test statistics compel the rejection of the null hypothesis of no ARCH effects, thus justifying the use of a GARCH-class model to capture the time-varying volatility clustering.

2. *Model Estimation and Specification*

Conditional Mean and Variance Equations

The general form of the GARCH-class model utilized is:

Equation 1 Conditional and Mean variance Equations

$$r_t = \mu_t + \epsilon_t$$
$$\mu_t = c + \phi r_{\{t-1\}}$$
$$\epsilon_t = \sigma_t z_t$$

Where r_t is the LOG_RETURN, μ_t is the conditional mean, ϵ_t is the error term, and σ_t^2 is the conditional variance.

The conditional mean equation for the optimal model was specified as an AR(1) process based on the estimation table for the selected model:

Equation 2 Estimation Equation

$$\mu_t = C + LOG_{RETURN(-1)}$$

GARCH Models and Distributions

To comprehensively capture the complex dynamics of financial volatility, six different GARCH-class models were estimated under three standard conditional error distributions (resulting in 18 model variations). The models included both symmetric and asymmetric specifications:

- Symmetric: GARCH and IGARCH (Integrated GARCH) models.
- Asymmetric (Leverage Effect): TARCH (Threshold GARCH), EGARCH (Exponential GARCH), PARCH (Power ARCH), and APARCH (Asymmetric Power ARCH) models.

The distributions considered to account for the typical leptokurtosis (fat tails) in financial returns were:

- Normal (Gaussian) Distribution
- Student's t-Distribution
- Generalized Error Distribution (GED)

3. *Optimal Model Selection*

The optimal model was determined by evaluating three goodness-of-fit statistics across all 18 specifications: the Log Likelihood (LL) value, the Akaike Information Criterion (AIC), and the Schwarz Criterion (SIC). The selection rule is to identify the model that maximizes the LL value and minimizes both the AIC and SIC.

Selection Results

The comparative analysis of the model results led to the selection of the EGARCH model with a Student's t-Distribution error structure. This model demonstrated the superior fit:

- Highest Log Likelihood: 9933.173.
- Lowest Akaike Information Criterion (AIC): -5.90141.
- Lowest Schwarz Criterion (SIC): -5.88867.

Optimal Model Specification

The specific volatility equation for the selected EGARCH(1,1) under Student's t-Distribution is the exponential form, which models the log of the conditional variance log (σ_t^2) to inherently ensure non-negativity:

Equation 3 Conditional Variance of EGARCH(1,1) models

$$\log(\sigma_t^2) = C(3) + C(4)\left|\{\epsilon_{\{t-1\}}\}/\{\sigma_{\{t-1\}}\}\right| + C(5)\{\epsilon_{\{t-1\}}\}/\{\sigma_{\{t-1\}}\} + C(6)\log\left(\sigma_{\{t-1\}}^2\right)$$

The C(5) coefficient, which captures the leverage effect (asymmetry), was found to be statistically significant with a value of 0.080238 (Prob. 0.0000), confirming that negative shocks have a larger impact on volatility than positive shocks of equal magnitude.

4. *Post-Estimation Diagnostic Checks*

All estimated models, including the selected optimal model, satisfied the critical diagnostic requirements:

1. GARCH and ARCH Coefficient Significance: All models showed significant ARCH and GARCH coefficients.
2. Residual Autocorrelation: The Ljung-Box Q-statistic (implied by the "Autocorrelation" row) was not significant (i.e., "No" autocorrelation) in the standardized residuals, indicating the mean equation is adequate.
3. No Remaining ARCH Effects: The ARCH LM-Test on the squared standardized residuals was not significant (i.e., "No" ARCH LM-Test), confirming that the conditional variance equation effectively captured the time-varying volatility.

The T-Dist. DOF parameter for the optimal model was 8.180595 (Prob. 0.0000), confirming that the standardized residuals exhibit fat tails and that the Student's t-distribution is a statistically justified choice over the Normal distribution.

