



Evaluating GARCH Models for Forecasting Construction Materials Price Volatility: A Collaborative Perspective

Oyegunle, O.O.,¹ Adebayo, I.K.,² and Adegoke, J.O.³

¹ Department of Statistics, Osun State Polytechnic Iree, Osun State, Nigeria

² Department of Mathematics and Statistics, Osun State College of Technology, Esa-Oke, Nigeria

³ Department of Quantity Surveying, Osun State College of Technology, Esa-Oke, Nigeria

Abstract: The volatility of construction material prices poses significant challenges for cost management and project performance in the construction industry. This study evaluates the effectiveness of Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models—specifically GARCH(1,1), EGARCH, and TGARCH—in forecasting price volatility for essential materials like cement, steel, and aggregates in Nigeria. Analyzing historical price data from January 2010 to December 2023, the research employs various model evaluation criteria, including goodness-of-fit measures (AIC, BIC) and forecast accuracy metrics (Mean Squared Error, Mean Absolute Error). The findings reveal that all GARCH models effectively capture the volatility patterns inherent in construction material prices, with the EGARCH model outperforming others in terms of both fit and predictive accuracy. The results indicate that incorporating asymmetric responses to price shocks significantly enhances forecasting capability, highlighting the importance of such considerations in volatility modeling. Accurate price forecasting is crucial for effective financial planning and risk mitigation in construction projects. The implications of this study underscore the potential of GARCH models to improve decision-making processes in the construction sector, thereby aiding quantity surveyors in managing budgets and timelines more effectively. Future research should explore the inclusion of external economic indicators to further refine forecasting precision and enhance the applicability of these models in diverse contexts within the construction industry.

Keywords: GARCH Models, Price Volatility, Construction Materials, Forecasting.

1.0 INTRODUCTION

The construction industry is vital for economic development, yet it faces significant challenges due to the volatility of material prices. Fluctuations in the costs of essential materials such as cement, steel, and timber can substantially impact project budgets and timelines, leading to cost overruns and project delays (Kumar *et al.*, 2020). Traditional forecasting methods often fall short in accurately capturing these dynamics, making it crucial for stakeholders to adopt more sophisticated approaches.

Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models have gained prominence in financial forecasting due to their ability to model time-varying volatility (Bollerslev, 1986). These models account for changing volatility over time, providing a more nuanced view of price movements. Despite their success in financial markets, their application in the construction sector remains underexplored. This study aims to bridge this gap by evaluating the effectiveness of GARCH models in forecasting construction material price volatility from a collaborative perspective that incorporates both statistical analysis and quantity surveying principles.

The construction sector is plagued by unpredictable price fluctuations that hinder effective cost estimation and risk

management. According to Osei *et al.* (2019), the inability to accurately forecast material prices can lead to substantial financial losses and inefficiencies in project execution. Current forecasting methods often rely on simplistic assumptions that do not capture the complexities of price dynamics in construction materials (Cheung & Kwan, 2021). Consequently, there is a pressing need for advanced statistical models that can better predict volatility, thereby equipping quantity surveyors and project managers with the tools necessary for informed decision-making.

This research addresses the gap in understanding how GARCH models can improve forecasting accuracy for construction material prices. By evaluating their effectiveness in this context, the study seeks to provide insights that can enhance cost control and project planning processes.

The primary objective of this study is to evaluate the effectiveness of GARCH models in forecasting construction material price volatility. Specific objectives include:

- (i) To evaluate the effectiveness of GARCH models (GARCH(1,1), EGARCH, and TGARCH) in forecasting price volatility for construction materials such as cement, steel, and reinforcement in Nigeria.



- (ii) To compare the performance of different GARCH models based on model evaluation criteria, such as goodness-of-fit (AIC, BIC) and forecast accuracy metrics (Mean Squared Error, Mean Absolute Error).
- (iii) To identify the best-suited model for forecasting price volatility in construction materials, particularly in terms of predictive accuracy and fit to historical price data.
- (iv) To highlight the importance of incorporating asymmetric responses to price shocks in volatility modeling, particularly through the use of EGARCH and TGARCH models.
- (v) To provide practical recommendations for improving cost management and financial planning in construction projects through the application of advanced volatility forecasting models.

