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DETERMINANTS OF GOVERNMENT DEBT PORTFOLIO MANAGEMENT: A VECM ANALYSIS OF INDONESIA'S FISCAL DYNAMICS

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Abstract
This paper explores the macroeconomic determinants shaping the composition of Indonesia's sovereign debt portfolio, distinguishing between foreign loans, government securities, and sukuk instruments. Using quarterly data from 2010 to 2025 and a Vector Error Correction Model (VECM), the study reveals robust long-run cointegration between key macro variables and debt composition. Exchange rate stability, global interest rate dynamics, and fiscal policy adjustments emerge as dominant drivers. Policy implications underscore the importance of active debt diversification and macroprudential coordination to enhance fiscal resilience. Employing the Vector Error Correction Model (VECM), the analysis examines the impact of the exchange rate (X1), LIBOR (X2), SIBOR (X3), U.S. Prime Rate (X4), Japan Prime Rate (X5), foreign exchange reserves (X6), inflation rate (X7), and GDP growth rate (X8) on the allocation of foreign loans (Y1), government debt securities (Y2), and state sharia securities (Y3) over the period 2010–2025. The findings reveal that the relationships between the dependent variables (Y1, Y2, Y3) and the macroeconomic indicators (X1–X8) are both dynamic and heterogeneous in the short and long term. These results underscore that the effectiveness of economic policy is not solely dependent on direct interventions targeting debt instruments, but also on the government's ability to manage long-term adjustment mechanisms and short-term transmission channels, particularly through key variables such as X5, X3, and X2.
Keywords: Fiscal policy; Government debt portfolio; Macroeconomic indicators; VECM

INTRODUCTION

Studies that specifically examine the debt structure (loans versus securities) using the VECM approach are relatively scarce (see Table 1). Most VECM-based research focuses on topics such as public debt, external debt, bond yields, or debt growth, while studies addressing debt structure are often found in the form of working papers or institutional data analyses (e.g., ECB, World Bank). The question of how institutions determine an optimal debt structure has been a subject of debate since the emergence of the Modigliani–Miller theorem (1958), which discusses corporate financing choices between debt and equity to support a given level of investment. Subsequently, several related theories were developed, including the Trade-off Theory, Pecking Order Theory, and Market Timing Theory. Within the framework of capital structure models, the Balancing Theory proposed by Myers (1984) and further elaborated by Bayles and Diltz (1994) emphasizes achieving an equilibrium between debt and equity composition (Myers, 1984, Frank & Goyal, 2009; Giglio, 2022).

The goal of debt management requires a thorough evaluation of the achievement of the optimal debt structure (Jagannayaki et al., 2024; Li, 2024). The evaluation includes the achievement of portfolio targets, debt risk, and the influence of economic factors to minimize debt costs. Debt structure is a collection of debt portfolios. What is meant by the optimal debt structure for companies is still much debated. On the other hand, the optimal government debt structure is also not well defined. Research on the choices of debt financing for government debt has not been seen much when compared to research for companies,(Corsetti et al., 1999; Missale et al., 2002). Some of the latest research that is considered quite constructive in the development of the theory of government debt instrument selection is research conducted by Asfaq, (Ashfaq & Padda, 2019), Prasad, (Prasad Bhatta & Mishra, n.d.) and Cicchiello, (Cicchiello et al., 2022).

The structure of government debt in practice is not simple. The structure of government debt reflects the composition and characteristics of the debt owned by the state, by the terms of period, sources of financing (domestic vs. foreign), and the instruments used. Macroeconomic indicators, including economic growth, interest rates, exchange rates, inflation, and state revenues, play a crucial role in shaping this structure. The government will choose the optimal debt structure, taking into account exchange rate risk, interest rates, and market volatility. This provides an overview of the importance of diversification of instruments and sources of financing.

This study contributes to the literature by extending the application of VECM to the context of sovereign debt portfolio composition—distinguishing between loans, conventional securities, and Islamic securities. Unlike previous studies that focus on aggregate debt ratios, this research provides a multidimensional framework linking macroeconomic indicators to instrument-level fiscal dynamics in an emerging market context.