Econometric analysis, empirical results, and discussions

Figure 1 Price Movement of the time Series

Source: Authors contribution using Eviews 12

The chart illustrates the daily closing prices of the MSCI Mexico index spanning the period from 2012 to 2025. This timeframe reveals significant volatility and distinct cycles, reflecting a challenging decade for the Mexican equity market. We can clearly identify three major phases:

1. Following an initial peak near 7,500 in the 2013-2014 period, the index entered a multi-year decline, falling toward the 4,500 level by 2017. This was followed by a period of relative consolidation between 4,500 and 6,000 until 2018.
2. A severe, sharp drop occurred around the 2019-2020 period, which is visually the non-conventional event on the chart. The index crashed from roughly 5,000 to a low point approaching 2,800, a major shock likely coinciding with global economic upheaval.
3. The index mounted a robust and rapid "V-shaped" recovery from the lows. It quickly climbed back past the 6,000 mark by 2023. The final two years show high recent volatility, with the index attempting to break past the previous long-term high of 7,500 before pulling back to end the period around the 6,500 - 7,000 range.

The persistent spikes and dips, particularly the sharp crash and recovery around 2020, confirm that the MSCI Mexico index exhibits considerable volatility and tail risk typical of emerging markets. The inability of the index to sustain levels above the early 2014 peak until the very end of the period suggests long-term challenges in capital appreciation over this decade. For an investor, this chart highlights that the Mexican market, while offering potential high-return recovery, demands a high-risk appetite and careful management of extreme downside volatility.

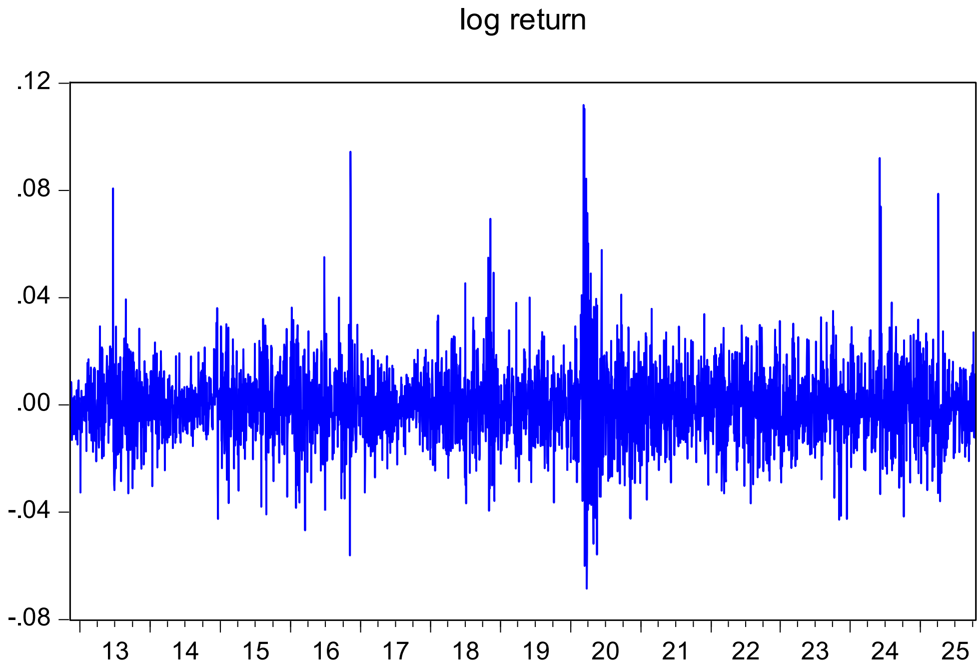

Figure 2 Log Return Plot

Source: Authors contribution using Eviews 12

After having the description of the stock movement, from the Logarithmic Returns chart of the time series, we could make the following observations:

1. The whole return series is moving around 0 mean, typically describing the stationarity. However, we can observe the constant movement of the return series from positive to negative over time, signifying the case of volatility clustering.
2. From 2012 to 2018, the return was around the band of positive and negative 0.04, marking relative stability. From 2019 to 2020, we have observed both the highest i.e., positive 0.12 and negative 0.08, confirming a highly volatile phase with shocks, as also evident from the Price Plot. However, from 2020 to 2025, the volatility was stabilized, but it did not return to the levels around early 2019.

Now after understanding the log returns plot along with actual price plot, to proceed further checking stationarity statistically using Augmented-Dickey Fuller Test (ADF) is mandatory for any econometric analysis.