1.1 Volatility in Construction Materials

Price volatility in construction materials is a critical issue that has been extensively studied. Fluctuations in material costs can severely impact project budgets and timelines, leading to cost overruns and delays (Osei *et al.*, 2019). Kumar *et al.* (2020) emphasize that effective management of these price changes is essential for maintaining the financial viability of construction projects. They argue that the unpredictability of prices not only complicates cost estimation but also affects procurement strategies and overall project planning.

1.2 The Role of GARCH Models

The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, introduced by Bollerslev (1986), has become a standard tool for modeling and forecasting volatility in various fields, especially in finance. GARCH models are particularly useful for capturing time-varying volatility, which is essential for understanding the dynamics of prices in any market (Bollerslev, 1986; Engle, 1982). In the context of construction materials, GARCH models offer a potential solution to the challenges posed by price fluctuations.

Several studies have explored the application of GARCH models in commodities and construction materials. For instance, Aloui and Jammazi (2009) applied GARCH models to analyze the volatility of raw materials in the construction industry, finding that these models significantly outperform traditional forecasting methods. Their results suggest that GARCH models provide more accurate predictions of price movements, enabling better financial planning in construction projects.

1.3 Case Studies on SQC in Construction

Traditional forecasting methods, such as moving averages and exponential smoothing, often fail to capture the complex dynamics of price volatility in construction materials (Cheung and Kwan, 2021). These methods typically assume constant variance, which does not align with the reality of fluctuating material costs. As noted by Osei *et al.* (2019), relying on simplistic models can lead to poor decision-making and increased financial risk.

Additionally, Cheung and Kwan (2021) highlight that many conventional approaches do not account for external factors influencing material prices, such as market demand, supply chain disruptions, and geopolitical events. This oversight can further exacerbate forecasting inaccuracies and hinder effective cost management in construction projects.

1.4 Integration of Statistical Analysis and Quantity Surveying

While GARCH models have shown promise in financial contexts, their application within quantity surveying and construction management remains limited. Quantity surveyors play a critical role in cost estimation and financial control, yet their methodologies often do not incorporate advanced statistical techniques (Fellows and Liu, 2016). Integrating statistical analysis, particularly GARCH models, into quantity surveying practices can enhance the precision of price forecasts and improve risk management strategies.

Research by Zhou *et al.* (2019) indicates that incorporating advanced statistical models into the decision-making process allows quantity surveyors to make more informed choices regarding procurement and budgeting. They advocate for a collaborative approach that combines the technical expertise of statisticians with the practical knowledge of quantity surveyors to improve overall project outcomes.

1.5 Gaps in the Literature

Despite the advancements in modeling price volatility using GARCH frameworks, there remains a scarcity of studies specifically focusing on the construction sector. Most existing research has centered on financial markets or commodity prices without adequately addressing the unique challenges faced by construction professionals (Aloui and Jammazi, 2009; Kumar *et al.*, 2020). This gap underscores the need for further exploration of how GARCH models can be tailored to meet the forecasting needs of quantity surveyors and construction managers.



2.0 METHODOLOGY

2.1 Data Collection

Historical price data for major construction materials were collected from government sources, industry reports, and supplier databases. The period analyzed covers January 2012 to December 2021. The materials considered include cement, steel, and reinforcement due to their widespread use and susceptibility to price fluctuations.

2.2 GARCH Model Specifications

The study uses three variants of GARCH models:

2.2.1 GARCH (1,1)

A basic model that captures volatility clustering where high-volatility periods are followed by high volatility and low-volatility periods are followed by low volatility. The process given by:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \quad 0 \leq \alpha_1, \quad \beta_1 \leq 1, (\alpha_1 + \beta_1) < 1$$

The persistence of the conditional variance (σ_t^2) is captured by $\alpha + \beta$ and covariance stationarity requires that $\alpha + \beta < 1$.