Table 1. Literature Review

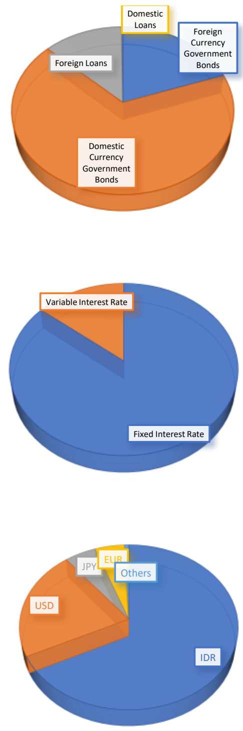
Author(s) (year)	Study focus	Key findings (brief)	Moderating factors
(Briceño & Perote, 2020)	Determinants of public debt in the Eurozone (dynamic econometric assessment; open access).	Economic growth, interest rates, unemployment, and government effectiveness play a major role in the evolution of the public debt ratio. The impact of COVID-19 has sharply increased debt. (Results based on dynamic models and cointegration/long-run analysis).	Eurozone panel data. It does not focus explicitly on loans vs securities but discusses the interest & instrument components as part of the debt ratio analysis.
(Ehikioya et al., 2020)	Long-term relationship between external/public debt and economic growth in several African countries, using cointegration & VECM.	Finding cointegrating relationships, The VECM indicates the direction of short-term causality/adjustment to the long-term balance between external debt and growth.	Focus: external debt (not detailed loans vs securities), but methodology (VECM) is relevant for the analysis of the dynamics of debt instruments.
(Marimuthu et al., 2021)	Is ASEAN's fiscal deficit alarming—econometric analysis includes VECM for some fiscal indicators.	VECM shows the long-term effects of deficits on macro variables (growth, interest), their implications on the public debt position;	Relevant methodology to test how macro indicators affect debt structure/composition.

Author(s) (year)	Study focus	Key findings (brief)	Moderating factors
		Variation between countries is important.	
(Bekiros & Avdoulas, 2020)	The dynamics of government bond yields (term structure) and links to macro indicators; models include VECM.	Finding cointegration between yield term structure and macro factors (inflation, interest rates, external), as well as short-term adjustment mechanisms (VECM). Implications for debt securities management.	Focus on securities (yield and macro relationships) — suitable if you want the "securities" part of the debt composition.
(De Graeve & Mazzolini, 2023)	Large dataset on maturity composition (OECD countries) — presents a pattern of changes in debt composition (securities maturities).	Present empirical evidence of the evolution of debt structures (maturity / type of instruments) over 25 years; shows shifts between instruments & cost/risk implications. ScienceDirect	Very useful for composition contexts (although not VECM).
(Matsuoka, 2020)	Analysis of debt instruments and debt composition; big data.	Explain the importance of composition (securities vs loans) for debt risk and market tolerance; Documentation datasets that include loans & securities.	Data sources & theories are useful for building composition variables (loans vs securities).

In the Indonesian Government Debt Management Strategy 2024-2027, we get an overview of the policies that affect the formation of various Indonesian government debt portfolios. The General Policy on Debt Management (loan and securitas) provides explanations related to the use of financing sources as follows: (1) prioritizing domestic debt financing sources, and; (2) utilizing foreign debt financing sources as a complement. Meanwhile, regarding the Government Securities Management Policy (securitas), we obtained the following explanations: (1) prioritizing issuance in the domestic market; (2) issuing foreign exchange SBN as a complement by prioritizing hard currency; (3) actively manage the SBN portfolio (i.e. cash buyback, debt switch); (4) diversify SBN instruments to support market development and deepening, reduce fragmentation, and control debt risk.

Figure 1. Various Definitions of Indonesia's Debt Portfolio

By Instrument	
Foreign Currency Government Bonds	19,54%
Domestic Currency Government Bonds	67,60%
Foreign Loans	12,76%
Domestic Loans	0,19%
By Interest Rate (Cost of Debt)	
Fixed Interest Rate	85,97%
Variable Interest Rate	14,03%
By Currency	
IDR	67,79%
USD	21,60%
JPY	5,09%
EUR	4,79%
Others	0,73%



Source: Medium-Term Debt Management Strategy Document for 2022-2025

The government's debt structure is an important tool for the government in stabilizing the fiscal system. Changes in macroeconomic indicators such as interest rates, exchange rates, trade balances, inflation, and other macroeconomic indicators can influence government preferences in choosing the type, term, and source of debt. The structure of Indonesian government debt in the last decade shows dynamics influenced by macroeconomic conditions. The proportion of external debt to total debt tends to decrease, while domestic debt increases, in line with the development of the domestic bond market and the government's strategy to reduce exchange rate risk. In addition, the composition of long-term debt is more dominant than short-term debt, reflecting the government's preference for long-term financing stability.