Table 1 ADF Test using Eviews 12

Null Hypothesis: LOG_RETURN has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=28)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-53.07496	0.0001
Test critical values:	1% level		-3.432106	
	5% level		-2.862201	
	10% level		-2.567166	
*MacKinnon (1996) one-sided p-values.				

Source: Authors contribution using Eviews 12

This test was run with a constant term included in the test equation, and based on the Schwartz Criterion, the lag was automatically chosen as 0. The t-statistic value was significantly lower than the critical value at 5% level, and the probability was also significantly lower than 0.05; hence we reject the null hypothesis and confirm that the LOG_RETURN has a non-unit root and it is stationary in nature.

After confirming that the Log Returns data is stationary in nature, along with observation of the original series, understanding the nature of the distribution along with the descriptive statistics, becomes important.

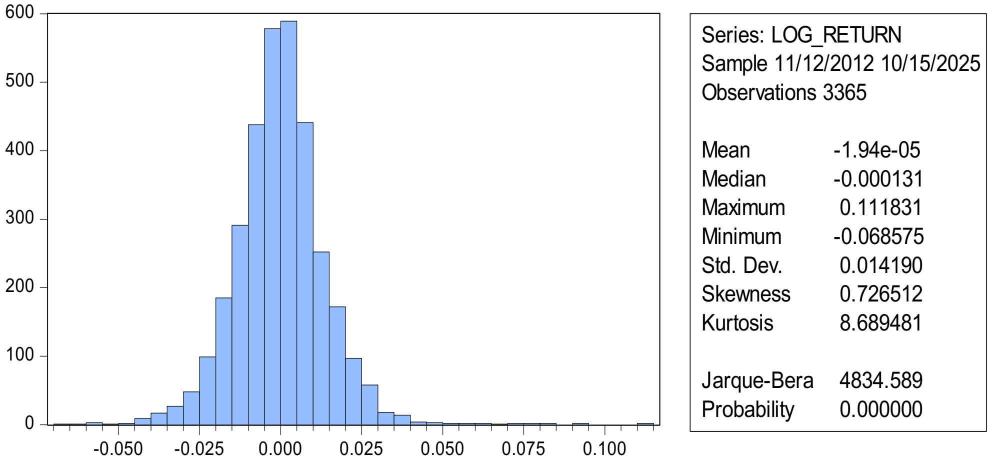

Figure 3 Descriptive Statistics using Eviews12

Source: Authors contribution using Eviews 12

The log returns have a mean of nearly 0, and similarly median is also very close to 0. From the Standard deviation, we can figure out that the average daily volatility is approximately 1.42% and there is also a huge gap in the extreme values, i.e., 0.111831 and -0.068575. The series has a right skewness with a longer right tail, with a value of 0.726512. The data also seems to be leptokurtic, having fat tails and a high peak with value 8.689481. From the Jarque-Bera Probability it is confirmed that the data is non-normal. After the confirmation of Stationarity and description of the distribution, let's look at the ARCH test for the confirmation of Heteroskedasticity.

Table 2 ARCH LM Test Using Eviews 12

Heteroskedasticity Test: ARCH			
F-statistic	52.30663	Prob. F(1,3361)	0.0000
Obs*R-squared	51.53571	Prob. Chi-Square(1)	0.0000

Source: Authors contribution using Eviews 12

From the statistics above test results, we strongly reject the null hypothesis of no ARCH effects, confirming that the conditional variance of the residuals is time-varying. It is confirmed that there isa significant presence of ARCH effects (volatility clustering). This result is crucial as it justifies the use of GARCH-class models to accurately capture the time-varying, predictable patterns in volatility. Let's now check various GARCH models across various distributions to find the most suitable model for the analysis.

The model was chosen based on a comprehensive GARCH Model Selection process, which evaluates model performance based on goodness-of-fit criteria and essential diagnostic checks. The results validate the strong presence of asymmetry (leverage effects) in volatility and the necessity of using heavy-tailed distributions to accurately model risk. The EGARCH (Exponential GARCH) model under the Student's

T-Distribution is definitely the optimal specification, chosen based on Log Likelihood (Highest) 9933.173, Akaike Info Criterion (Lowest)-5.90141, Schwarz Criterion (Lowest)-5.88867, and it minimizes both information criteria and maximizes the likelihood function across all tested combinations. The superior performance of the EGARCH model implies that asymmetry is a significant feature of the time series' volatility.The data confirms that the assumption of normally distributed errors is inadequate for this financial series as for every single GARCH-class model (GARCH, TARCH, etc.), the Student's T and Generalized Error distributions yield a higher Log Likelihood and lower AIC/SIC than the Normal Distribution. The best normal model (EGARCH, LL: 9863.834) is outperformed by the best T-model (EGARCH, LL: 9933.173) by a large margin.