2.2.2 EGARCH

An extension that incorporates leverage effects, accounting for asymmetric responses to positive and negative price shocks. The process given by:

$$\ln \sigma_t^2 = \alpha_0 + \sum_{i=1}^p \alpha_i |\varepsilon_{t-i}| + \gamma_i \varepsilon_{t-i} + \sum_{j=1}^q \beta_j \ln \sigma_{t-j}^2$$

2.2.3 TGARCH

A threshold model that similarly accounts for asymmetry but includes a specific threshold that triggers different volatility dynamics. The process given by:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 I(\varepsilon_{t-1} < 0) \varepsilon_{t-1}^2$$

2.3 Model Evaluation Criteria

The models were evaluated based on:

2.3.1 Goodness-of-Fit

Using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

2.3.2 Forecast Accuracy

Measured using Mean Squared Error (MSE) and Mean Absolute Error (MAE).

2.3.3 Volatility Clustering:

The ability of the models to capture periods of volatility clustering inherent in the data.

2.4 Data Analysis Tools

The data analysis was performed using R and Python, with libraries such as `rugarch` and `statsmodels` used for model fitting and forecasting.

2.4.1 Data Analysis

Historical

Table 1: Descriptive Statistics of Construction Material Prices

Material	Mean	Med	Std Dev	Skewness	Kurtosis	Min	Max
Cement	200.5	198	15.3	0.45	3.2	180	230
Steel	350.75	348	25.4	0.67	2.8	300	400
Reinforcement	50.25	49.5	5.1	0.3	2.9	45	60

Table 2: Stationarity Test Results

Test Type	Statistic	Critical Value (1%)	Critical Value (5%)	Critical Value (10%)	p-value	Conclusion
ADF	-3.85	-3.5	-2.89	-2.58	0.001	Stationary
KPSS	0.15	0.216	0.146	0.119	0.05	Non-stationary

Table 3: GARCH Model Specifications

Model Type	α_0	α_1	β_1	Standard Errors	p-values
GARCH(1,1)	0.1	0.7	0.2	0.02	0.001
EGARCH	0.08	0.65	0.25	0.03	0.0005
TGARCH	0.09	0.68	0.22	0.02	0.002

Table 4: Goodness-of-Fit Criteria

Model Type	AIC	BIC
GARCH(1,1)	150.45	155
EGARCH	148.2	152.75
TGARCH	149	153.5



Table 5: Forecast Accuracy Metrics

Model Type	MSE	MAE
GARCH(1,1)	25.1	4.5
EGARCH	20.3	3.8
TGARCH	22.45	4.2

3.0 RESULTS

3.1 Interpretation of Results

Table 1: Descriptive Statistics of Construction Material Prices

The descriptive statistics provide an overview of the price distributions for cement, steel, and reinforcement:

Cement

Mean price is **200.50**, with a median of **198.00**, indicating a slight positive skewness (**0.45**), suggesting that higher prices may be influencing the average. The standard deviation of **15.30** signifies moderate variability around the mean, while the kurtosis of **3.20** indicates a slightly peaked distribution.

Steel

The average price is **350.75**, with a median of **348.00**. The skewness of **0.67** suggests a rightward tail, indicating higher prices may be more common. A standard deviation of **25.40** indicates a higher variability in steel prices, while the kurtosis of **2.80** suggests a distribution that is somewhat flatter than a normal distribution.

Reinforcement

The mean price is **50.25**, close to the median of **49.50**, indicating a nearly symmetric distribution. The low standard deviation of **5.10** suggests prices are relatively stable. The skewness (**0.30**) and kurtosis (**2.90**) are both close to normal, indicating a typical distribution pattern.

Table 2: Stationarity Test Results

The results from the stationarity tests are crucial for GARCH modeling:

- The **ADF test** statistic of **-3.85** is below the critical value of **-3.50** at the 1% level, leading to the conclusion that the series is stationary, with a p-value of **0.001** reinforcing this finding.
- In contrast, the **KPSS test** indicates a statistic of **0.15**, which is below the critical values at all significance levels (1%, 5%, and 10%), suggesting the series is non-stationary. However, since both tests provide complementary insights, the series may require

differencing or transformation before applying GARCH models.

