



## Modeling the Gross Returns of the Big Four Banks' Stocks in Indonesia Using a Generalized Linear Model (GLM) with the AIC, BIC, and Deviance Approaches

Wahyu Dwi Lesmono<sup>1\*</sup>, Ayu Nor Aisah<sup>2</sup>

<sup>1-2</sup> Institut Teknologi Kalimantan, Indonesia

email: [wahyu.lesmono@lecturer.itk.ac.id](mailto:wahyu.lesmono@lecturer.itk.ac.id)<sup>1</sup>

### Article Info :

Received:  
12-05-2026  
Revised:  
19-05-2026  
Accepted:  
23-05-2026

### Abstract

*This study examines the macrofinancial sensitivities and returns dynamics of the four systemically important banks in Indonesia using a Generalized Linear Model framework optimized via operational parameter criteria. Utilizing daily returns data, the empirical framework evaluates the transmission channels of domestic equity index movements, foreign exchange fluctuations, and central bank monetary policies while explicitly addressing non-Gaussian error distributions. The statistical estimations demonstrate that domestic capital market performance acts as the definitive anchor for banking stock returns, although public and private banking instruments exhibit divergent elasticity profiles reflecting distinct institutional mandates and funding structures. Furthermore, residual diagnostics reveal a complete rejection of error normality across all asset vectors, confirming that traditional linear estimation models produce inefficient standard errors under conditions of extreme market volatility. By accommodating alternative exponential distribution profiles and flexible non-linear link functions, the generalized framework minimizes unexplained variance and yields highly consistent parameter metrics. These findings underscore the critical utility of non-linear structural modeling in accurately identifying systematic risks, optimizing corporate banking portfolios, and strengthening macroprudential surveillance systems within emerging financial architectures.*

**Keywords :** Generalized Linear Model, Systemic Banking Assets, Macrofinancial Transmission, Non-Gaussian Distribution, Capital Market Volatility.



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## INTRODUCTION

The structural dynamics of contemporary global financial markets increasingly demand robust econometric methodologies to decipher the complex behavior of asset returns under volatile macroeconomic climates. Academic literature has long established that the econometrics of financial markets require sophisticated frameworks to analyze price behaviors and volatility transmission across borders (Campbell et al., 1997). This imperative becomes more pronounced as global evidence highlights the intricate linkages between financial deepening and sustainable economic development across emerging markets (Waheed et al.). Furthermore, the modern landscape of international capital allocation relies heavily on advanced rational frameworks for foreign direct investment decision making to navigate the intricacies of localized market fluctuations (Singh, 2024). Within this global paradigm, banking sectors in developing economies serve as the primary conduits of systemic liquidity and macroeconomic resilience, making their market performance a critical subject of continuous academic inquiry.

In exploring these financial dynamics, prior researchers have actively investigated the predictive behavior and structural integrity of banking systems across various emerging economies. Significant efforts have been dedicated to stock price modeling of Indonesian banks using diverse forecasting methodologies to anticipate equity price trajectories under shifting market conditions (Simarmata et al., 2025). Concurrently, international scholars have scrutinized the internal and external factors affecting financial statement fraud and reporting accuracy within dynamic banking environments to preserve institutional credibility (Tomak & Yilmaz, 2025). These collective investigations demonstrate a consensus regarding the high sensitivity of banking equities to systemic shifts, indicating that

institutional performance cannot be analyzed in isolation from broader market movements. However, these classical assessments often overlook the mathematical complexities underlying daily asset returns, thereby leaving a critical gap in the precise statistical characterization of market volatility.

A profound methodological limitation in the existing literature resides in the widespread reliance on standard linear frameworks that assume normal distributions, which consistently fail when applied to empirical financial data characterized by heavy tails and skewness. While recent scholarship has attempted to apply a generalized additive model to explain the relationships between total reserves and financial indicators, such approaches remain largely confined to national reserve metrics rather than individual equity return distributions (Salan et al., 2023). Similarly, modern methodological comparisons between linear and nonlinear modeling approaches to develop abundance indices have demonstrated that rigid linear assumptions severely compromise model validity when data limits or non normal parameters exist (Yuan et al., 2024). The persistent application of symmetric normal distributions to asymmetric gross returns generates skewed parameter estimations, which ultimately distorts the true risk profile of systemically important financial assets. This empirical inconsistency highlights a severe conceptual void regarding how non normal return characteristics should be mathematically integrated into asset valuation models.

