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Long-Run Equilibrium and Shock Transmission among Indonesian Major State-Owned Banks: Evidence from VECM, Generalized Variance Decomposition, and Impulse Responses

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Abstract

This study investigates long-run equilibrium and shock transmission among Indonesian major state-owned banking equities, focusing on Bank Mandiri, Bank Negara Indonesia (BNI), and Bank Rakyat Indonesia (BRI). While existing research has examined government ownership, bank performance, lending behaviour, financial stability, and shock exposure, comparatively less attention has been given to the dynamic interdependence of state-owned banks through their equity-market valuations. Using 199 weekly stock-price observations from 25 September 2021 to 11 July 2025, this study examines whether the three banks share a common long-run equilibrium and how institution-specific shocks propagate across the system. The empirical strategy applies Augmented Dickey-Fuller, Phillips-Perron, and KPSS tests, followed by Johansen cointegration analysis, a Vector Error Correction Model (VECM), generalized forecast-error variance decomposition, and generalized impulse-response functions. The results show that the three stock-price series are non-stationary in levels but stationary after first differencing, supporting an I(1) specification. Johansen tests provide evidence of one long-run relationship, although the trace and maximum-eigenvalue statistics indicate different levels of strength, requiring cautious interpretation. The VECM reveals asymmetric equilibrium adjustment, with BNI displaying the clearest and statistically significant response to deviations from the long-run relationship. Generalized variance decomposition shows that forecast uncertainty is not purely institution-specific, as shocks originating in other state-owned banks explain meaningful proportions of future variation and their relative importance changes across horizons. BRI becomes increasingly influential in explaining longer-horizon variation in the system. Generalized impulse responses further confirm substantial cross-bank transmission, with shocks affecting all three equities before stabilising over time. Overall, the findings portray Indonesia's major state-owned banks as an interconnected but asymmetrically structured financial subsystem in which common long-run forces coexist with heterogeneous adjustment and horizon-dependent shock transmission.

Keywords

State-Owned Banks, VECM, Cointegration, Shock Transmission, Variance Decomposition

Introduction

State-owned banks occupy a distinctive position in financial systems because they combine the characteristics of commercial financial institutions with the institutional influence associated with government ownership. As publicly listed corporations, they are exposed to market discipline, investor expectations, changes in profitability, risk perceptions, and capital-market conditions. At the same time, their ownership structure may connect them more closely to public policy, national development objectives, government intervention, and broader macroeconomic priorities than privately controlled banks. This dual identity creates an important empirical question. When several state-owned banks operate under the same regulatory architecture, are exposed to common macroeconomic conditions, and share the state as a controlling shareholder, should their equity prices converge toward a common long-run equilibrium? Alternatively, can substantial institution-specific differences remain sufficiently strong for their stock-price dynamics to follow distinct trajectories even within the same state-owned banking segment?

The question is particularly relevant because common ownership does not necessarily imply economic homogeneity. The literature has documented substantial differences between state-owned and privately owned banks in terms of performance and institutional behaviour (Cornett et al., 2010). Government ownership may also generate specific consequences for minority shareholders because the objectives of a controlling public shareholder need not always coincide perfectly with those of private investors (Achsanta et al., 2022). More recent evidence further suggests that government ownership can affect the market's assessment of bank-stock risk, including expected downside and volatility risk (Srivastava et al., 2025). These findings suggest that ownership structure is economically consequential, but they also imply that state ownership should not be interpreted as sufficient evidence that individual banks will be valued identically by capital markets. Differences in business models, balance sheet composition, customer segmentation, loan portfolios, earnings structures, market liquidity, and investor expectations can preserve substantial heterogeneity even among institutions operating under the same ownership category.

This distinction becomes more important when attention shifts from individual bank characteristics toward the transmission of financial shocks. Banks are linked through common exposures to interest rates, macroeconomic activity, financial-market sentiment, liquidity conditions, regulatory decisions, and changes in investor risk appetite. A disturbance affecting one major bank may therefore carry information relevant to the valuation of other institutions. Evidence that state-owned banks can influence the transmission of international shocks reinforces the importance of analysing these institutions as interconnected rather than isolated entities (Borsuk et al., 2024). More broadly, systemic-risk research emphasises that the stability of the financial sector cannot be understood solely by assessing financial institutions independently, since vulnerabilities may propagate through interconnected components of the financial system (Arnold et al., 2012). In equity markets, similar interdependence may be reflected in the extent to which innovations in one bank contribute to the future price uncertainty or dynamic adjustment of other banking equities.

The presence of short-run co-movement, however, does not automatically establish a stable long-run relationship. Stock prices may react simultaneously to common macroeconomic news or market sentiment while continuing to follow different stochastic trends. Conversely, prices may diverge considerably over shorter intervals while still being constrained by an equilibrium mechanism that causes deviations to be corrected over time. This distinction between temporary interdependence and persistent equilibrium is fundamental to the analysis of financial integration. Earlier research applying cointegration to equity markets demonstrates that common stochastic trends can provide information about long-run market co-movement beyond what is revealed by contemporaneous correlation (Leachman et al., 1994). Evidence from Asian equity markets similarly shows that dynamic interdependence and transmission mechanisms can become especially important when financial systems are exposed to common disturbances (In et al., 2001). Recent research on emerging stock markets further indicates that market dynamics may be influenced by gradual structural shifts and common factors, underscoring the importance of treating equity relationships as dynamic rather than static phenomena (Nazlioglu et al., 2024).

The banking sector is particularly suitable for this type of analysis because equity prices provide forward-looking assessments of institutions whose financial activities are themselves highly interconnected with the wider economy. Episodes of financial contagion can affect bank equity markets as investors reassess common exposures and counterparty risks (Halstead et al., 2004). At the same time, the strength and direction of these relationships need not remain constant across forecast horizons. A bank may initially be dominated by its own innovations, while shocks originating elsewhere become increasingly important as information is absorbed through the financial system. Alternatively, an institution that responds strongly to short-run disturbances may subsequently play a limited role in the long-run equilibrium. Identifying these different mechanisms therefore requires an empirical design capable of distinguishing long-run equilibrium adjustment from the propagation of innovations over time.

Indonesia provides an especially relevant setting in which to examine these questions. Its banking system contains several large state-controlled institutions that simultaneously perform major commercial functions and trade publicly in the domestic capital market. Among them, PT Bank Mandiri (Persero) Tbk, PT Bank Negara Indonesia (Persero) Tbk (BNI), and PT Bank Rakyat Indonesia (Persero) Tbk (BRI) represent three of the country's most prominent listed state-owned banking institutions. Although they operate within the same national monetary, regulatory, and capital-market environment, they are not identical institutions. Their historical development, customer composition, lending orientation, funding structure, operational strategies, and market positioning differ. These differences provide a strong empirical reason not to assume that common state ownership automatically produces identical equity-price behaviour.

Existing research on Indonesia has predominantly examined the banking system from perspectives other than the long-run relationships among the stock prices of individual state-owned banks. For example, Zulverdi et al. (2007)investigate bank portfolio behaviour and monetary policy in Indonesia, highlighting the interaction between banking decisions and monetary-policy

transmission. Mara et al. (2021)examine the relationship between capital flows and banking credit, demonstrating the importance of external financial conditions for domestic banking activity. During the COVID-19 period, Naiborhu & Ulfa (2023) analyse the lending implications of a funding-for-lending policy for Indonesian banks, further illustrating how policy intervention can shape banking behaviour under exceptional economic conditions. At the capital-market level, Ivancio et al. (2024) apply multivariate forecasting techniques to Indonesian banking stocks. Taken together, this literature confirms that Indonesian banks are exposed to common macroeconomic, financial, and policy forces, but it leaves a separate question insufficiently addressed: whether the equity prices of Indonesia's major state-owned banks themselves are bound by a common long-run relationship and how shocks propagate among them over time.

Addressing this question has both financial market and banking system significance. If the stock prices of Bank Mandiri, BNI, and BRI share a cointegrating relationship, their individual prices may deviate temporarily but should remain constrained by a common long-run stochastic equilibrium. Such evidence would suggest that investors ultimately price the three institutions in a manner that reflects shared structural forces despite their institutional differences. The absence of such a relationship, by contrast, would indicate that the banks retain substantially independent long-run valuation paths. Yet long-run integration alone does not reveal which institution responds most strongly when equilibrium is disturbed. Nor does it explain how shocks originating in one bank affect the future uncertainty of the others. A more complete assessment therefore requires examining both the error-correction process and the propagation of innovations across different horizons.

This paper consequently investigates long-run equilibrium and shock transmission among Bank Mandiri, BNI, and BRI using weekly equity price observations from 25 September 2021 to 11 July 2025. The balanced dataset comprises 199 observations for each institution. Rather than comparing the standalone profitability or investment performance of the three banks, the analysis focuses explicitly on the relationships among their stock-price processes. The study asks three interconnected questions. First, do the equity prices of Bank Mandiri, BNI, and BRI share a stable long-run equilibrium relationship? Second, if such an equilibrium exists, how do the individual banks respond when the system departs from that equilibrium? Third, how are shocks originating in each bank transmitted across the remaining institutions, and does the relative importance of those shocks change from shorter to longer forecast horizons?