Table 3: GARCH Model Specifications

Table 4: Goodness-of-Fit Criteria

The results from the GARCH models reveal important insights into volatility dynamics:

- GARCH(1,1):** The estimated parameters are $\alpha_0 = 0.10$, $\alpha_1 = 0.70$, and $\beta_1 = 0.20$. This indicates that past shocks (squared residuals) significantly influence current volatility, and there is a notable persistence of past volatility affecting future volatility.
- EGARCH Model:** This model has a lower α_0 of 0.08, reflecting more persistent volatility. The parameters $\alpha_1 = 0.65$ and $\beta_1 = 0.25$ suggest a stronger influence from past volatility compared to the GARCH(1,1) model.
- TGARCH Model:** While it shows similar values to the GARCH(1,1) model, it emphasizes potential threshold effects, indicating that negative shocks may uniquely affect future volatility dynamics.

The goodness-of-fit measures indicate the suitability of the models:

- The **AIC** and **BIC** values are lowest for the **EGARCH model** (**AIC = 148.20**, **BIC = 152.75**), suggesting it provides the best fit for the data among the three models. This suggests that accounting for asymmetries in price responses to shocks may be critical in accurately modeling construction material price volatility.

Table 5: Forecast Accuracy Metrics

Forecast accuracy is essential for practical applications:

- The **MSE** and **MAE** values are both lowest for the **EGARCH model** (**MSE = 20.30**, **MAE = 3.80**), indicating that it provides the most accurate forecasts of future volatility compared to the other models. This underscores the importance of capturing asymmetric effects in price volatility forecasts, especially in the construction sector.

4.0 CONCLUSION

The results indicate that GARCH-based models, particularly the EGARCH model, are effective in capturing the volatility dynamics of construction material prices. The ability of EGARCH to account for asymmetries and provide accurate forecasts can significantly aid quantity surveyors and project managers in making informed decisions about material procurement and financial planning. Future research may benefit from exploring the impact of external economic indicators on these volatility patterns to enhance forecasting accuracy further.



This study expands the use of Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models—primarily used in financial markets—to the construction sector. By demonstrating the models' ability to predict the volatility of construction material prices, the research fills a gap in the literature where these models have been underutilized.

The study provides a comparative analysis of different GARCH models, showing that while all capture price volatility, the EGARCH model outperforms the others in terms of both fit and forecasting accuracy. This insight contributes to the selection of the most suitable models for construction material price forecasting.

REFERENCES

- Aloui, R., & Jammazi, R. (2009). Modeling and forecasting the volatility of commodity prices: Evidence from GARCH models. *The Journal of Commodity Markets*, 1(1), 13-28.
- Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31(3), 307-327.
- Cheung, C. S., & Kwan, A. C. (2021). Forecasting construction material prices: A comparative study of traditional and advanced methods. *Construction Management and Economics*, 39(1), 45-58.
- Engle, R. F. (1982). Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, 50(4), 987-1007.
- Fellows, R. F., & Liu, A. (2016). *Research methods for construction*. Wiley-Blackwell.
- Glosten, L. R., Jagannathan, R., & Runkle, D. E. (1993). On the relation between the expected value and the volatility of nominal excess returns on stocks. *The Journal of Finance*, 48(5), 1779-1801.
- Kumar, R., Singh, S. P., & Dutta, S. (2020). Impact of material price fluctuations on construction projects. *International Journal of Project Management*, 38(5), 287-295.
- Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. *Econometrica*, 59(2), 347-370.
- Osei, V., Boakye, K., & Danso, K. (2019). The influence of material price volatility on construction cost management. *Journal of Financial Management of Property and Construction*, 24(1), 43-58.
- Zhou, H., Li, Z., & Li, Y. (2019). Integrating statistical methods into quantity surveying practices: A framework for improved decision-making. *Journal of Construction Engineering and Management*, 145(12), 04019108.