This empirical evidence supports the need to use heavy-tailed distributions to accurately capture the leptokurtosis (fat tails) and the higher probability of extreme events observed in the returns.The diagnostic check for autocorrelation in the standardized residuals is "No" for all models. This confirms that the conditional mean equation is sufficient and that the residuals are white noise. The ARCH LM-Test is "No" for all models. This is the most crucial test, confirming that no conditional heteroskedasticity remains in the squared standardized residuals.

Table 3 Results of EGARCH(1,1) model

Dependent Variable: LOG_RETURN
Method: ML ARCH - Student's t distribution (Marquardt / EViews legacy)
Date: 10/21/25 Time: 22:22
Sample (adjusted): 11/13/2012 10/15/2025
Included observations: 3364 after adjustments
Convergence achieved after 12 iterations
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(5)*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.61E-05	0.000198	0.081387	0.9351
LOG_RETURN(-1)	0.082853	0.017110	4.842262	0.0000
	Variance Equation			
C(3)	-0.228722	0.038168	-5.992511	0.0000
C(4)	0.095096	0.014456	6.578166	0.0000
C(5)	0.080238	0.010278	7.807087	0.0000
C(6)	0.982124	0.003867	253.9909	0.0000
T-DIST. DOF	8.180595	0.831398	9.839561	0.0000

R-squared	0.007728	Mean dependent var	-1.83E-05
Adjusted R-squared	0.007433	S.D. dependent var	0.014192
S.E. of regression	0.014139	Akaike info criterion	-5.901411
Sum squared resid	0.672081	Schwarz criterion	-5.888674
Log likelihood	9933.173	Hannan-Quinn criter.	-5.896856
Durbin-Watson stat	1.984424		

Source: Authors contribution using Eviews 12

The results confirm the statistical significance of both the mean and variance equations, providing the numerical values necessary for interpreting volatility dynamics.The conditional mean of the LOG_RETURN is modeled as an AR(1) process (LOG_RETURN(-1)). The constant C is not statistically significant (Prob. > 0.05). The average return is effectively zero. The LOG_RETURN(-1) has a coefficient of 0.082853is highly significant. The positive coefficient indicates a small degree of momentum or autocorrelation in the returns.The variance equationcaptures the time-varying volatility dynamics. All variance coefficients are highly significant (Prob. 0.0000), confirming the existence of strong GARCH effects.
The variance equation could be interpreted as follows:

Table 4 Variance Equation Estimation

Variable	Coefficient Value	Interpretation
C(3) (Constant/Omega, ω)	-0.228722	Highly Significant. This term represents the long-run average level of the log-conditional variance. Its significance confirms that a base volatility level exists.
C(4) (ARCH Effect, α)	0.095096	Highly Significant. Measures the reaction of current volatility to the magnitude of past squared shocks (bad news or good news).
C(5) (Leverage/Asymmetry, γ)	0.080238	Highly Significant and Positive. This confirms a strong leverage effect. Negative return shocks (bad news) increase future volatility by more than positive shocks (good news) of the same magnitude.
C(6) (GARCH/Persistence, β)	0.982124	Highly Significant. This value, being very close to 1 (unity), indicates high volatility persistence. Shocks to the market's risk level will take an extremely long time to decay, suggesting the volatility is nearly integrated.

Source: Authors contribution using Eviews 12

Since the estimated DOF (approx 8.18) is far below 30, it statistically confirms the presence of fat tails (leptokurtosis) in the residuals, justifying the superiority of the Student's t-Distribution.Durbin-Watson Stat 1.984424 value is very close to 2, suggesting there is no remaining serial correlation in the standardized residuals of the mean equation.