The empirical strategy follows a sequential time-series framework. The stock price series are expressed in logarithmic form and initially examined for their order of integration. Augmented Dickey–Fuller, Phillips–Perron, and KPSS procedures are employed as complementary tests because unit-root inference can be affected by lag specification, persistence, and the statistical characteristics of the underlying series. Research has demonstrated that the performance of the Augmented Dickey–Fuller procedure may be sensitive to both persistence and lag selection (Krämer, 1998; Weber, 2001), while alternative stationarity procedures can provide complementary evidence when conventional unit-root inference is uncertain (Elliott et al., 1996;

Sephton, 1995). Establishing that the three logged equity-price series are integrated of the same order provides the statistical foundation for investigating whether their non-stationary movements contain a stationary long-run combination.

The long-run relationship is subsequently assessed using the Johansen cointegration framework. Unlike a single-equation procedure, the Johansen approach treats the variables as components of a multivariate system and evaluates the number of independent cointegrating vectors jointly (Johansen, 1988; Juselius, 1990). Where a cointegrating relationship is supported, the analysis proceeds through a Vector Error Correction Model (VECM). The VECM is particularly appropriate because it simultaneously captures changes in equity prices over shorter horizons and the mechanism through which deviations from the long-run equilibrium are corrected. The error-correction coefficients are therefore economically important: they indicate whether each bank responds to disequilibrium and provide information about the relative contribution of individual institutions to restoring the common long-run relationship.

The VECM analysis is complemented by generalized forecast-error variance decomposition and generalized impulse-response functions. Variance decomposition quantifies how much of the forecast uncertainty associated with each bank is attributable to its own innovations and how much originates from shocks to the other banks. This allows interdependence to be assessed across multiple forecast horizons rather than inferred from individual regression coefficients alone. The broader usefulness of combining vector error correction with variance-decomposition analysis in identifying dynamic relationships has been demonstrated in multivariate financial applications (Masih et al., 2009). Generalized impulse responses provide a complementary perspective by tracing the direction, magnitude, and persistence of the effect generated by an innovation in one banking equity on the rest of the system. The use of generalized procedures is particularly relevant because it permits the dynamic effects of innovations to be examined without relying exclusively on an arbitrary ordering of the variables.

The preliminary empirical evidence reveals a more nuanced structure than either complete independence or uniform co-movement. Bank Mandiri, BNI, and BRI stock prices exhibit persistent non-stationary behaviour in logarithmic levels but become stationary following first differencing, indicating that the series are predominantly integrated of order one. The Johansen analysis provides evidence consistent with a common long-run relationship, although the statistical strength of the result differs between the trace and maximum-eigenvalue criteria. The trace statistic supports one cointegrating vector at the conventional significance level, whereas the maximum-eigenvalue statistic provides comparatively weaker evidence. The existence of long-run equilibrium is therefore interpreted cautiously rather than treated as mechanically unambiguous.

Within the resulting adjustment framework, the banks do not react uniformly to disequilibrium. BNI displays the clearest error-correcting behaviour, suggesting that its equity price responds comparatively strongly when the system moves away from the estimated long-run relationship. BRI also exhibits meaningful equilibrium adjustment, whereas Bank Mandiri shows a weaker

response. Such asymmetry is substantively important. Cointegration implies that the equities may share a long-run stochastic relationship, but it does not require every institution to perform the same adjustment role. Some institutions may respond to disequilibrium, while others may contribute more strongly to the formation of the common long-run price path. The results therefore point toward an interconnected system characterised by heterogeneous rather than homogeneous adjustment.

The generalized variance decomposition reinforces this interpretation. Forecast uncertainty in the three banking equities is not explained solely by their respective own shocks. Innovations originating elsewhere in the system account for economically meaningful shares of future variation, and the relative importance of these cross-bank contributions changes as the forecast horizon expands. This suggests that the structure of state-owned banking interdependence is horizon-dependent: the institution that appears most influential immediately following a shock need not remain the dominant source of variation over longer periods. The generalized impulse-response functions similarly show that institution-specific innovations generate responses elsewhere in the system before their effects gradually diminish and the system approaches a more stable longer-run configuration. Shock transmission is therefore meaningful but not permanently destabilising.

These findings provide three main contributions to the literature. First, the paper extends research on state ownership beyond conventional questions of efficiency, performance, governance, risk, and lending behaviour by examining whether common public ownership is reflected in the "dynamic relationships among the equity prices of individual state-owned banks". Existing evidence demonstrates that state ownership can influence bank performance (Cornett et al., 2010), minority-shareholder outcomes (Achsanta et al., 2022), market-based risk (Srivastava et al., 2025), and the transmission of international shocks (Borsuk et al., 2024). The present study complements these perspectives by examining long-run equilibrium and internal shock propagation among state-owned banking equities within a single national financial system.

Second, the study adds a capital-market dimension to the literature on Indonesian banking. Existing Indonesian research has investigated monetary policy transmission through bank portfolios (Zulverdi et al., 2007), the relationship be-tween international capital flows and domestic bank credit (Mara et al., 2021), policy-supported lending during crisis conditions (Naiborhu & Ulfa, 2023), and the forecasting of banking-sector stock prices (Ivancio et al., 2024). This paper instead places the relationship among state-owned bank equity prices at the centre of the analysis. By doing so, it provides evidence on whether investors treat the major state-controlled institutions as components of a common long-run valuation system and how information originating in one institution is transmitted to others.

Third, the paper integrates long-run equilibrium, adjustment behaviour, and shock propagation within a unified empirical framework. Cointegration alone establishes neither the direction of adjustment nor the relative importance of shocks. VECM coefficients alone likewise provide an incomplete picture of how disturbances evolve over multiple horizons. Combining Johansen

cointegration, VECM estimation, generalized variance decomposition, and generalized impulse responses therefore permits the internal architecture of the system to be examined more comprehensively. The analysis distinguishes between the existence of a common equilibrium, the institutions that respond to disequilibrium, and the banks whose innovations contribute to future uncertainty elsewhere in the system.

The findings have implications for both investors and policymakers. For investors, meaningful cross-bank shock transmission implies that diversification across several state-owned banking equities may provide less protection than would be expected if the institutions were priced independently. Nevertheless, asymmetric equilibrium adjustment and changing variance-decomposition shares also indicate that Bank Mandiri, BNI, and BRI should not be treated as perfect substitutes. For policymakers and regulators, the findings provide a market-based perspective on interconnectedness within an important segment of Indonesia's banking system. Identifying how rapidly disturbances dissipate, which institutions respond most strongly to disequilibrium, and how the sources of forecast uncertainty evolve over time may complement conventional assessments based on bank balance sheets and prudential indicators.

The broader implication is that common state ownership can coexist with heterogeneous market behaviour. Bank Mandiri, BNI, and BRI operate within the same national banking system and are exposed to many of the same macroeconomic, regulatory, and policy forces, but their equity prices need not respond to those forces in identical ways. The relevant empirical question is therefore not simply whether the banks are "connected", but how that connection operates across different dimensions of time. Long-run cointegration, equilibrium adjustment, forecast-error transmission, and impulse responses capture distinct aspects of that relationship. Taken together, they provide a richer representation of the dynamic structure of Indonesia's major state-owned banking equities.

The remainder of the paper is organised as follows. The next section reviews the literature on state ownership, banking-sector interconnectedness, financial market integration, and shock transmission, and develops the empirical positioning of the study. The methodology section then describes the dataset, variable transformations, unit-root tests, lag-selection procedure, Johansen cointegration framework, VECM specification, generalized forecast-error variance decomposition, generalized impulse-response analysis, and model diagnostics. The empirical results section presents the evidence on long-run equilibrium, adjustment dynamics, and shock transmission among Bank Mandiri, BNI, and BRI. The subsequent discussion relates the findings to the wider literature on state-owned banking and financial-market interdependence. The final section concludes by outlining the principal implications, limitations, and directions for future research.

Literature review

State Ownership, Banking Behaviour, and Equity-Market Heterogeneity

State ownership represents an important institutional characteristic of banking systems because government-controlled banks operate at the intersection of commercial objectives and public policy considerations. Unlike purely privately owned banks, state-owned institutions may simultaneously pursue profitability, financial intermediation, economic-development objectives, credit-policy priorities, and broader government mandates. This institutional configuration can influence the behaviour of banks and the way investors assess their financial prospects. Consequently, common state ownership may generate similarities among banks through shared exposure to government policy and national economic conditions, while differences in strategy, efficiency, risk, and balance-sheet composition can preserve considerable heterogeneity across individual institutions.

A substantial strand of banking literature has examined whether government ownership affects bank performance. Cornett et al. (2010) compare privately owned and state-owned banks internationally and establish state ownership as an important dimension in explaining differences in banking performance. Their work is particularly relevant because it cautions against assuming that ownership is simply a legal classification without economic consequences. The ownership structure of banks may influence incentives, resource allocation, managerial discipline, and responses to changes in the economic environment. Accordingly, equity investors may incorporate state ownership into their valuation processes while simultaneously differentiating among individual state-controlled institutions.