The urgency of addressing this unanswered problem is both scientifically vital and practically imperative due to the unprecedented monetary policy shifts and macroeconomic adjustments observed in recent years. In the context of the Indonesian financial system, the Big Four banking institutions represent the overwhelming majority of market capitalization and dictate national economic stability. When domestic interest rates and exchange rates experience substantial fluctuations, the gross returns of these systemically important banks exhibit severe non linear responses that standard regression models completely miscalculate. Failure to accurately model these returns deprives policymakers of the capacity to monitor systemic risk transmission and prevents institutional investors from executing precise portfolio optimization strategies. Therefore, developing a flexible statistical framework that accommodates non normal data distribution is an immediate necessity to safeguard financial stability against unexpected market shocks.

To resolve these critical theoretical and empirical gaps, this research establishes its unique position within the scientific landscape by introducing a comprehensive generalized linear model framework specifically tailored for the Indonesian banking sector. This study deviates from conventional rigid modeling by incorporating alternative probability distributions from the exponential family to capture the exact asymmetric structures of daily gross stock returns. The framework explicitly incorporates the Indonesia Composite Index, the USD IDR exchange rate, and the Bank Indonesia benchmark interest rate as principal explanatory variables. By deploying the Akaike information criterion, the Bayesian information criterion, and the deviance approaches, this research provides a rigorous statistical comparative mechanism to determine the optimal mathematical fit for each banking asset. This distinct positioning allows the study to bridge the gap between abstract econometric theory and empirical financial market realities within an emerging economy.

The primary objective of this investigation is to model the daily gross returns of the Big Four banking stocks in Indonesia and to identify the most accurate probability distribution for each individual issuer. Methodologically, this study contributes a novel comparative paradigm by demonstrating how different banking equities within the same market tier require distinct statistical distributions to yield unbiased estimations. Theoretically, the findings enrich the literature on financial econometrics by validating the superiority of generalized linear models over classical linear structures when analyzing highly sensitive emerging market assets. By providing an empirically verified modeling structure, this research delivers an advanced toolkit for risk managers, central bank regulators, and global investors to execute more precise asset evaluations and policy assessments.

## **RESEARCH METHODS**

This empirical study employs a quantitative descriptive analytical research design to examine the determinants of stock market returns within the framework of modern financial economics. The population comprises all systemically important commercial banking institutions listed on the Indonesia Stock Exchange, from which a purposive sample is drawn consisting of the Big Four banks, namely Bank Central Asia (BBCA), Bank Rakyat Indonesia (BBRI), Bank Mandiri (BMRI), and Bank Negara Indonesia (BBNI). Secondary daily time series data covering the period from January 1, 2023, to April

30, 2025, are obtained from public financial databases, including Yahoo Finance and Statistics Indonesia. The operationalization of variables designates the daily gross return of each banking stock as the dependent variable, which reflects the fundamental asset price dynamics described in investment theory. The independent variables comprise three macroeconomic indicators hypothesized to drive equity returns: the daily gross return of the Composite Stock Price Index (IHSG) representing market sentiment, the daily USD/IDR exchange rate return capturing currency exposure, and the Bank Indonesia benchmark interest rate (BI Rate) representing monetary policy interventions.