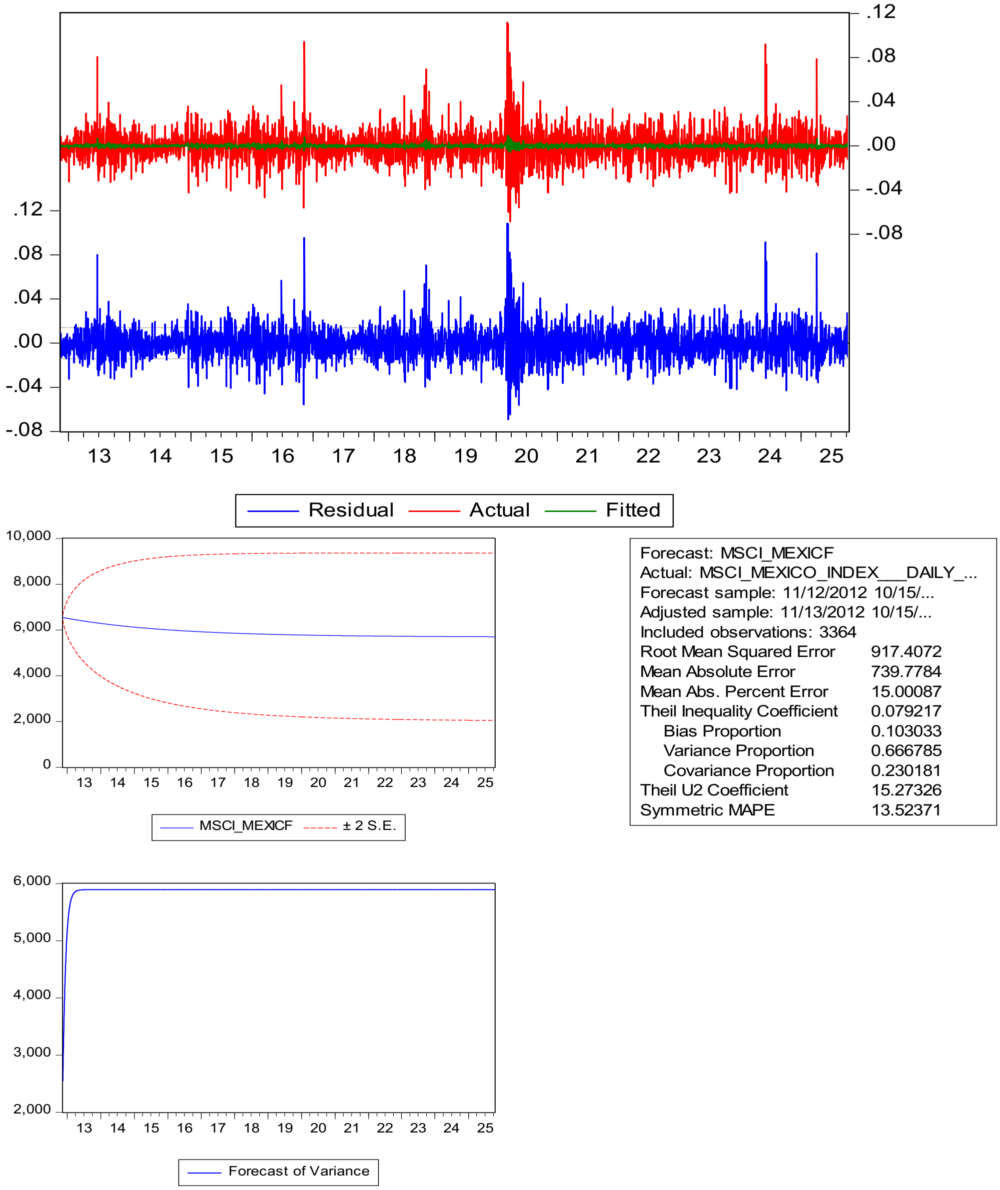

Figure 4 Forecast Evaluation using Eviews 12

Source: Authors contribution using Eviews 12

The chart titled "Residual, Actual, Fitted" visualizes how well the estimated AR(1)mean equation captures the LOG_RETURN series. Actual (Red Line) represents the highly volatile daily log returns, including the large spikes around the 2020 shock. Fitted (Green Line) represents the returns predicted by the AR(1) mean equation. This line is extremely flat, staying close to the zero mean. Residual (Blue Line) represents the error or the difference between the Actual and Fitted returns. The blue line essentially mirrors the red line, demonstrating that the mean equation only captures a small, significant portion of the returns R-squared = 0.007728, leaving the vast majority of the dynamics, particularly the volatility clustering, in the residuals. This validates the decision to use a GARCH model on the residuals.