The implications of government ownership extend beyond operational performance. Achsanta et al. (2022) examine government ownership from the perspective of minority shareholders, highlighting the relevance of ownership structure for investors in publicly listed banks. This distinction is especially important for state-owned banking equities because the government may remain the controlling shareholder while a substantial proportion of shares is held and traded by private investors. Market prices must therefore reflect expectations concerning both commercial performance and the consequences of government control. The resulting valuation process may differ from that of either fully private banks or non-listed public institutions.

Market-based risk provides another dimension through which state ownership becomes relevant. Srivastava et al. (2025) investigate whether government ownership affects expected left-tail and volatility risk in bank stocks. The presence of such research indicates that ownership characteristics can be reflected directly in financial-market assessments of risk rather than being confined to accounting or balance-sheet outcomes. Investors may perceive government-controlled banks as benefiting from implicit support during periods of stress, while at the same time recognising that these institutions can be required to perform policy functions that do not necessarily maximise shareholder value. The resulting relationship between state ownership and equity valuation is therefore unlikely to be homogeneous across banks.

This literature provides an important foundation for the present study. Bank Mandiri, Bank Negara Indonesia (BNI), and Bank Rakyat Indonesia (BRI) all share the Indonesian government as a controlling shareholder, yet common ownership does not imply identical economic structures.

Each bank maintains its own lending portfolio, customer base, funding characteristics, operational strategy, risk profile, and market valuation. The relevant empirical issue is therefore whether common state ownership and exposure to the same national financial environment are sufficiently strong to produce a shared long-run equity price relationship, while allowing individual institutions to perform different adjustment roles within that relationship.

Long-Run Equilibrium and Financial-Market Integration

The distinction between short-run co-movement and long-run equilibrium is central to the analysis of financial-market integration. Correlation among equity prices can arise because different securities respond contemporaneously to the same information, yet high correlation does not necessarily imply that their price levels are linked by a stable equilibrium relationship. Similarly, temporary divergence among equity prices does not necessarily indicate permanent segmentation if a mechanism exists through which deviations are eventually corrected.

Cointegration provides a theoretical and empirical framework for evaluating such relationships among non-stationary financial variables. The foundational multivariate framework developed by Johansen (1988) permits the identification of stationary linear combinations among variables that are individually non-stationary. The maximum-likelihood extension associated with Juselius (1990) further provides a system-based approach through which long-run equilibrium relationships can be estimated and tested within a multivariate setting. When equity prices are individually integrated of order one but contain a stationary linear combination, their stochastic trends cannot drift independently without bound. They instead remain connected through a long-run equilibrium mechanism.

The relevance of this concept for equity markets is reflected in earlier empirical research. Leachman et al. (1994) apply the Engle–Granger approach to national equity-market co-movements, demonstrating how cointegration can be used to distinguish persistent relationships from temporary market co-movement. This distinction is particularly useful when analysing securities belonging to closely related institutions. If several bank equities share common macroeconomic exposure and similar ownership characteristics, cointegration would indicate that these common forces impose a long-run constraint on their relative valuations.

However, financial integration is not necessarily constant or complete. In et al. (2001) examine dynamic interdependence and volatility transmission among Asian stock markets during the Asian financial crisis, illustrating the importance of examining market relationships dynamically and particularly during episodes in which common shocks become more influential. More recent research by Nazlioglu et al. (2024) considers gradual shifts and common factors in emerging stock markets, reinforcing the idea that financial-market behaviour can evolve as underlying structural conditions change. These studies imply that integration should not be reduced to a static correlation coefficient; rather, it is a dynamic phenomenon involving common trends, adjustment mechanisms, and responses to shocks.

For banking equities, this perspective is particularly relevant because financial institutions respond simultaneously to monetary conditions, economic growth, credit-market developments, investor sentiment, regulatory changes, and sector-specific information. If the stock prices of Bank Mandiri, BNI, and BRI share a cointegrating relationship, deviations among them should contain information about subsequent adjustment. A Vector Error Correction Model therefore becomes useful not only because it preserves the long-run relationship but also because it identifies how individual banks contribute to the restoration of equilibrium.

The empirical application of VECM techniques has consequently developed beyond simple tests of whether cointegration exists. Masih et al. (2009), for example, combine vector error correction with variance-decomposition methods to examine causality and dynamic relationships among financial variables. This methodological combination is relevant to the present research because the existence of a long-run relationship alone does not identify the institution that adjusts most strongly to disequilibrium or the source from which shocks originate. Long-run equilibrium and dynamic transmission therefore represent related but conceptually distinct dimensions of financial interconnectedness

Shock Transmission, Interdependence, and Systemic Risk

The literature on financial interconnectedness further emphasises that shocks to one institution or market can propagate through other parts of the financial system. Such transmission may occur through direct financial exposures, common asset holdings, funding conditions, information spillovers, changes in investor sentiment, or revisions to expectations concerning the financial sector. Bank equities provide a particularly informative setting because market prices can respond rapidly to information concerning both individual institutions and systemic financial conditions.

Evidence of contagion in bank equity markets predates the more recent systemic-risk literature. Halstead et al. (2004) examine financial contagion involving municipal bond and bank equity markets following the Orange County bankruptcy, illustrating how disturbances originating in one part of the financial system may influence valuation elsewhere. The implication is that equity market responses cannot always be interpreted exclusively as firm specific phenomena. When investors perceive common exposures or financial connections, shocks to one institution can contain information regarding the expected performance or risk of others.

This perspective has subsequently developed into a broader systemic-risk literature. Arnold et al. (2012) connect systemic risk with financial stability and regulation, demonstrating the importance of analysing the financial system as an interconnected structure rather than merely as a collection of independent institutions. Similarly, Nucera et al. (2016) examine the information embedded in systemic-risk rankings, while Bostandzic & Weiß (2018) investigate why some banks contribute more strongly than others to global systemic risk. Such research highlights a fundamental point: financial interconnectedness is generally asymmetric. Banks need not contribute equally to system-wide vulnerability, nor must they react equally strongly when the system is disturbed.

Institutional characteristics and structural developments can further modify such interconnectedness. Weiß, Bostandzic, et al. (2014) examine systemic risk in relation to bank consolidation, whereas Weiß, Neumann, et al. (2014) investigate factors associated with systemic risk during international financial crises. Portfolio structures and financial network configurations also matter. Tasca et al. (2017) consider diversification and systemic risk within interbank networks, while Jin et al. (2024) analyse financial-risk contagion through a dynamic multilayer network linking banks and firms. Although these studies employ different methodological approaches, they share the proposition that the consequences of a shock depend not only on the institution in which it originates but also on the structure of relationships connecting that institution to the rest of the financial system.

This issue becomes particularly relevant to state-owned banking. Borsuk et al. (2024) directly examine state-owned banks and international shock transmission, placing public ownership within the literature on financial propagation mechanisms. Their contribution establishes an especially close conceptual connection with the present study. If state-owned banks perform a distinctive role in transmitting shocks internationally, an important related question is whether shocks are also transmitted among individual state-owned banking equities operating within the same domestic market. In the Indonesian case, common state ownership, exposure to national economic policies, and overlapping investor expectations may create channels through which innovations affecting one state-owned bank influence the valuations of others.

The implications of shock transmission cannot be evaluated solely through contemporaneous responses. Some disturbances may be strong initially but dissipate rapidly, whereas others may become more important as the forecast horizon increases. Impulse-response functions are therefore valuable because they trace the temporal path of the system following an innovation. Forecast-error variance decomposition provides complementary information by quantifying the proportion of future uncertainty attributable to shocks originating in different variables. When used together with a VECM, these tools permit a distinction between three related phenomena: the existence of a common long-run equilibrium, the speed at which individual institutions respond to disequilibrium, and the relative importance of shocks originating from each institution.

The Indonesian Banking and Institutional Context

Indonesia provides an important setting for investigating these relationships because banking institutions remain closely connected to macroeconomic policy, credit formation, and economic development. Previous studies demonstrate that Indonesian banking behaviour cannot be separated from wider monetary and financial conditions. Zulverdi et al. (2007), for example, examine bank portfolio behaviour in relation to monetary policy in Indonesia, placing banks directly within the monetary-policy transmission process. Their approach underscores the importance of understanding how financial institutions respond to changes originating outside the individual bank.

International financial conditions constitute another important source of exposure. Mara et al., (2021) examine capital flows and banking credit in Indonesia, illustrating the connection between external financial developments and domestic banking activity. Such relationships are relevant for equity market analysis because changes in international capital conditions may simultaneously alter funding expectations, credit conditions, investor sentiment, and bank valuations. Common exposure to these forces can strengthen co-movement among bank equities even when differences in bank-specific characteristics remain substantial. The COVID-19 period further demonstrates the importance of policy intervention in shaping Indonesian banking behaviour. Naiborhu & Ulfa (2023) analyse the lending implications of a funding-for-lending policy during the pandemic, illustrating the capacity of policy measures to influence banking activity during periods of exceptional economic stress. Because the sample employed in the present study begins in September 2021, its early observations are situated within the transition from pandemic-related disruption toward economic normalisation. The period therefore captures an environment in which banks were simultaneously adjusting to changing economic conditions, policy normalisation, and shifts in financial market expectations.