The measurement technique operationalizes daily gross returns through the mathematical ratio of the closing price on the current trading day to the closing price on the preceding trading day. To ensure robustness, data preprocessing involves the imputation of missing values using the forward fill method and the exclusion of extreme outliers exceeding a specific threshold. The ekonometrik analysis utilizes the Generalized Linear Model (GLM) framework, which extends classical linear regression to accommodate the non normal distributional characteristics inherent in financial asset returns. Two distinct specifications are estimated: a Gaussian GLM utilizing an identity link function for additive effects, and a Gamma GLM utilizing a log link function for multiplicative effects. Model selection and optimization are conducted through the evaluation of the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), and model deviance metrics. Finally, pengujian asumsi and goodness of fit diagnostics are performed using the Shapiro Wilk test to evaluate residual distribution properties, alongside the calculation of Pseudo R Squared, Root Mean Squared Error (RMSE), and Mean Absolute Error (MAE) to validate predictive accuracy

## RESULTS AND DISCUSSION

### Empirical Profile of Financial Asset Metrics and Preliminary Associative Dynamics

The systematic evaluation of equity asset behavior requires a comprehensive initialization through descriptive statistical parameters to establish baseline distributional tendencies. Based on the observational data, the empirical results demonstrate that the central tendency metrics for all dependent and independent variables remain concentrated around the baseline value of 1.0000, which fundamentally indicates that the aggregate performance of the banking asset returns experienced localized stationarity without exhibiting permanent drift functions during the designated timeline. This structural property of the primary time series underscores the presence of short-term equilibrium conditions wherein the daily price operationalization alternates tightly around the historical mean parameter. Financial economic theory posits that asset returns in highly competitive markets gravitate toward zero net innovations over protracted intervals, a phenomenon closely linked to the efficient market hypothesis under rational expectations frameworks (Campbell et al., 1997). The uniform distribution of the median values at exactly 1.0000 across the banking group emphasizes a balanced temporal allocation of positive and negative trading day innovations, validating the statistical stability of the operationalized gross return metrics.

Beyond the metrics of central location, the secondary variation properties expose substantial disparities in individual asset risk profiles, separating the banking institutions into distinct tiers of volatility. The empirical distribution demonstrates that Bank Mandiri (BMRI) and Bank Rakyat Indonesia (BBRI) register the most pronounced dispersion metrics, with standard deviations quantified at 0.0195 and 0.0185 respectively, thereby reflecting a heightened sensitivity to daily market microstructures. Conversely, Bank Central Asia (BBCA) exhibits the most resilient operational profile among the systemically important entities, generating a standard deviation of 0.0143, which marks it as the anchor asset within the domestic financial ecosystem. This variation hierarchy suggests that capital structures heavily exposed to retail or corporate lending cycles experience wider fluctuations in investor valuation than diversified private banking entities under identical macroeconomic constraints (Gunawan & Soma, 2025). The structural dispersion documented within these banking returns serves as the primary empirical justification for migrating away from ordinary least squares configurations toward generalized estimating equations.

The boundaries of the empirical distributions are further illuminated by examining the minimum and maximum extremes, which capture the maximum potential drawdown and capital appreciation within the trading window. Bank Rakyat Indonesia (BBRI) records the most severe single-day contraction with a minimum gross return value of 0.8987, while simultaneously achieving the highest single-day expansion at 1.0922, illustrating an asymmetric distribution with extended tails. The

macroeconomic indicators, in contrast, display significantly narrower operational bands, where the standard deviations of the USD/IDR exchange rate and the Bank Indonesia benchmark interest rate remain strictly below the 0.0050 threshold. This compressed operational range in the policy variables implies that while the regulatory environment remained structurally controlled through deliberate monetary interventions, the equity market retained independent volatility vectors. Such distributional features necessitate the application of flexible link frameworks to model the conditional mean without introducing structural specification errors (Abubakar et al., 2025).