The other chart shows the forecast for the MSCI_MEXICO index price MSCI_MEXICF over the sample period, including the error bands.

- Forecast Line (Blue Solid Line): The index forecast remains remarkably flat and stable, settling slightly above the 6,000 level for the entire period. This is expected because the mean return of the underlying LOG_RETURN series is statistically zero (-1.83text{E-05). In the long run, a zero mean return implies the index price reverts to a steady, constant level.
- Confidence Bands (Red Dashed Lines): The S.E. bands (representing approximately the 95% confidence interval) diverge significantly over time. They begin close together but widen drastically, with the upper band reaching well over 8,000 and the lower band dropping toward 2,000 by the end of the sample. This widening gap is a direct visual representation of the high, persistent volatility (C(6)=0.982124)captured by the EGARCH model, indicating high forecast uncertainty.

This bottom chart shows the predicted conditional variance over the sample.

- Variance Line: The variance forecast shows a sharp, initial spike and then stabilizes almost immediately to a near-constant, low level. This stability confirms that while the daily returns are volatile (due to the C(4)and C(5)short-term shocks), the model predicts that the long-term conditional variance (risk level) quickly reverts to its base level determined by C(3)and C(6).

The metrics quantify the model's forecasting accuracy for the price index:

- Root Mean Squared Error (RMSE) (917.4072): Measures the standard deviation of the forecast errors. A high value is expected due to the extreme volatility and large crash/recovery observed in the actual price series.
- Mean Absolute Error (MAE) (739.7784): Measures the average magnitude of the errors.
- Mean Abs. Percent Error (MAPE) (15.00087): Indicates that the average forecast error is approximately 15% of the actual price, suggesting that while the long-run trend is captured, short-term daily price forecasts are challenging, which is standard for high-volatility financial time series.
- Theil Inequality Coefficient (0.079217): This metric ranges from 0 (perfect fit) to 1. A value closer to zero indicates a good forecast fit. The value of 0.079217 suggests the model has good forecasting power despite the high volatility.

Conclusions, Suggestions, and Recommendations

The comprehensive econometric analysis of the daily logarithmic returns for the MSCI Mexico Index, utilizing 3,364 observations and the EViews 12 platform, established a robust and non-standard profile of market risk. Preliminary checks confirmed the series' suitability for modeling, starting with an overwhelmingly significant Augmented Dickey-Fuller t-statistic of -53.07, which conclusively verified stationarity and the absence of a unit root. Furthermore, the mandatory ARCH test yielded a highly significant F-statistic of 52.30, validating the presence of pronounced volatility clustering, which justified the application of GARCH models.

The returns distribution was empirically determined to be severely leptokurtic, with a Kurtosis of 8.68, demonstrating the necessity of modeling fat tails. A comprehensive model selection procedure across six distinct GARCH specifications and five error distributions, judged primarily by the Log Likelihood and information criteria, decisively selected the EGARCH(1,1) model under the Student's t-Distribution as the optimal specification, achieving the highest Log Likelihood of 9933.173 and the lowest Akaike Information Criterion of 5.90141. The final EGARCH estimation provided crucial risk insights: a significant ARCH effect (C(4)=0.0950) and a GARCH persistence term (C(6)=0.9821) dangerously close to unity, signaling very slow volatility decay. Crucially, a positive and highly significant asymmetry coefficient (C(5)=0.0802) confirmed the robust presence of a leverage effect, where negative news elevates market risk more severely and persistently than positive news of equivalent magnitude. This inherent instability is best captured by a Student's t-distribution with a statistically validated Degrees of Freedom of 8.18, confirming the high probability of extreme, high-impact events.

The econometric modeling of the logarithmic returns for this index reveals that its volatility dynamics are fundamentally different from the assumptions underpinning classical financial theory. The rigorous process, which culminated in the selection of the EGARCH model with a Student's t-Distribution, moves beyond simplistic Gaussian frameworks to define a risk profile that is three-dimensionally complex: it is highly persistent, markedly asymmetric, and characterized by excessive leptokurtosis.