Other studies approach Indonesian financial development from different institutional perspectives. Soedarmono et al. (2017) examine the non-linear relationship between financial development and economic growth in Indonesia, while Sukmana et al. (2020) analyse the financial performance of Indonesian rural banks. Collectively, this literature reinforces the heterogeneous character of Indonesia's banking system: banks differ in institutional form, economic function, scale, and operational performance even though they operate within the same national financial architecture.

At the equity-market level, Ivancio et al. (2024) employ multivariate forecasting techniques for the Indonesian banking stock market. This work is particularly relevant because it recognises that banking equities contain interdependent information that may be exploited through a multivariate framework. Nevertheless, forecasting accuracy and long-run equilibrium address different research questions. A model may successfully use information from several stocks for prediction without establishing whether those equity prices share a common stochastic trend, how deviations from that trend are corrected, or how the relative contribution of shocks changes across forecast horizons. The present study therefore complements forecasting-oriented research by focusing explicitly on equilibrium and transmission mechanisms.

The Indonesian financial system is also shaped by a wider institutional and regulatory architecture. In a different but related domain, Bin-Armia et al. (2024) examine the implementation of Shariah economic principles in Indonesia and highlight tensions that can emerge between formal economic arrangements and their underlying institutional or normative foundations. More recently, Bin-Armia (2026) applies institutional theory to the development of Indonesia's QRIS regulatory environment. Although these studies examine different segments of the Indonesian financial system, they reinforce the broader point that financial behaviour in Indonesia is embedded within institutional, regulatory, and policy structures rather than being determined solely by market forces.

This institutional perspective is relevant to state-owned banks because government ownership itself constitutes a structural feature capable of shaping both bank behaviour and investor expectations.

For Bank Mandiri, BNI, and BRI, the national institutional environment is therefore simultaneously a source of commonality and differentiation. All three institutions operate under Indonesian banking and capital-market regulation and are exposed to many of the same macroeconomic and public-policy developments. Yet they retain distinct commercial strategies and market positions. Whether common institutional exposure dominates these differences in the long run is ultimately an empirical question, as is the extent to which innovations in one bank are transmitted to the others.

Research Gap and Empirical Expectations

The literature reviewed above reveals three relatively well-developed but only partially connected research streams. The first examines the consequences of state ownership for bank performance, governance, shareholder interests, and market risk (Achsanta et al., 2022; Cornett et al., 2010; Srivastava et al., 2025). The second considers financial integration, cointegration, dynamic interdependence, and the transmission of shocks across markets (In et al., 2001; Leachman et al., 1994; Nazlioglu et al., 2024). The third examines systemic risk and the mechanisms through which disturbances propagate across banks and financial networks (Arnold et al., 2012; Borsuk et al., 2024; Bostandzic & Weiß, 2018; Nucera et al., 2016). Indonesian banking studies, meanwhile, have concentrated largely on monetary-policy transmission, credit formation, institutional performance, crisis-period lending, and forecasting (Ivancio et al., 2024; Mara et al., 2021; Naiborhu & Ulfa, 2023; Zulverdi et al., 2007).

What remains comparatively underdeveloped is the intersection of these literatures: whether the equity prices of major state-owned banks within a single emerging economy share a common long-run equilibrium and how shocks are transmitted among those institutions once that equilibrium relationship is explicitly considered. This distinction is important because state ownership alone does not determine the direction of equity-price adjustment. Two institutions can share the same controlling shareholder yet respond differently to common information. Similarly, cointegration does not imply that shocks are distributed symmetrically across the system. One bank may react strongly to disequilibrium while another behaves as a relatively persistent source of price information.

The present study addresses this gap by treating Bank Mandiri, BNI, and BRI as a three-bank dynamic system rather than as isolated securities. Its analytical framework separates long-run equilibrium from short-run adjustment and subsequently examines the transmission and persistence of shocks through generalized variance decomposition and impulse-response analysis. This approach permits the study to move from the question of whether the banks are connected to the more informative questions of how, through which institution, and over what horizon that connection operates.

Based on the literature, four empirical expectations guide the analysis. First, the common ownership structure and shared macro-financial environment of the three banks provide a basis for expecting a persistent equilibrium relationship among their equity prices:

$$\mathrm{H1} = \textit{The equity prices of Mandiri, BNI, and BRI share a long} - \textit{run cointegrating relationship} \quad (1)$$

Second, the literature on heterogeneous bank behaviour and systemic-risk contribution suggests that adjustment to the long-run equilibrium should not be assumed to occur uniformly across institutions:

$$\mathrm{H2} = \textit{The speed and significance of equilibrium adjustment differ across the three banks} \quad (2)$$

Third, evidence on contagion, financial interdependence, and state-owned-bank shock transmission suggests that innovations originating in one bank should explain part of the future uncertainty of the others:

$$\mathrm{H3} = \textit{Institution} - \textit{specific shocks are transmitted across the banking equity system} \quad (3)$$

Finally, because financial transmission evolves dynamically, the relative im-portance of individual banks is expected to change across forecast horizons rather than remain constant:

$$\mathrm{H4} = \textit{The magnitude and direction of cross} - \textit{bank shock transmission vary across horizons} \quad (4)$$

Together, these expectations connect the state-ownership literature with the empirical literature on cointegration and dynamic financial interdependence. The resulting framework does not presume that one institution must permanently lead the system. Instead, it allows long-run adjustment and short-run shock transmission to reveal potentially different roles for Bank Mandiri, BNI, and BRI. This distinction provides the conceptual foundation for the VECM, generalized variance-decomposition, and impulse-response analyses developed in the following section.

Methods

Research Design

This study employs a quantitative multivariate time-series design to examine long-run equilibrium and shock transmission among Indonesia's major publicly listed state-owned banks. The empirical framework distinguishes between two related dimensions of financial interconnectedness. The first is long-run equilibrium, which considers whether the equity prices of the selected banks are tied together by a common stochastic relationship. The second is dynamic shock transmission, which examines how innovations originating in one banking equity influence the remaining institutions over subsequent periods.

The analysis is conducted sequentially. First, the time-series properties of the individual stock-price series are evaluated through descriptive analysis and stationarity tests. Second, an appropriate lag structure is identified for the multivariate system. Third, the Johansen procedure is applied to determine whether a cointegrating relationship exists among the three equity-price series. Where

cointegration is supported, a Vector Error Correction Model (VECM) is used to distinguish short-run price changes from adjustment toward the long-run equilibrium. Finally, generalized forecast-error variance decomposition and generalized impulse-response functions are employed to examine the magnitude, direction, and persistence of cross-bank shock transmission.

This sequence allows the study to move beyond simple correlation among banking equities. Two stocks may respond to similar information in the short run without sharing a persistent equilibrium path. Conversely, temporary divergence may occur even when their long-run trajectories remain connected. The use of a VECM therefore provides an appropriate framework when the variables are individually non-stationary but jointly cointegrated (Johansen, 1988).

Data and Sample

The study uses weekly equity-price observations for three major publicly listed Indonesian state-owned banks: PT Bank Mandiri (Persero) Tbk, PT Bank Negara Indonesia (Persero) Tbk, and PT Bank Rakyat Indonesia (Persero) Tbk. The stock-price data were collected from the Refinitiv LSEG database and subsequently organised into a balanced weekly time series dataset.

The sample covers the period from 25 September 2021 to 11 July 2025 and contains 199 observations for each bank. The use of weekly observations provides a balance between capturing market-price adjustments and reducing some of the high-frequency noise associated with daily equity data. The period also provides a common observation window for all three institutions.

The variables used in the analysis are summarised in Table 1.

Code	Institution	Ticker	Series
BM	Bank Mandiri	BMRI.JK	Weekly stock price
BN	Bank Negara Indonesia (BNI)	BBNI.JK	Weekly stock price
BR	Bank Rakyat Indonesia (BRI)	BBRI.JK	Weekly stock price

Table 1. Variables and Sample Composition

The analysis uses the natural logarithm of each stock-price series. Accordingly,

$$LBM_t = \ln(BM_t), \quad LBN_t = \ln(BN_t), \quad LBR_t = \ln(BR_t), \quad (5)$$

where BMt, BNt, and BRt denote the observed weekly equity prices of Bank Mandiri, BNI, and BRI, respectively. Logarithmic transformation reduces differences in scale across the three securities and allows changes in the transformed series to be interpreted approximately as proportional price changes.

Stationarity and Order of Integration

Establishing the order of integration of the three-price series is a necessary first step before testing for cointegration. A long-run relationship among non-stationary variables is meaningful only when their stochastic properties are appropriately identified.

Three complementary procedures are employed: the Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. The ADF and PP procedures evaluate the null hypothesis that a series contains a unit root, whereas the KPSS test approaches the issue from the opposite direction by treating stationarity as the null hypothesis. Using these complementary procedures reduces reliance on any single unit-root testing framework.

The ADF procedure is widely used in applied time-series research, although its performance can be affected by persistence and lag specification (Krämer, 1998; Weber, 2001). The PP test provides complementary inference under alternative treatment of serial correlation and heteroskedasticity (Rothe & Sibbertsen, 2006), while the KPSS procedure provides an additional stationarity-based assessment (Sephton, 1995).