**Table 1. Descriptive Statistical Parameters for Daily Asset Returns**

Statistik	BBCA _Gros s	BBRI_G ross	BMRI_G ross	BBNI_G ross	IHSG_G ross	USDIDR_G ross	BIRate_G ross
<b>Count</b>	548	548	548	548	548	548	548
<b>Mean</b>	1.0002	1.0001	1.0005	1.0003	1.0000	1.0001	1.0000
<b>Std</b>	0.0143	0.0185	0.0195	0.0190	0.0094	0.0050	0.0040
<b>Min</b>	0.9147	0.8987	0.8980	0.9200	0.9209	0.9753	0.9583
<b>25%</b>	0.9918	0.9904	0.9901	0.9910	0.9953	0.9975	1.0000
<b>50%</b>	1.0000	1.0000	1.0000	1.0000	1.0005	1.0002	1.0000
<b>75%</b>	1.0078	1.0094	1.0105	1.0095	1.0050	1.0029	1.0000
<b>Max</b>	1.0590	1.0922	1.0864	1.0897	1.0479	1.0157	1.0454

Source: Processed Primary Data from Research Findings, Lesmono & Aisah (2026)

To transition from univariate descriptive characteristics to multivariate linkages, the preliminary associative dynamics must be analyzed via a standard linear correlation matrix. The diagnostic output reveals that all four systemically important banking stocks possess a robust, positive co-movement pattern with the Composite Stock Price Index (IHSG), generating correlation coefficients that range from 0.50 to 0.69. This empirical reality corroborates the theoretical premise that large-cap financial institutions function as the primary drivers of broad market sentiment, making their returns inextricably bound to the market portfolio. Within this associative framework, BBCA exhibits the most distinctive profile, generating the lowest correlation coefficient with the aggregate index at 0.62, while the other three banking institutions maintain tightly coupled coefficients exceeding 0.61. Investment portfolio theory suggests that assets displaying lower systemic correlations offer superior diversification benefits, an attribute that explains the historical premium investors allocate to BBCA shares (Jogiyanto, 2017).

The empirical relationships between the endogenous banking returns and the exogenous macroeconomic risk vectors reveal predominantly negative directional movements across the trading horizon. Currency exposure, operationalized via the USD/IDR exchange rate return, correlates negatively with all equity assets, impacting the broad market index most severely with a coefficient of -0.16, while affecting BMRI least at -0.05. The negative alignment between exchange rate depreciation and domestic stock returns reflects the classic portfolio balance model, which dictates that capital outflows triggered by currency instability depress domestic asset valuations (Samsul, 2015). Concurrently, the monetary policy vector, captured by the BI Rate returns, yields weak negative correlations with the banking group, with the notable exception of BBRI, which exhibits a higher sensitivity coefficient of -0.15. This specific vulnerability underscores the institutional dependence of micro-finance portfolios on interest rate margins, which contract rapidly during aggressive monetary tightening cycles.

The institutional variations identified through these preliminary associations suggest that the transmission mechanism of macroeconomic risk is not uniform across the domestic banking landscape. The correlation between the USD/IDR exchange rate and the BI Rate is computed at -0.01, which establishes that these two policy variables operated as orthogonal risk factors over the specified observation window. This statistical independence is highly advantageous for multivariate modeling because it mitigates the threat of severe multicollinearity, allowing the generalized linear frameworks to isolate individual elasticities cleanly (Myers et al., 2010). The weak linear ties exhibited by the interest rate variable suggest that traditional linear estimators might fail to capture the underlying transmission channels, thereby demanding non-linear alternative link formulations. The presence of

non-zero correlations across the asset group reinforces the imperative to control for broad market innovations when isolating macro-financial sensitivities.

The spatial arrangement of the first quartile boundaries across all four banking entities exhibits an exceptionally homogeneous pattern, stabilizing firmly between 0.9901 and 0.9918. This structural convergence implies that under adverse market conditions, the baseline downside risk is relatively uniform across the tier-one banking sector, regardless of independent corporate governance structures. Such uniform down-market behavior supports the systemic risk paradigm in financial economics, which states that during market corrections, asset class linkages converge toward unity (Santoso et al., 2023). The divergence in the third quartile metrics, where BBKA stabilizes at 1.0078 and BMRI reaches 1.0105, indicates that the upward return elasticity during positive market regimes is skewed toward the more volatile state-owned entities. This distributional asymmetry confirms that the underlying returns do not conform to the rigid assumptions of standard normal distribution properties.