Indonesia's debt increased from Q1:2010 to Q1:2024 (see Table 2). We can see that the total debt of Rp1,618 trillion to Rp8,680 trillion. The debt-to-GDP ratio increased from 27.0% in Q1:2010 to 39.2% in Q1:2024. Indonesia's portion of financing in foreign loans reaches 11% of total debt. The external debt-to-GDP ratio remains below safe limits, despite concerns about global economic conditions and the need for real sector strengthening. The government continues to strive to reduce the debt-to-GDP ratio through optimizing state revenue through tax reform, natural resource management, and measurable fiscal incentives to encourage investment acceleration.

Table 2. Position of Outstanding Debt of the Government of Indonesia Q1:2010-Q1:2024

Year	**Estimated Outstanding Total Debt**	**Ratio to GDP**	**Estimated Foreign Loans (Rp)**	**Estimated SBN (Rp)**
2010	(+/-) IDR 1,618 trillion	27,0%	(+/-) IDR 653 trillion	(+/-) IDR 1,074 trillion
2024	(+/-) IDR 8,680 trillion	39,2%	(+/-) IDR 988.38 trillion	(+/-) IDR 7,648.87 Trillion

Source: Data processed from various sources (Kamalina, 2024; Rachman, 2024)

Sources of debt financing involve the active role of investors who have economic preferences in anticipating profits faced with risks to government credibility, financial market conditions, and macroeconomic fundamentals. To identify the main sources of risk to macroeconomic and financial stability, investors generally look at the capabilities of economic indicators, (Babecký et al., 2014; Brzoza-Brzezina et al., 2010). Financial market volatility due to the high cost of government debt will cause fiscal burdens, for example, in terms of high SBN repurchase costs and the rescheduling of foreign loan payments.

Meanwhile, the composition of debt costs also forms the portfolio structure in terms of costs, which consists of loan interest rates (rates) and yields (yields). The cost of debt is an important consideration in the use of loan instruments and debt securities. The portfolio fee structure comes from the process of accumulating costs resulting from loan negotiations and the government securities trading auction system. The cost of debt in principle also reflects the profit expectations of each party (creditors and debtors) where the determination is faced with the economic conditions at that time and the projections in the future. In addition to debt costs, the components that will form the structure of the government debt portfolio are the number of debt issuance/procurement transactions and the nominal value of debt issuance/procurement. The use of the term issuance usually refers to SBN and the term procurement refers to Loans.

In Indonesia, in accordance with the Government Debt Management Strategy, there are at least three definitions of the composition of the Central Government Debt Portfolio that form the debt structure. The composition of the debt structure is arranged based on Instruments, Interest Rates, and Currencies (Figure 1). Meanwhile, according to Abbas et al., (2014), the composition of government debt forms a debt funding structure that is broadly grouped into currency, maturity (short and long term), holder profile, and marketability. The features of government debt are generally related to the terms and conditions listed in the debt document.

The formation of a debt portfolio is to create a more stable and balanced portfolio of government debt that will reduce vulnerability to external economic shocks and lead to a reduction in the cost of debt. Successful debt management performance will have a positive effect on economic fundamentals, and vice versa, (Potekhina et al., 2024).

The composition and features of government debt provide relevant information to the capital market when determining the price of new issuances and secondary market transactions. The development of debt instruments in the form of, among others, variations in feature changes requires appropriate fiscal policies from time to time in the context of fiscal sustainability. The literature on government debt control studies has not discussed much about the relationship between fiscal policy and the characteristics of changes in debt instruments.

The purpose of this study was to analyze the effect of shocks from macroeconomic indicators on government debt structure and identify selected macroeconomic variables that contribute most to changes in debt structure. In addition, the purpose of the research is also to provide policy recommendations based on the results of empirical studies. This research is expected to contribute to the literature on financing decisions by examining the determinants that influence the selection of government debt portfolios, (Cicchiello et al., 2022; Latifah et al., 2024; Potekhina et al., 2024; Privea & Safitri, 2023).