The tests are first applied to the logarithmic price levels (LBM , LBN , and LBR) and subsequently to their first differences:

$$\Delta LBM_t,\ \Delta LBN_t,\ \Delta LBR_t. \qquad (6)$$

A series that is non-stationary in logarithmic levels but stationary after first differencing is treated as integrated of order one, $I(1)$. Evidence that all three equity-price series are $I(1)$ provides the basis for proceeding to multivariate cointegration analysis

Lag-Length Selection

Before estimating the long-run relationship, an appropriate lag structure is determined for the multivariate system. Lag selection is important because an insufficient number of lags may leave residual serial dependence, whereas excessive lags reduce degrees of freedom and can make estimation unnecessarily inefficient.

The lag-selection exercise considers standard information criteria, including the Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC/BIC), and Hannan–Quinn Criterion (HQC). Given the relatively moderate sample of 199 weekly observations, model parsimony is also considered. The final specific-cation balances information-criterion recommendations with residual diagnostic performance.

For the cointegrating system used in this study, the final specification is represented by a second-order VAR in levels. Consequently, the corresponding VECM contains one lag of the first-differenced variables together with the lagged error-correction term.

Johansen Cointegration Analysis

Long-run equilibrium among Bank Mandiri, BNI, and BRI is examined using the Johansen cointegration procedure (Johansen, 1988; Juselius, 1990). Unlike a pairwise or single-equation approach, the Johansen method considers the three stock prices jointly and determines whether one or more stationary long-run relationships exist within the multivariate system.

Two complementary statistics are considered: the trace statistic and the maximum-eigenvalue statistic. The trace test evaluates the number of cointegrating relationships against a broader alternative, while the maximum-eigenvalue test evaluates successive cointegration ranks. Cointegration is interpreted cautiously when the two criteria provide different levels of statistical support.

The empirical system includes LBM , LBN , and LBR, together with the deterministic components appropriate to the estimated model. Where one cointegrating relationship is identified, the cointegration rank is set to r = 1 and the analysis proceeds through the VECM.

The cointegrating vector is normalised for identification purposes. However, economically restrictive exclusion conditions are not treated as valid merely because they simplify the estimated relationship. Additional zero restrictions on individual bank coefficients are retained only where they are supported statistically by likelihood-ratio testing. This avoids imposing a long-run structure that is inconsistent with the observed data.

Vector Error Correction Model

When the three equity prices are cointegrated, their short-run movements and long-run adjustment can be represented jointly through a Vector Error Correction Model. In simplified form,

$$\Delta = c + \alpha ECT_{t-1} + \Gamma \Delta \mathbf{L}_{t-1} + \boldsymbol{\varepsilon}_t. \qquad (7)$$

Where

$$Yt = \begin{vmatrix} LBM_t \\ LBN_t \\ LBR_t \end{vmatrix}$$

ECT_{t-1} represents the lagged deviation from the estimated long-run equilibrium, $\boldsymbol{\alpha}$ contains the adjustment coefficients, Γ captures short-run relationships among changes in the three equity prices, and $\boldsymbol{\varepsilon}_t$ represents innovations to the system.

The principal long-run parameters of interest are the adjustment coefficients contained in $\boldsymbol{\alpha}$. A negative and statistically significant error-correction coefficient indicates that the corresponding equity price responds when the system moves away from long-run equilibrium. The absolute magnitude of the coefficient provides an indication of the speed with which disequilibrium is corrected. Differences in the adjustment coefficients are particularly relevant to the present study. If one bank displays little or no statistically significant adjustment while the others react more strongly, the long-run relationship is asymmetric. Such a pattern suggests that the three institutions do not contribute equally to restoring equilibrium, even though their equity prices may be linked by a common long-run relationship.

Short-run coefficients are interpreted separately from the error-correction term. This distinction prevents short-run predictive relationships from being confused with long-run equilibrium adjustment.

Generalized Forecast-Error Variance Decomposition

The VECM coefficients indicate whether individual banks adjust to disequilibrium, but they do not directly show the relative importance of shocks originating throughout the system. Generalized forecast-error variance decomposition is therefore employed to quantify how much of the future forecast uncertainty of each banking equity is attributable to shocks originating in Bank Mandiri, BNI, and BRI.

For each bank, the forecast-error variance is divided into two broad com-ponents: variation explained by its own innovations and variation explained by innovations originating in the other banks. A relatively high own-shock contribution indicates greater autonomy in price formation, whereas larger cross-bank contributions indicate stronger dynamic interdependence.

The generalized approach is preferred because it reduces dependence on an arbitrary ordering of the three banks. This is particularly useful in the present setting because there is no strong theoretical justification for assuming in advance that Bank Mandiri, BNI, or BRI must always occupy the first position in the transmission structure.

Because generalized variance-decomposition shares do not necessarily sum automatically to unity, the contributions are normalised before being presented as percentages. The normalised share for bank ***j*** in explaining bank ***i*** is calculated as:

$$\theta_{ij}(h) = \frac{\theta_{ij}(h)}{\sum_{j=1}^{N} \theta_{ij}(\mathrm{h})} \qquad (8)$$

The analysis compares the variance shares across shorter and longer forecast horizons. This allows the study to determine whether the relative importance of a particular bank increases, decreases, or remains stable as shocks propagate through the system. Variance-decomposition methods provide an established means of examining such dynamic relationships within a vector error-correction framework (Masih et al., 2009).

Generalized Impulse-Response Analysis

Generalized impulse-response functions complement the variance-decomposition analysis by tracing how the three equity prices respond over time following an unexpected innovation in one of the banks.

Rather than focusing solely on whether an effect is statistically present, impulse responses provide information on three dimensions: the direction of the response, its magnitude, and its persistence. The analysis therefore considers whether a shock originating in one bank generates a positive or negative response in the remaining institutions, how quickly the effect develops, and how long it takes for the system to approach a stable path.

The generalized formulation is again useful because the resulting responses are less dependent on the ordering of the variables. This is consistent with the study's objective of allowing the data to reveal the relative position of Bank Mandiri, BNI, and BRI rather than imposing a predetermined hierarchy among them.

The impulse-response results are evaluated jointly with the generalized variance decomposition. Whereas variance decomposition indicates how important a particular source of shock is in explaining forecast uncertainty, the impulse-response function shows how the effect of that shock evolves over time. The two procedures therefore provide complementary evidence on dynamic shock trans-mission.

Persistence of System-Wide Shocks.

As an additional measure of long-run stability, the study examines the persistence profile associated with a system-wide shock to the cointegrating relationship. The persistence profile indicates how quickly the effect of a disturbance to the long-run equilibrium diminishes over subsequent periods.

A declining persistence profile provides evidence that deviations from the long-run relationship are temporary and that the system eventually returns toward equilibrium. In contrast, a highly persistent profile would indicate that disturbances to the equilibrium relationship dissipate only slowly.

The persistence profile is interpreted together with the VECM adjustment coefficients and impulse-response functions rather than as an independent test. This provides a broader assessment of whether the estimated system displays economically meaningful mean-reverting behaviour.

Model Diagnostics and Empirical Interpretation.

Post-estimation diagnostic tests are used to assess whether the estimated dynamic system is adequately specified. The principal diagnostics include tests for residual serial correlation, functional-form misspecification, heteroskedasticity, and residual normality. Attention is given to residual serial correlation because remaining temporal dependence may indicate that the selected lag structure does not adequately represent the data.

Residual normality is interpreted more cautiously. Stock-price changes frequently display skewness, excess kurtosis, and unusually large observations, so rejection of normality is not treated automatically as evidence that the complete dynamic specification is invalid. Diagnostic evidence is instead considered collectively when evaluating the reliability of the estimated results.

The empirical interpretation proceeds in three stages. First, the Johansen tests determine whether Bank Mandiri, BNI, and BRI share a long-run equilibrium. Second, the VECM adjustment coefficients identify how individual banks respond when that equilibrium is disturbed. Third, generalized variance decomposition and impulse responses determine how shocks are transmitted across institutions and whether their relative importance changes over forecast horizons.

The overall empirical framework can therefore be summarised as follows:

Weekly Stock Prices

↓

Stationarity and Cointegration Test

↓

VECM Adjustment

↓

Variance Decomposition

↓

Impulse Responses (9)

This framework permits long-run equilibrium and dynamic shock transmission to be examined within a single coherent system while retaining a relatively parsimonious specification appropriate to the available weekly sample.

Result and Discussion

Descriptive Behaviour of State-Owned Banking Equities

The empirical analysis begins by examining the behaviour of the three state-owned banking equities over the sample period. Table 2 reports the principal descriptive statistics for Bank Mandiri, Bank Negara Indonesia (BNI), and Bank Rakyat Indonesia (BRI). The raw price levels differ substantially across institutions, which is expected because nominal share prices are affected by firm-specific market structures, corporate actions, and valuation levels. The analysis therefore relies primarily on logarithmic prices and their changes rather than comparing nominal prices directly.

Bank	Mean Price	Std. Dev	Min	Max.	Mean Δ ln P (%)	SD Δ ln P (%)
Mandiri	5379.52	715.31	4410	7225	0.196	2.536
BNI	4462.81	402.43	3720	5675	0.097	2.559
BRI	4058.39	321.82	3360	4990	0.090	2.423

Table 2. Descriptive Statistics of the State-Owned Bank Equities

Figure 1 plots the logarithmic price series. Several features are immediately visible. First, the three stocks exhibit substantial persistence, with relatively prolonged upward and downward movements rather than fluctuations around constant means.