The empirical verification of non-normal behavior is further substantiated by evaluating the absolute distance between the minimum observations and the respective first quartile values. For instance, the minimum gross return of BBRI drops to 0.8987, exposing an extreme negative deviation that sits far outside the standard interquartile range, validating the presence of fat-tailed distributions. In financial econometrics, these sudden, large-scale asset price adjustments are modeled as jump processes or heavy-tailed innovations that violate regular Gaussian constraints (Medyawati & Yunanto, 2023). Modeling such phenomena through restrictive ordinary least squares methodologies introduces severe heteroscedasticity, invalidating standard hypothesis testing procedures. By documenting these structural attributes, the necessity of utilizing exponential family specifications within a generalized linear framework is empirically established.

The synthesis of these descriptive and associative parameters provides a definitive foundation for the subsequent generalized linear model estimations. The strong positive dependence on the market index, coupled with the heterogeneous, non-linear pressures exerted by currency fluctuations and monetary policy shifts, highlights the complexity of domestic banking returns. The independent movement of the policy interest rate relative to currency movements ensures that both variables can be integrated into the regression matrix without destabilizing parameter efficiency (Zahro et al., 2018). The subsequent sections will formally evaluate how these isolated relationships behave when subjected to rigorous alternative link functions designed to optimize predictive power and minimize deviance parameters.

### **Probability Distribution Alignment and Link Function Specification**

Identification of the conditional probability distribution represents a fundamental prerequisite to mitigate specification bias within empirical financial econometrics. Based on the initial estimation of the intercept only model, the empirical evidence demonstrates that daily asset returns of the systemically important commercial banking institutions in Indonesia do not conform to a singular homogeneous distribution. The daily gross return series for Bank Central Asia (BBKA) and Bank Negara Indonesia (BBNI) exhibit a superior structural alignment when fitted using the Gamma probability distribution combined with a log link function. This distributional compatibility is mathematically validated by the minimization of the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), which penalize parameter overparameterization without compromising predictive exactness (Abubakar et al., 2025; Myers et al., 2010). The asymmetric tail behavior observed in Figure 2 and Figure 3 underscores why traditional Gaussian assumptions fail to capture the compound growth properties and positive skewness inherent in these specific high capitalization equities (Nelder & Wedderburn, 1972; Zahro et al., 2018).

Conversely, the interday gross return trajectories for Bank Rakyat Indonesia (BBRI) dan Bank Mandiri (BMRI) are more efficiently optimized through a Gaussian distribution utilizing an identity link function. This symmetric configuration implies that price innovations on banking stocks heavily tied to micro-financing and corporate credit portfolios respond linearly to market liquidity adjustments. Financial asset returns frequently deviate from standard normality due to structural volatility clustering and heavy tails, which introduces substantial inefficiency if modeled via classical ordinary least squares (Campbell et al., 1997; Rehman & Gul, 2025). The utilization of the Generalized Linear Model (GLM) framework effectively resolves this limitation by allowing the conditional mean to vary non-linearly with the predictors while preserving parameter efficiency (Karaye et al., 2024; Olatayo & Ekerikevwe,

2022). Consequently, the mapping of distinct probability distributions across the Big Four banks establishes a rigorous methodological foundation for subsequent macro-financial elasticity modeling.

**Table 2. Information Criteria Matrix for Intercept-Only Model and Probability Selection**

Asset Code	Selected Distribution	Link Function	AIC Metric	BIC Metric	Log-Deviance
BBCA	Gamma	Log	-3092.51	-3088.20	0.113162
BBRI	Gaussian	Identity	-2813.35	-2809.05	0.188415
BMRI	Gaussian	Identity	-2757.99	-2753.69	0.208443
BBNI	Gamma	Log	-2784.60	-2780.30	0.198503

Source: Primary Data Processed, Lesmono & Aisah (2026)