In Figure 2 we can see the trend based on logarithmic graphs of LnY1, LnY2, and LnY3 from 2010 to the first quarter of 2025. During the period 2010–2025, the three variables show different trend dynamics, reflecting contrasting growth characteristics. The variable LnY1 appears as the most stable entity, with a near-flat logarithmic value around the number 11. Its immutability indicates stagnation or very slow growth, likely coming from sectors that have not experienced significant expansion or are permanent in the economic structure. In contrast, LnY2 is showing a consistent and strong growth trend. Starting from around 13.5 at the beginning of the period, its logarithmic value increases gradually until it reaches 15.5 in 2025.

This pattern reflects continuous expansion and can be associated with dynamic sectors such as investment, consumption, or technology that are constantly evolving. Meanwhile, LnY3 showed a moderate growth trend. From the starting point of about 11.5, this variable increases to close to the number 14. Although not as fast as LnY2, this positive trend still shows significant development, perhaps coming from sectors that are undergoing transformation or gradual reform.

Figure 2. Target Variable Data Y1,Y2,Y3 Period Q1:2010 n.d. Q1:2025

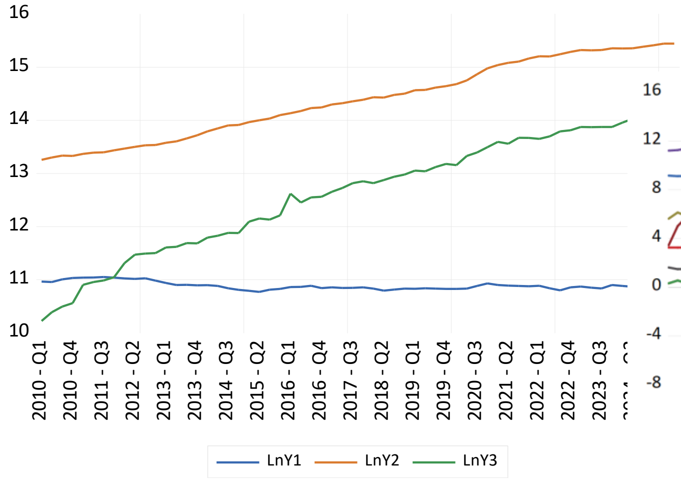
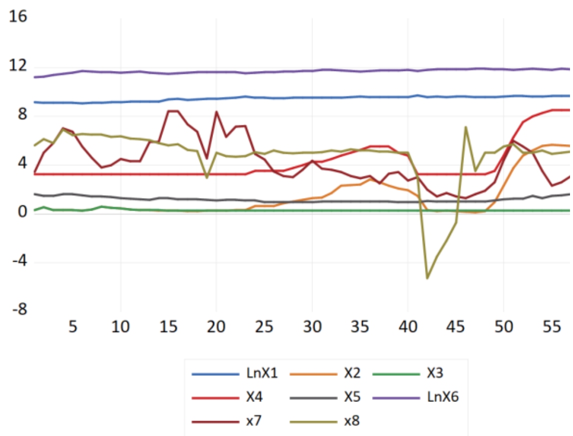


Figure 3. Economic Indicator Variable Data Period Q1:2010 n.d. Q1:2025



Overall, this graph illustrates the contrast between stagnation and growth in the observed system. LnY2 and LnY3 move in the same direction, indicating a potential structural linkage or response to similar external factors. Meanwhile, LnY1 stands as a stable comparator, reinforcing the narrative about the difference in the rate of development between variables.

Figure 3 represents the evolution of eight economic variables along 60 observation points, identified by codes LnX1, X2, X3, X4, X5, LnX6, x7, and x8, respectively. This visualization provides a preliminary overview of the temporal characteristics and potential interactions between variables in a dynamic system.

In general, LnX6 shows high stability, with a consistent value around the number 12. This pattern indicates that the variable serves as a structural component or anchor in the system, which is relatively unaffected by short-term fluctuations. In contrast, x8 exhibits extreme volatility, including a sharp drop around the 45th observation point. This phenomenon can be associated with exogenous shocks or disruptive policy changes.

The LnX1 variable shows a gradual logarithmic growth trend, leading to interpretation as an exponential indicator of expansion or accumulation. Meanwhile, X2 and X3 move relatively flat in the lower range of the chart, reflecting a more passive role or limited contribution to the overall dynamics of the system.

The X4, X5, and x7 variables show moderate to high fluctuations, with a more dynamic pattern and not completely random. These movements can reflect a response to economic cycles, market pressures, or policy interventions that are temporary.