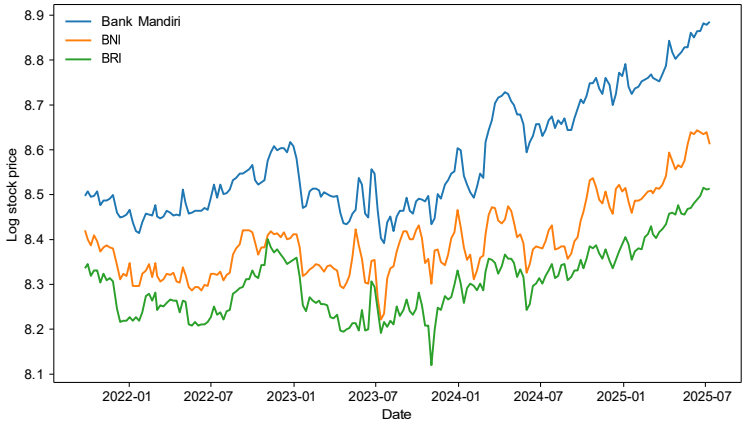

Figure 1. Logarithmic Stock Prices of Bank Mandiri, BNI, and BRI

Second, there are periods of common movement, particularly during broader market adjustments, but the magnitude of those movements differs across the three institutions. Third, Bank Mandiri displays a particularly pronounced upward trajectory toward the end of the sample, whereas BNI and BRI also appreciate but remain on distinct price paths.

These preliminary patterns already illustrate why contemporaneous co-movement alone is insufficient for evaluating integration. Similar directional movement can occur because the banks are exposed to common macroeconomic and policy information, while differences in institutional characteristics continue to generate substantial dispersion. This is consistent with the broader banking literature showing that common state ownership does not eliminate differences in performance, governance, shareholder incentives, or market risk (Achsanta et al., 2022; Cornett et al., 2010; Srivastava et al., 2025).

Descriptive Behaviour of State-Owned Banking Equities

The apparent persistence of the logarithmic price series is formally evaluated through unit-root and stationarity procedures. Table 3 reports representative results from the ADF, Phillips–Perron, and KPSS tests under an intercept specification. The three tests provide broadly consistent evidence.

Variable	Transformation	ADF	PP	KPSS
LBM	Level	-0.712	0.157	0.655
	First difference	-11.796	-13.686	0.288
LBN	Level	-1.834	-1.087	0.623
	First difference	-10.531	-13.463	0.352
LBR	Level	-1.222	-1.277	0.509
	First difference	-12.251	-15.784	0.331

Table 3. Unit-Root and Stationarity Test Result

ADF statistics are reported using one augmentation lag and an intercept. PP and KPSS tests use the intercept specification. For the ADF and PP tests, the null hypothesis is a unit root. For KPSS, the null hypothesis is stationarity. The corresponding 5% KPSS critical value is approximately 0.419. The results collectively support classifying all three logarithmic stock-price series as $I(1)$.

At their levels, none of the three-price series provides robust evidence of stationarity under the intercept specification. The KPSS statistics are also above their 5% critical value for all three-level series, rejecting the stationarity null. In contrast, first differencing generates strongly negative ADF and PP statistics, while the KPSS values fall below the stationarity critical value. The evidence therefore supports the classification:

$$LBM_t,\ LBN_t,\ LBR_t \sim I(1).$$

This common integration order permits investigation of whether the three non-stationary equity prices nevertheless contain a stationary linear combination.

Evidence of Long-Run Equilibrium

Table 4 reports the Johansen cointegration results. The estimated system employs a VAR of order two in levels with an unrestricted intercept and a restricted deterministic trend. The trace statistic rejects the null hypothesis of no cointegration, with a value of 45.930 compared with the 5% critical value of 42.340. The subsequent null of at most one cointegrating relationship cannot be rejected. The trace evidence therefore supports a cointegration rank of one.

Test	Null Hypothesis	Statistic 5%	CV 10%	CV
Maximum Eigenvalue	$r = 0$	25.052	25.420	23.100
	$r \leq 1$	13.904	19.220	17.180
	$r \leq 2$	6.974	12.390	10.550
Trace	$r = 0$	45.930	42.340	39.340
	$r \leq 1$	20.878	25.770	23.080
	$r \leq 2$	6.974	12.390	10.550

Table 4. Johansen Cointegration Tests

The maximum-eigenvalue result is more borderline. Its r = 0 statistic of 25.052 falls narrowly below the 5% critical value of 25.420, although it exceeds the 10% critical value of 23.100. Consequently, the evidence should not be described as uniformly overwhelming. Rather, the results provide meaningful but somewhat criterion-sensitive support for one common long-run relationship.

This qualification is economically useful. State ownership and shared exposure to Indonesia's macro financial environment provide reasons for long-run commonality, but the individual banks remain sufficiently heterogeneous for the equilibrium relationship not to be mechanically strong under every statistical criterion. Such a finding is consistent with the view that state ownership creates common institutional exposure without making publicly listed banks perfect substitutes.

Cointegrating Vector and Equilibrium Adjustment

The estimated cointegrating relationship is normalised on BNI. Importantly, only the identifying normalisation is imposed. Additional restrictions that excluded BRI or both BRI and Bank Mandiri from the long-run relation were rejected by likelihood-ratio testing and are therefore not retained in the final specification. Table 5: Normalised Long-Run Cointegrating Relationship. The vector is normalised by setting the coefficient on LBN equal to unity. The normalisation is for identification and should not be interpreted as establishing BNI as the economic "dependent" variable in the long-run relation. Additional exclusion restrictions were rejected by likelihood-ratio tests.

Term	Coefficient	Standard Error
LBM	0.5152	0.3828
LBN	1.0000	—
LBR	-1.3590	0.4694
Trend	-0.000861	0.000379

Table 5. Normalised Long-Run Cointegrating Relationship

The long-run vector should primarily be interpreted as evidence of a common equilibrium combination rather than through the isolated economic interpretation of each normalised coefficient. Of greater relevance for the present paper is the way each institution responds when the system moves away from this equilibrium. Table 6 reports the corresponding VECM adjustment and short-run coefficients. ECT_{t-1} is based on the exactly identified cointegrating relationship in Table 5. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Dependent Variable		
Regressor	ΔLBM_t	ΔLBN_t	ΔLBR_t
ECT_{t-1}	-0.0574	-0.1324***	0.0468
ΔLBM_{t-1}	-0.1031	-0.0087	0.0045
ΔLBN_{t-1}	0.4581***	0.3172***	0.2040**
ΔLBR_{t-1}	-0.1852*	-0.2068*	-0.2027*
Constant	0.0849	0.1925***	-0.0669

Table 6. Normalised Long-Run Cointegrating Relationship

The most important result is the asymmetric error-correction mechanism. The adjustment coefficient for BNI is negative and statistically significant at the 1% level, with an estimated value of approximately −0.132. Thus, when the three-bank system deviates from the estimated equilibrium, BNI's equity price provides the clearest statistically identifiable equilibrium-correcting response.

In contrast, the adjustment coefficients for Bank Mandiri and BRI are not statistically significant at conventional levels. The evidence is therefore consistent with a system in which BNI bears a larger observable burden of correcting disequilibrium, while Mandiri and BRI display comparatively weaker adjustment with respect to the estimated long-run vector.

This result is significant for interpreting Hypothesis *H2*. The existence of a common long-run equilibrium does not imply equal adjustment across the three banks. Instead, the long-run structure is asymmetric. This is broadly consistent with systemic-risk research showing that financial institutions

can occupy differ-ent positions within the same interconnected system (Arnold et al., 2012; Bostandzic & Weiß, 2018; Nucera et al., 2016).

The short-run coefficients reveal another dimension of this asymmetry. Lagged changes in BNI are positively associated with subsequent price changes in both Bank Mandiri and BRI. The coefficient on ΔLBN_{t-1} is approximately 0.458 in the Mandiri equation and 0.204 in the BRI equation, with both statistically significant. BNI's own lag is also significant in its own equation.

This pattern is noteworthy because BNI appears simultaneously as an important short-run information variable and the institution most clearly responsible for correcting long-run disequilibrium. The role of an institution in short-run information transmission is therefore not necessarily identical to its role as a source of persistent shocks.

Generalized Variance Decomposition

The VECM coefficients provide information about equilibrium adjustment but do not quantify the relative contribution of shocks originating in each bank to future uncertainty throughout the system. Generalized forecast-error variance decomposition addresses this issue. Because generalized decomposition shares do not automatically sum to one, the values reported in Table 7 are row-normalised and expressed as percentages. Entries represent row-normalised generalised forecast error variance shares in percentages. Each row sums to approximately 100. Horizon 0 represents the contemporaneous decomposition; subsequent horizons are measured in weeks.