A deeper exploration of the information criteria matrix in Table 2 reveals a strict consistency in parameter penalties, where Bank Central Asia yields the absolute minimum metric values. This optimization demonstrates that introducing a multi-parameter Gamma specification successfully captures the empirical data variance without inducing overfitting or inflation of the log deviance metric (Alomair & Al Naim, 2025; Yuan et al., 2024). The empirical necessity of the log link function for Bank Central Asia and Bank Negara Indonesia stems from its capacity to transform additive linear predictors into a multiplicative framework, reflecting the compounding nature of compounding asset returns (Yuan et al., 2024; Zahro et al., 2018). This mathematical transformation helps isolate structural asset volatility from transient market noise, which is crucial when analyzing institutions with large foreign ownership concentrations (Nguyen et al., 2023).

Although Bank Negara Indonesia converges toward the same Gamma family as Bank Central Asia, it demonstrates a marginally higher log deviance, indicating greater dispersion within its residual structure. This variation in deviance magnitude among issuers sharing identical distributional profiles is highly influenced by differences in secondary market trading liquidity and institutional investor concentration (Nguyen et al., 2023). From a modern portfolio theory perspective, the positive skewness captured by the Gamma model reflects a risk premium demanded by market participants navigating macroeconomic uncertainty (Campbell et al., 1997; Jogiyanto, 2017). This structural divergence confirms that evaluating the goodness of fit of the baseline intercept only model remains a vital diagnostic anchor before evaluating predictive equations (Salan et al., 2023). By executing this rigorous distribution selection procedure, the validity of the subsequent hypothesis testing and elasticity analysis is safeguarded against classical specification errors.

The operationalization of these probabilistic models aligns directly with established capital asset pricing frameworks that examine how market wide shifts influence individual equity performance (Samsul, 2015; Santoso et al., 2023). The historical return distributions shown in the empirical histograms display significant fat tails, which validates the deployment of optimization algorithms tailored for exponential family models (Abubakar et al., 2025; Mansor et al., 2025). Furthermore, modeling financial performance through flexible distributions prevents the artificial deflation of standard errors, a common problem in empirical corporate finance research (Al-Qudah et al., 2023; Tomak & Yilmaz, 2025). It is also essential to recognize that bank stock stability is tied to broader macro-financial health and regional financial development, which influences capital flows (Jameaba, 2024; Waheed et al.). Understanding how individual banking instruments deviate from standard normal parameters allows risk managers to better evaluate downside vulnerabilities during periods of intense monetary contraction (Huq et al.; Oanh et al., 2023).

Furthermore, the application of machine learning and advanced regression techniques on the Indonesia Stock Exchange confirms that non-linear adjustments provide superior predictive accuracy over extended horizons (Ningsih et al., 2024; Simarmata et al., 2025). The asymmetric return profile identified in the Gamma distributed assets highlights why traditional linear forecasting tools often underestimate the probability of extreme positive market movements (Lina & Anatha, 2026; Ningsih et al., 2024). This analytical distinction becomes vital when evaluating commercial banks whose balance sheets are highly exposed to international commerce and external commodity price shocks (Amer et al., 2024; Singh, 2024). In developing economies, corporate governance quality and the strength of internal controls further interact with market forces to determine how quickly equity prices digest

macroeconomic shocks (Jizi & Thomas, 2026; Cm et al., 2023). Financial institutions that maintain high asset quality often display more predictable return distributions, lowering the overall deviance within empirical generalized linear specifications (Gangadharan & Murugesan, 2025; Jizi & Thomas, 2026). Consequently, confirming the statistical distribution of the dependent variables provides clarity regarding how macroeconomic policies transmit to the equity market (Gunawan & Soma, 2025; Medyawati & Yunanto, 2023).

**GLM Parameter Estimation, Macrofinancial Sensitivity, and Model Residual Diagnostics**

The empirical estimation of the Generalized Linear Model framework provides statistically robust evidence that domestic market performance serves as the definitive anchor for the daily returns of systemically important financial institutions in Indonesia. The mathematical derivation reveals that the composite index exert an omnipresent influence across all distinct link function specifications without exception (Campbell et al., 1997). This structural co-movement demonstrates that equity returns are heavily bound to baseline domestic market variance, reflecting high systematic risk exposure within the national financial architecture (Jogiyanto, 2017). The magnitude of this transmission indicates a highly integrated risk transmission channel where domestic capital allocation remains highly responsive to aggregate macroeconomic sentiments (Santoso et al., 2023).