From a methodological perspective, these patterns provide a solid basis for the application of econometric models such as VAR (Vector Autoregression) or VECM (Vector Error Correction Model), in order to identify the causal relationships, direction of influence, and relative contribution of each variable to the system. Advanced analysis, such as the Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD), will enrich understanding of the short-term and long-term dynamics between system components.

Factors such as exchange rates, interest rates, and inflation are commonly used in the VAR/VECM model to identify policy shocks and responses. The exchange rate affects the foreign debt burden in foreign currencies. Inflation and global interest rates (LIBOR/SIBOR/Prime Rate) affect borrowing costs and debt tenor preferences. Foreign exchange reserves act as a buffer against exchange rate risk and increase investor confidence. GDP growth determines fiscal capacity and the debt-to-GDP ratio, (Abid & Rault, 2021; Bernoth & Herwartz, 2021; Glebocki & Saha, 2024) .

METHODS

This study used a quantitative approach with VECM (Vector Error Correction Model). VECM is a special version of VAR that is used when non-stationary variables are cointegrated (have a stable long-term relationship). The use of VECM allows us to separate long-term relationships (cointegration) and short-run dynamics (short-run adjustment). As part of the data analysis process, this study also employed artificial intelligence tools, including ChatGPT, to support the synthesis, interpretation, and refinement of results. (Cheng et al., 2025; Kacena et al., 2024; Yoo, 2025) .

Debt management policies and variations in their features require fiscal policies that take into account economic conditions and certain economic variables. Exchange rate fluctuations, rising global interest rates, and other macroeconomic indicators, as well as geopolitical risks, are factors in policy determination. (Rahayu et al., 2020; Surdikina et al., 2025). The research data are believed to be closely related to each other. The use of the VAR/VECM model is believed to be suitable enough for use in the study. (Lee, 2025; Rehal, 2022).

The data source is obtained from the Indonesian Economic and Financial Statistics (SEKI) published by Bank Indonesia and includes monetary, government finance, and real sector data. The research data period is made every quarter, covering the period Q1:2010-Q3:2025.

Table 3. Research Variables

Symbol	Information
LnY1	FOREIGN LOANS - ODA (USD Million)
LnY2	GOVERNMENT DEBT SECURITIES (SUN) (Billions of Rupiah)
LnY3	STATE SHARIA SECURITIES (SBSN) (Billions of Rupiah)
LnX1	Exchange rate (IDR/USD)
X2	LIBOR in USD (3 months) (% of Years) – Q4:2024 through Q2:2025 values are projected figures.
X3	SIBOR in USD (3 months) (% of Years)
X4	US Prime Rates (% of Years)
X5	Japan Prime Rates (% of Years)
LnX6	Foreign Exchange Reserves (Billion USD)
X7	Inflation Rate (%)
X8	Gross Domestic Product Growth (PDB) %

Source: SEKI Bank Indonesia, various tables

Conceptually and empirically, the reasons for the eight variables chosen in multivariate economic analysis, particularly in the context of macroeconomics and monetary policy, are:

Table 4. Relevance and Analytical Function

Variables	Relevance	Analytical Function
Exchange Rate (X1)	Reflects economic competitiveness; affects exports, imports, and international capital flows	Key external indicators for measuring balance of payments pressures and the effectiveness of monetary interventions
LIBOR (X2)	Global benchmark interest rates for interbank transactions and derivatives	Representing international liquidity conditions and loan costs; Influencing capital flows and investment
SIBOR (X3)	Regional interest rate benchmarks in Asia	Providing a regional perspective on interest rate dynamics and the integration of Asian financial markets
U.S. Prime Rate (X4)	Major loan interest rates in the US	Representing U.S. monetary policy; has a direct impact on global capital flows
Japan Prime Rate (X5)	Japan's main interest rate is relevant in regional stability and the carry trade	Providing context for the country's monetary policy with low interest rates and large foreign exchange reserves
Foreign Exchange Reserves (X6)	Demonstrate the country's capacity in exchange rate stabilization and external financing	Measuring the external resilience and effectiveness of monetary intervention
Inflation Rate (X7)	Affects purchasing power, interest rates, and macroeconomic stability	The main target variable in monetary policy; important indicators in the VAR/VECM model
GDP Growth Rate (X8)	Represents the overall economic performance	Measuring the impact of monetary and fiscal policies on real output