Response	Horizon	Shock: Mandiri	Shock: BNI	Shock: BRI
Panel A: Bank Mandiri				
Mandiri	0	50.61	23.87	25.52
	4	43.93	29.23	26.84
	13	42.74	25.62	31.65
	26	42.33	23.90	33.77
	50	42.11	22.95	34.94
Panel B: BNI				
BNI	0	23.98	50.86	25.16
	4	21.50	49.62	28.88
	13	19.41	43.43	37.16
	26	18.45	40.43	41.12
	50	17.89	38.69	43.42
Panel C: BRI				
BRI	0	25.22	24.75	50.02
	4	25.70	30.31	43.99
	13	25.64	30.98	43.38
	26	25.60	31.09	43.30
	50	25.59	31.15	43.27

Table 7. Normalised Generalized Forecast-Error Variance Decomposition

Several important patterns emerge. First, own innovations remain important for all three banks but do not dominate the system completely. Even contemporaneously, approximately half of each

bank's normalised uncertainty is associated with innovations originating elsewhere in the three-bank system. This confirms that the equities are not informationally isolated.

Second, the relative importance of external shocks changes considerably with the forecast horizon. For Bank Mandiri, the contribution of its own innovations falls from approximately 50.6% contemporaneously to 42.1% at horizon 50. Over the same interval, BRI's contribution rises from 25.5% to almost 35%. BNI shocks remain relevant but account for a smaller long-horizon share.

Third, BNI exhibits the most pronounced shift in the source of forecast uncertainty. Its own contribution declines from 50.9% to 38.7%, whereas the contribution of BRI shocks increases from 25.2% to 43.4%. At longer horizons, BRI innovations therefore explain a larger proportion of BNI's forecast variance than BNI's own innovations.

The BRI equation is comparatively more stable. BRI's own contribution falls from approximately 50.0% to 43.3%, while BNI accounts for about 31.2% and Mandiri approximately 25.6% at horizon 50.

The broader pattern therefore suggests that BRI becomes increasingly important as a source of longer-horizon variation within the system. This should not, however, be interpreted as contradicting the VECM result. The two methods answer different questions. The error-correction coefficient identifies which institution responds to disequilibrium; generalized variance decomposition identifies whose innovations explain future forecast uncertainty. BNI appears more important for equilibrium adjustment, while BRI innovations become increasingly influential in the longer-horizon variance structure.

This distinction is central to the contribution of the paper. State-owned banking interdependence cannot be reduced to a single concept of "leadership". An institution can act as an equilibrium adjuster without being the dominant longer-horizon source of shocks. Such multidimensional interdependence is consistent with the wider literature showing that state-owned banks can play distinctive roles in shock transmission (Borsuk et al., 2024).

Generalized Impulse Responses

The generalized impulse-response analysis provides a complementary perspective on how innovations propagate through the three-bank system. Figure 2, 3 and 4 presents the responses to one-standard-error innovations originating separately in Bank Mandiri, BNI, and BRI.

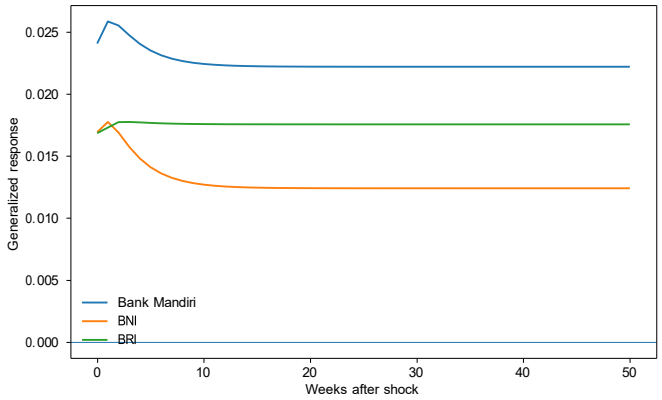

Figure 2. Generalized responses to a Bank Mandiri shock

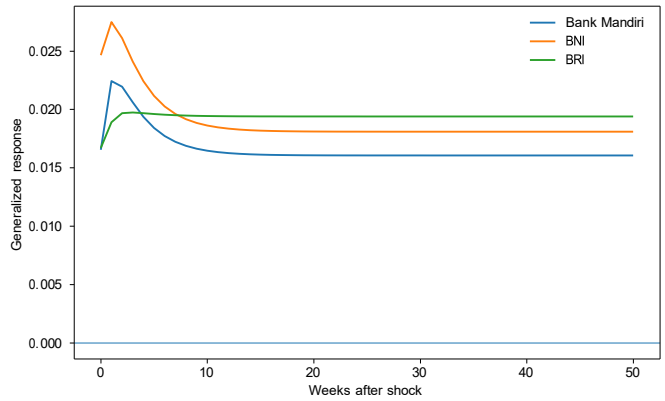

Figure 3. Generalized responses to a BNI shock

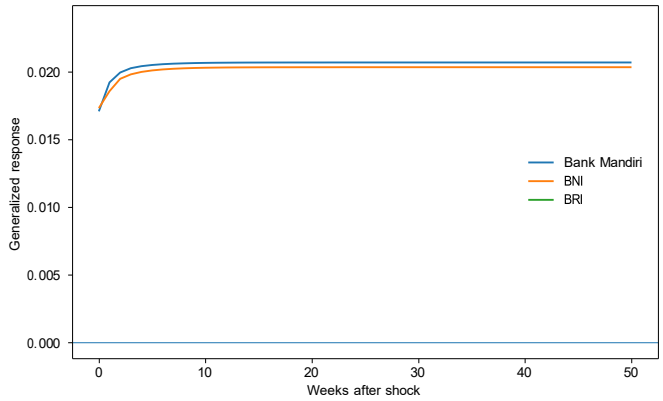

Figure 4. Generalized responses to a BNI shock

A positive shock to Bank Mandiri generates an immediate positive response in all three equities. Mandiri itself displays the strongest response, whereas the effect transmitted to BNI is

comparatively weaker. The responses gradually settle into stable longer-horizon values rather than continuing to expand.

The BNI shock produces a somewhat different pattern. Its initial effect is strongest on BNI itself, but the responses of Mandiri and BRI are also economically meaningful. Over subsequent weeks, the BRI response becomes particularly persistent. This is consistent with the variance-decomposition evidence indicating that BNI and BRI are strongly connected dynamically.

The response to a BRI shock is the most broadly distributed across the three institutions. Both Mandiri and BNI respond quickly, and their longer-run responses remain relatively close to BRI's own response. This reinforces the GFEVD result that BRI innovations acquire substantial importance for the system at longer horizons.

Importantly, the generalized impulse responses of the logarithmic price levels do not need to return to zero. Because the variables form an I(1) system with a common stochastic trend, an innovation may produce a permanent shift in the level of the common trend. What should stabilise is the relationship among the cointegrated variables. The flattening of the impulse-response paths therefore indicates convergence toward a new long-run configuration rather than a return of every stock price to its pre-shock level.

This result provides support for Hypothesis H3: innovations originating in one state-owned bank generate economically meaningful responses throughout the system. It also supports Hypothesis H4, because both the relative strength and distribution of those responses vary across horizons. The findings fit the broader literature on financial contagion and interdependence, which emphasises that banking shocks may propagate through common information, investor expectations, and systemic linkages rather than remaining confined to the originating institution (Arnold et al., 2012; Halstead et al., 2004). The Indonesian evidence demonstrates that these mechanisms are visible even within a narrowly defined group of state-controlled banks.

Persistence of the Long-Run Relationship

The persistence profile provides a more direct assessment of how rapidly a system-wide disturbance to the cointegrating relationship is eliminated. Figure 5 plots the normalised persistence profile.

The profile begins at unity by construction and declines quickly. It falls to approximately 0.514 by week 2, 0.139 by week 4, and 0.069 by week 5. By week 10, the remaining effect is approximately 0.002, while by approximately week 13 the effect of the system-wide disequilibrium shock is economically close to zero.

This rapid decline is important because it distinguishes persistence in the individual stock-price levels from persistence in the equilibrium error. Individual price shocks can shift the common stochastic trend permanently, as shown by the impulse responses, while deviations from the

cointegrating relationship itself are temporary. The three equity prices therefore need not return to their previous absolute levels for long-run equilibrium to be restored.

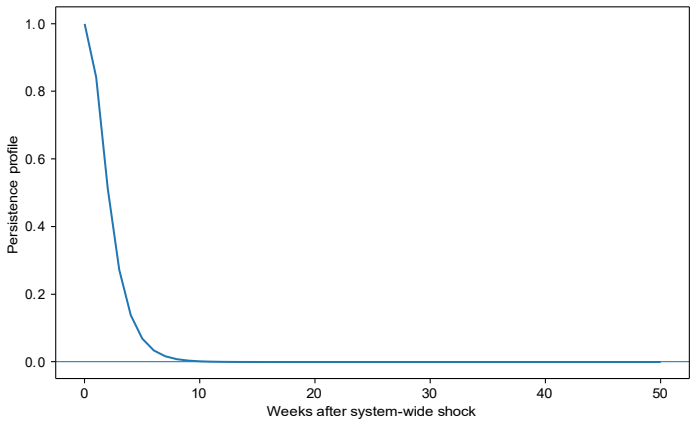

Figure 5. Persistence Profile of a System-Wide Shock to the Cointegrating Relationship

This result provides additional support for the interpretation of the three state-owned banks as a cointegrated financial subsystem rather than three independent equity-price processes.