The core conclusion rests on the estimated coefficients of the EGARCH variance equation. Firstly, the volatility persistence term (C(6)) is estimated at 0.9821, a value so close to unity that it signifies an almost integrated volatility process. This finding is perhaps the single most critical result, establishing that shocks to the market's risk level—whether initiated by domestic political events or global macroeconomic turmoil—do not decay rapidly. Instead, a period of heightened uncertainty tends to become a semi-permanent feature of the market landscape, requiring a shift in mindset from risk management to sustained risk containment. The mean-reverting properties of volatility are weak, meaning that expecting risk to simply fade away is an untenable strategy.

Secondly, the existence of a statistically significant leverage effect is confirmed by the positive asymmetry coefficient (C(5)) of 0.0802. This phenomenon, where the market penalizes bad news more harshly than it rewards good news, is not merely anecdotal; it is a mathematical property of the volatility process. The practical implication is profound: any defensive portfolio action taken must account for the fact that a market decline does not just increase risk, it increases the rate at which risk increases. This non-linear relationship dictates that hedging must be biased towards protecting against downside movements.

Finally, the statistical necessity of the Student's t-Distribution with a Degrees of Freedom parameter estimated at 8.18 constitutes a formal repudiation of the Normal distribution assumption. This low figure confirms that the financial returns possess exceptionally thick tails, translating to a much higher-than-theoretically-predicted frequency of extreme positive and negative returns. Any conventional risk metric, such as Value-at-Risk (VaR) calculated under a Gaussian assumption, would systematically and materially underestimate the true potential for large losses. The selected model, therefore, provides the statistically correct distribution required to accurately capture the probability of these high-impact tail events.

The successful removal of all remaining autocorrelation and ARCH effects in the final model validates its structure, ensuring that the parameters reliably reflect the market's true underlying volatility dynamics. Based on the quantitative findings, the immediate, actionable suggestions are the complete and mandatory overhaul of the standard risk measurement framework. All institutions relying on Value-at-Risk (VaR) or Conditional Value-at-Risk (CVaR) calculations derived from the Normal distribution must transition immediately to utilizing the Student's t-Distribution with the estimated Degrees of Freedom parameter. Continuing to use a Gaussian framework is mathematically indefensible and introduces unnecessary, systematic exposure to underestimation of market crashes. For instance, a one percent VaR calculated using the Normal assumption might only correspond to a two percent VaR in the reality of the fat-tailed Student’s t-Distribution, creating a dangerous false sense of security during tranquil periods. This transition is not optional; it is a statistical imperative for accurate risk assessment.

Given the confirmed and significant leverage effect (asymmetry), passive or neutral hedging strategies are inefficient. Portfolio managers should strategically overweight downside protection relative to upside exposure. Since a one percent negative return adds more to future volatility than a one percent positive return subtracts, the marginal value of protective instruments, such as long put options or short futures positions, is inherently higher. A tactical shift towards dynamically adjusting the portfolio's delta and gamma exposure, constantly biasing the hedge book toward the short side, will provide superior risk-adjusted returns during inevitable market corrections.

The high volatility persistence implies that volatility is not temporary. Therefore, the long-term capital asset pricing model (CAPM) beta, which assumes mean-reverting volatility, may be misleading. Investment committees should instead use the conditional beta derived from the GARCH model as an input for capital allocation decisions. When volatility is high, the conditional beta will be inflated, appropriately signaling a higher required rate of return for holding the asset. This approach ensures that capital is only allocated to the asset when the expected return truly compensates for the currently elevated and persistent risk level.