To evaluate these macrofinancial transmissions alongside the mathematical validity of the structural equations, a unified performance matrix is compiled. Table 3 condenses the operational parameter estimates, descriptive significance test statistics, global fit criteria, and residual diagnostic parameters to allow direct cross-model inspection.

**Table 3. Comprehensive GLM Parameters, Comparative Goodness-of-Fit, and Residual Diagnostic Matrix**

Dependent Vector	Link Specification	Predictor Element	Coefficient	p-value	Pseudo R2	RMS E	Shapiro-Wilk (p)
<b>BBCA</b>	Gamma-Log	Intercept	-0.995	0.000*	0.466	0.011	0.980 (0.000*)
		IHSG_Gross	0.957	0.000*			
		USDIDR_Gross	0.076	0.435			
		BI_Rate_Gross	-0.038	0.752			
<b>BBRI</b>	Gaussian-Id	Intercept	0.231	0.259	0.596	0.014	0.989 (0.001*)
		IHSG_Gross	1.324	0.000*			
		USDIDR_Gross	-0.098	0.395			
		BI_Rate_Gross	-0.456	0.001*			
<b>BMRI</b>	Gaussian-Id	Intercept	-0.795	0.000*	0.607	0.014	0.995 (0.049*)
		IHSG_Gross	1.461	0.000*			
		USDIDR_Gross	0.238	0.049*			
		BI_Rate_Gross	0.097	0.514			
<b>BBNI</b>	Gamma-Log	Intercept	-0.962	0.000*	0.470	0.015	0.987 (0.000*)
		IHSG_Gross	1.244	0.000*			

USDIDR_Gross	-0.089	0.486
BI Rate Gross	-0.193	0.221

Note: \* denotes statistical significance at the alpha 5% level ( $p < 0.05$ ).

Source: Primary Data Processed, Lesmono & Aisah (2026)

The statistical parameters explicitly establish that state-owned banking instruments display aggressive cyclical patterns that amplify broader equity movements. This high-beta behavior indicates that large public-sector banks behave as highly pro-cyclical financial vehicles due to their expansive national developmental mandates (Samsul, 2015). Conversely, private financial instruments demonstrate clear defensive qualities under identical market conditions. This structural insulation originates from a highly diversified retail deposit base and stringent internal risk controls that mitigate sudden systemic shocks (Jizi & Thomas, 2026). The varying elasticities highlight how public and private capital pools diverge in absorbing market shocks within emerging equity landscapes (Simarmata et al., 2025).

The empirical results reveal that international currency exposures and national monetary policies propagate via highly localized transmission paths. Tightening monetary measures introduce a statistically valid contractionary force that is restricted to micro-oriented lending institutions. This sensitivity points to a rapid compression of net interest margins when macrofinancial funding conditions tighten unexpectedly (Gunawan & Soma, 2025). Such imbalances stem from the underlying mismatch between fixed-rate long-term small-scale credit portfolios and immediate floating-rate short-term funding pressures (Huq et al.). These dynamics illustrate how heterogeneous microstructures alter bank asset sensitivity to standard central bank policy shifts (Oanh et al., 2023).

Foreign exchange movements induce significant returns volatility exclusively within large trade-financing corporate bank institutions. This positive co-movement implies that currency shifts stimulate specific balance sheet configurations through active foreign currency corporate lending and international trade settlements (Medyawati & Yunanto, 2023). These entities utilize superior commercial market infrastructure to extract transactional revenue streams during times of heightened currency adjustment (Alomair & Al Naim, 2025). Corporate-focused banking institutions leverage localized asset structures to maintain operational resilience during periods of macroeconomic rebalancing (Gangadharan & Murugesan, 2025). The remaining banking assets demonstrate notable insulation against international currency shocks, suggesting effective macroprudential hedging mechanisms (Jameaba, 2024).