Diagnostic Assessment

The principal system diagnostics are reported in Table 8. The residual-autocorrelation test does not reject the null of no serial correlation, suggesting that the selected dynamic structure adequately captures the principal temporal dependence in the system. Residual normality is rejected, which is not unusual for financial price and return data where extreme observations, skewness, and excess kurtosis are common. The normality result is there-fore treated as a qualification for inference rather than as evidence against the economic relevance of the complete model.

Diagnostic	**Statistic**	***p*-value**	**Conclusion**
Residual autocorrelation	99.214	0.391	No evidence of residual autocorrelation
Residual normality	114.377	< 0.001	Normality rejected

Table 8. Selected VECM Diagnostic Tests

Discussion of the Main Findings

Taken together, the empirical results reveal a state-owned banking equity system characterised by *long-run commonality but heterogeneous dynamic roles*. This distinction is more informative than classifying Bank Mandiri, BNI, and BRI simply as either integrated or independent.

First, the Johansen evidence indicates that common state ownership and exposure to the same Indonesian macro-financial environment are associated with a persistent equilibrium relationship. This supports Hypothesis *H*1, although the conclusion remains qualified because the maximum-eigenvalue result is weaker than the trace result at the 5% level. The evidence should therefore be understood as supporting a common equilibrium rather than establishing perfect integration.

This finding contributes to the literature on state-owned banks by showing that the consequences of state ownership can also be visible through relationships among publicly traded equity valuations. Existing studies primarily emphasise differences in bank performance, governance, shareholder outcomes, and risk (Achsanta et al., 2022; Cornett et al., 2010; Srivastava et al., 2025). The present results demonstrate that institutional heterogeneity can coexist with a statistically meaningful long-run market relationship.

Second, equilibrium adjustment is strongly asymmetric. BNI is the only institution whose error-correction coefficient is statistically significant at conventional levels. Hypothesis *H*2 is therefore supported: the three state-owned banks do not correct deviations from equilibrium at the same speed. The result is consistent with the broader systemic-risk literature, in which institutions occupying the same financial system may perform different functions in absorbing, transmit-ting, or responding to shocks (Bostandzic & Weiß, 2018; Nucera et al., 2016).

At the same time, BNI also displays a significant short-run relationship with the subsequent movements of Mandiri and BRI. This makes BNI important for short-run price dynamics, but it should not automatically be labelled the permanent "leader" of the system. The generalized variance decomposition demonstrates why such a conclusion would be too simplistic.

Third, the GFEVD identifies BRI as an increasingly important source of longer-horizon forecast uncertainty. BRI shocks explain approximately 34.9% of Mandiri's and 43.4% of BNI's normalised forecast variance at horizon 50. For BNI, the contribution from BRI eventually exceeds the contribution from BNI's own innovations. Consequently, the institution that adjusts most clearly to long-run disequilibrium is not the same institution whose innovations become most important at longer horizons.

This distinction offers an important conceptual contribution. In a cointegrated banking system, equilibrium adjustment, short-run predictive influence, and shock transmission represent separate dimensions of interconnectedness. Treating them as equivalent may lead to misleading statements about which institution "leads" the market.

Fourth, the generalized impulse responses confirm substantial cross-bank transmission. Shocks originating in each institution affect the other two banks, supporting Hypothesis H3. The relatively broad response generated by BRI innovations is particularly consistent with the longer-horizon GFEVD results. The pattern is also compatible with evidence that state-owned banks can occupy distinctive positions in shock-transmission processes (Borsuk et al., 2024).

The changing variance shares across horizons further support Hypothesis H4. The system does not possess a fixed transmission hierarchy. Own shocks become less dominant over time, while cross-bank effects acquire greater importance. This horizon dependence is consistent with the broader literature on dynamic financial interdependence, where common information and market linkages evolve rather than remaining constant (In et al., 2001; Nazlioglu et al., 2024).

From an Indonesian perspective, the results complement earlier research that has connected banking behaviour with monetary transmission, capital flows, policy-supported lending, and equity-market information (Ivancio et al., 2024; Mara et al., 2021; Naiborhu & Ulfa, 2023; Zulverdi et al., 2007). The present study adds another dimension by showing that the publicly traded valuations of the major state-owned banks themselves form a dynamically interconnected system.

The institutional setting is also relevant. Indonesian financial development is strongly shaped by interactions between regulatory arrangements, public pol-icy, and market institutions. This broader institutional character has also been emphasised in research on other components of the Indonesian financial system (Bin-Armia, 2026; Bin-Armia et al., 2024). In the present context, state ownership constitutes an additional institutional layer: the three banks share a common public shareholder and national policy environment while remaining separately managed, traded, and valued institutions.

The resulting evidence therefore favours neither complete homogeneity nor complete independence. Instead, Bank Mandiri, BNI, and BRI appear to form an *interconnected but asymmetrically structured state-owned banking equity system*. Their prices are constrained by a common long-run relationship, but they perform different roles in equilibrium adjustment and shock transmission.

Summary of Hypotheses

Table 9 summarises the empirical assessment of the four hypotheses. The findings indicate that common state ownership does not produce uniform equity-price dynamics. The three banks share evidence of a long-run relationship, but their roles in equilibrium adjustment and shock transmission differ. In particular, the bank that responds most strongly to disequilibrium need not be the same institution whose shocks become most influential over longer horizons.

Hypothesis	Main Evidence	Assessment
H_1	The trace test supports one cointegrating relationship at 5%, while the maximum-eigenvalue test provides weaker evidence	Qualified Support
H_2	Equilibrium adjustment differs across banks, with BNI showing the clearest significant adjustment	Supported
H_3	GFEVD and impulse responses indicate meaningful cross-bank shock transmission	Supported
H_4	The relative importance of shocks changes across forecast horizons	Supported

Table 9. Short-Run Granger-Causality Results

Conclusion

This study examines long-run equilibrium and shock transmission among three major publicly listed Indonesian state-owned banks—Bank Mandiri, Bank Negara Indonesia (BNI), and Bank Rakyat Indonesia (BRI)—using weekly equity-price data from Refinitiv LSEG covering September 2021 to July 2025. The empirical framework combines unit-root testing, Johansen cointegration, a Vector Error Correction Model (VECM), generalized forecast-error variance decomposition, generalized

impulse-response analysis, and a persistence profile to distinguish long-run equilibrium adjustment from short- and longer-horizon shock transmission.

The findings indicate that the three logarithmic stock-price series are integrated of order one and provide evidence of one common long-run relationship. However, the strength of the cointegration result is not identical across the Johansen criteria: the trace test supports one cointegrating vector at the 5% level, whereas the maximum-eigenvalue test provides weaker support. The long-run relationship should therefore be interpreted as meaningful but not mechanically conclusive. Within the VECM, equilibrium adjustment is clearly asymmetric. BNI exhibits the strongest and statistically significant error-correction response, while Bank Mandiri and BRI display comparatively weaker adjustment. This confirms that a shared long-run equilibrium does not imply that all state-owned banks perform the same role in restoring that equilibrium.

The dynamic results further demonstrate that shock transmission is both economically meaningful and horizon dependent. Generalized variance decomposition shows that forecast uncertainty in each bank is influenced not only by its own innovations but also by shocks originating in the other state-owned banks. BRI becomes increasingly important as a source of longer-horizon variation, especially for BNI and Bank Mandiri. The generalized impulse responses likewise indicate that shocks originating in one bank are transmitted across the three-bank system before the responses gradually stabilise. The persistence profile further suggests that disturbances to the long-run equilibrium diminish relatively quickly, supporting the view that deviations from the cointegrating relationship are temporary even when innovations can shift the common price trend.

Taken together, the results portray Indonesia's major state-owned banking equities as an interconnected but asymmetrically structured financial subsystem. Common state ownership and exposure to the same national economic and regulatory environment appear to support a long-run relationship, yet the individual banks retain distinct roles in equilibrium adjustment and shock transmission. Importantly, the institution that responds most strongly to disequilibrium is not necessarily the institution whose shocks become most influential over longer horizons. This distinction suggests that financial interconnectedness should be understood as multidimensional rather than reduced to a single concept of mar-ket leadership.

The findings have implications for both investors and policymakers. For investors, meaningful cross-bank shock transmission suggests that diversification across state-owned banking equities may provide more limited protection than would be expected if the stocks were independently priced. At the same time, heterogeneous adjustment patterns indicate that the three banks should not be treated as perfect substitutes. For regulators and policymakers, the evidence provides a market-based perspective on interconnectedness within an important segment of Indonesia's banking system and highlights the value of monitoring not only individual bank conditions but also the pathways through which disturbances may propagate across institutions.

Several limitations should nevertheless be acknowledged. The analysis is based on three major state-owned banks and a weekly sample of 199 observations, so the findings should not be

generalised automatically to all Indonesian banks or to different market periods. The study also focuses on stock-price dynamics and does not explicitly incorporate trading volume, bank fundamentals, macroeconomic controls, or structural-break regimes. Future research may therefore extend the analysis by incorporating broader samples, alternative market-frequency data, rolling or time-varying connectedness measures, and macro-financial variables to assess whether the structure of long-run equilibrium and shock transmission changes across different economic and policy environments.

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