The primary technical recommendation is to address the remaining volatility persistence by moving beyond the standard EGARCH(1,1) model to a Fractionally Integrated GARCH (FIGARCH) or FIAPARCH models specification. The estimated C(6) coefficient of 0.9821 is exceptionally close to unity, which strongly suggests the volatility process might exhibit long memory. This means that current volatility levels could be influenced by shocks that occurred many periods in the distant past. Standard GARCH models cannot adequately distinguish between high short-term persistence and true long-term memory; implementing a fractional integration model would more accurately calibrate the rate of volatility decay. This is crucial for generating superior long-horizon forecasts necessary for calculating regulatory capital requirements or determining the true long-term cost of hedging. While the current EGARCH model accurately captures internal, or endogenous, market dynamics, the base level of variance (represented by the constant term, C(3)) remains unexplained. This base level could be made more predictive by linking it to relevant, observable macroeconomic variables. Variables such as the policy rate, global crude oil prices, or country-specific sovereign credit default swap (CDS) spreads could be introduced as exogenous drivers in the variance equation. This modification would transform the model from a purely statistical forecasting tool into an economically interpretable risk management instrument, providing leading indicators for changes in the market's fundamental risk environment. Finally, the third recommendation concerns the application of these highly significant estimated parameters to derivative pricing. The Black-Scholes model and its variations rely on the assumption of constant, log-normally distributed volatility, which this analysis has statistically rejected. The robust, highly significant parameters, specifically the leverage term C(5) and the high persistence C(6),are critical inputs for more advanced pricing methodologies, such as Monte Carlo simulations driven directly by the EGARCH process. Utilizing these parameters would allow for more accurate valuation of options and structured products, particularly those with long maturities or those sensitive to large, rapid volatility spikes. This rigorous approach would ensure the organization's derivative book is priced based not on convenient, outdated theory, but on the empirically proven realities of the market's asymmetric and persistent volatility behavior.

Authors' Contributions:

The authors contributed equally to this work.

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Appendix Table 5 GARCH decision Table

Models		GARCH	IGARCH	TARCH	EGARCH	PARCH	APARCH
Normal Distribution	*Akaike info criterion*	-5.842761	-5.81657	-5.85230	-5.86078	-5.85873	-5.84297
	Schwarz criterion	-5.833663	-5.811107	-5.84139	-5.84986	-5.84599	-5.83205
	Log Likelihood	9832.524	9786.463	9849.573	9863.83400	9861.38300	9833.873
	ARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	Autocorrelation	No	No	No	No	No	No
	ARCH LM-Test	No	No	No	No	No	No
	GARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	significant coefficient	Yes	Yes	Yes	Yes	Yes	Yes
Student's T	*Akaike info criterion*	-5.884583	-5.873405	-5.89513	-5.90141	-5.90013	-5.88497
	Schwarz criterion	-5.873666	-5.866127	-5.88240	-5.88867	-5.88557	-5.87223
	Log Likelihood	9903.869	9883.068	9922.61	9933.173	9932.012	9905.52100
	ARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	Autocorrelation	No	No	No	No	No	No
	ARCH LM-Test	No	No	No	No	No	No
	GARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	significant coefficient	Yes	Yes	Yes	Yes	Yes	Yes
Generalized Error	*Akaike info criterion*	-5.878402	-5.86478	-5.88682	-5.89336	-5.89180	-5.87857
	Schwarz criterion	-5.867485	-5.857504	-5.87408	-5.88062	-5.87724	-5.86584
	Log Likelihood	9893.473	9868.564	9908.632	9919.626	9917.999	9894.762
	ARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	Autocorrelation	No	No	No	No	No	No
	ARCH LM-Test	No	No	No	No	No	No
	GARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	significant coefficient	Yes	Yes	Yes	Yes	Yes	Yes
T-distribution (Parameter)	*Akaike info criterion*	-5.884018	-5.872566	-5.89461	-5.90130	-5.89990	-5.88438
	Schwarz criterion	-5.87492	-5.86711	-5.88369	-5.89038	-5.88716	-5.87346
	Log likelihood	9901.918	9880.656	9920.734	9931.983	9930.63	9903.52600
	ARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	Autocorrelation	No	No	No	No	No	No

	ARCH LM-Test	No	No	No	No	No	No
	GARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	significant coefficient	Yes	Yes	Yes	Yes	Yes	Yes
Generalised Error (Parameter)	***Akaike info criterion***	-5.877955	-5.863369	-5.88657	-5.89342	-5.89178	-5.87814
	Schwarz criterion	-5.868857	-5.85791	-5.87565	-5.88250	-5.87905	-5.86722
	Log Likelihood	9891.72	9865.186	9907.211	9918.734	9916.977	9893.025
	ARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	Autocorrelation	No	No	No	No	No	No
	ARCH LM-Test	No	No	No	No	No	No
	GARCH significant	Yes	Yes	Yes	Yes	Yes	Yes
	significant coefficient	Yes	Yes	Yes	Yes	Yes	Yes

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