The comparative goodness-of-fit metrics indicate that the explanatory power of the model peaks within the pro-cyclical state-owned banking sector. The high pseudo-coefficients of determination reflect the structural alignment between macroeconomic indices and state-allocated credit institutions (Yuan et al., 2024). In terms of forecasting precision, the uniform reduction in predictive deviations demonstrates tight tracking across all designated model variants (Olatayo & Ekerikevwe, 2022). The small margins of error prove that the selected model specifications capture short-term financial asset trajectories with high precision (Ningsih et al., 2024). These results confirm that accommodating alternative data densities improves the overall calibration of empirical corporate asset models (Karaye et al., 2024).

The residual diagnostic evaluations reveal a complete statistical rejection of error term normality across all banking institutions. This systematic violation reflects persistent temporal anomalies, extreme price gaps, and structural fat-tails within high-frequency financial returns (Rehman & Gul, 2025). Traditional ordinary least squares procedures would yield inefficient standard errors and invalid inference structures under these conditions (Myers et al., 2010). However, the optimization of generalized structural links maintains estimator consistency without relying on traditional residual symmetry (Abubakar et al., 2025). This non-linear mapping capability enables non-Gaussian structures to capture asymmetric risk realities better than classical linear models (Nelder & Wedderburn, 1972).

The choice of exponential distribution parameters proves highly effective for modeling asymmetric financial returns. Relaxing the strict requirement for residual normality avoids artificial parameter inflation and preserves asymptotic properties under non-standard distributions (Zahro et al., 2018). This mathematical flexibility is essential for constructing corporate risk monitoring systems that operate in volatile emerging capital markets (Lina & Anatha, 2026). The structural stability of the

parameters confirms that generalized frameworks handle non-linear market shocks effectively (Salan et al., 2023). Financial assets characterized by heavy tails require specialized link architectures to produce unbiased sensitivity metrics for portfolio optimization (Singh et al., 2024).

The comparative diagnostics underscore the value of using flexible non-linear links when processing complex market returns data. The lower information criteria values recorded for specific non-Gaussian frameworks show that adding distribution parameters is statistically justified by the resulting reduction in unexplained variance (Yuan et al., 2024). Managing non-constant variance profiles ensures that error structures do not skew the derived macroeconomic coefficients (Tomak & Yılmaz, 2025). These modeling adjustments prevent misspecifications that often occur when applying linear regression to volatile asset markets (Amer et al., 2024). Consequently, these analytical findings demonstrate that non-linear optimization offers a reliable empirical method for evaluating banking assets in changing macrofinancial environments (Cm et al., 2023). The systematic validation of these statistical parameters reinforces the role of generalized linear modeling in supporting sustainable financial market development (Waheed et al.).

## CONCLUSION

The empirical findings confirm that the generalized linear model framework offers a superior mathematical architecture for evaluating the macrofinancial sensitivities of the four largest systemic banking assets in Indonesia. The structural estimation establishes that domestic aggregate market movements exert a uniform, dominant influence across both public and private financial instruments, whereas the transmission channels for international currency movements and central bank policy rates operate through highly localized, asset-specific configurations. State-owned banking instruments display pronounced pro-cyclical beta parameters that amplify wider capital market fluctuations, contrasting sharply with the defensive insulation observed in private banking assets due to their resilient retail deposit distributions and localized asset structures. Furthermore, the explicit rejection of error term normality across all models highlights the presence of persistent temporal anomalies and heavy-tailed distributions in high-frequency financial returns, a structural reality that invalidates traditional ordinary least squares procedures. By successfully relaxing strict residual symmetry and leveraging alternative non-linear links, the optimized framework captures asymmetric market shocks with exceptional precision, thereby providing an advanced, mathematically stable methodology for corporate risk monitoring and strategic asset allocation within volatile emerging capital markets.

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