The present model includes three endogenous variables $(\ln Y_1), (\ln Y_2), \text{and} (\ln Y_3)$ as dependent variables, alongside eight exogenous indicator variables denoted as $(\ln X_1), (X_2), (X_3), (X_4), (X_5), (\ln X_6), (X_7)$, and (X_8). For analytical purposes, several variables were transformed to their natural logarithmic forms to address issues such as heteroscedasticity and to enable elasticity-based interpretation in subsequent regression analyses. In the context of VAR/VECM estimation, all time series variables underwent preliminary stationarity assessment. Accordingly, data were analyzed at two distinct stages: (i) in levels, and (ii) after first differencing, consistent with the stationarity characteristics of each variable as determined by unit root tests (e.g., the Augmented Dickey-Fuller test). This approach ensures that the requirements for stationarity in VAR/VECM methodologies are rigorously satisfied, thereby supporting valid model estimation and inference.

Variable notation and transformation

- Targets (log level outstanding):
  $\ln Y_{1,t}$= **FOREIGN LOANS - ODA** (USD million)
  $\ln Y_{2,t}$= **GOVERNMENT DEBT SECURITIES (SUN)** (Rp billion)
  $\ln Y_{3,t}$= **STATE SHARIA SECURITIES (SBSN)** (Rp billion)
- Indicators :
  $\ln X_{1,t}$= Exchange rate (IDR/USD) — log
  $X_{2,t}$= LIBOR (3-month, % p.a.)

$X_{3,t}$= SIBOR (3-month, % p.a.)
$X_{4,t}$= US Prime Rate (% p.a.)
$X_{5,t}$= Japan Prime Rate (% p.a.)
$\ln X_{6,t}$= Foreign Exchange Reserves (miliar USD) — log
$X_{7,t}$= Inflation rate (%)
$X_{8,t}$= GDP growth rate (%)

for the three target variables, $\ln Y_{1,t}$, $\ln Y_{2,t}$, $\ln Y_{3,t}$, the VECM Model is written in the form of differential (short-term dynamics) plus the term error correction term derived from the long-term relationship (cointegration). Common models for each target:j = 1,2,3

$$\mathbf{DY}_t = \alpha\beta'\mathbf{Y}_{t-1} + \sum_{i=1}^{p-1} \mathbf{\Gamma}_i \mathbf{DY}_{t-i} + \mathbf{AX}_t + \mathbf{BDX}_t + \mathbf{\Phi D}_t + \epsilon_t$$

Table 5. Variable Operationalization

Symbol	General Meaning	Variable Type	Information
D(LNY1/LNY2 /LNY3)	Natural log changes of variable Y	Target (dependent variable)	Describe the growth or relative change between time of Y (Y1/Y2/Y3)
D(LNX1)	Natural log changes of variable X1	Indicators (explanatory variables)	Represents the X1 dynamic affecting Y
D(X2)	Changes from variable X2 (non-log)	Indicator	Reflects the actual change of X2 between periods
X3	Level values of X3 (non-differentiated)	Indicator	Left in the level because it is stationary or plays a role in the long-term equilibrium
D(X4)	Changes from X4	Indicator	Describe short-term variations of X4
D(X5,2)	Second differentiation from X5	Indicator	Indicates that X5 needs to be differentiated twice to achieve stationarity
LNX6	Natural logs of X6 (level)	Indicator	Left in the level because it is stationary or plays a role in the long-term equilibrium
D(X7)	Changes from X7	Indicator	Short-term dynamics of the X7
X8	Level value of X8	Indicator	Left in the level because it is stationary or plays a role in the long-term equilibrium

RESULTS AND DISCUSSION

VECM Analysis

The debt structure (Yn) in this study is a target variable and uses the definition of debt structure in the form of types of debt instruments: Loans and Securities. The research variables that are influenced or dependent on the variable (Yn) are in the form of Foreign Loans (Y1), Government Bonds (Y2) and State Sharia Securities (Y3) that have been transacted by the Indonesian government (outstanding). The economic factors of the influencing variables of the study (Xn), in the form of macroeconomic indicators: exchange rate (X1), LIBOR (X2), SIBOR (X3), U.S. Prime Rate (X4), Japan Prime Rate (X5), foreign exchange reserves (X6), inflation rate (X7), and GDP growth rate (X8). The research data period started from Q1:2010 to Q1:2010. Q1:2024 (57 Observations).

The Vector Error Correction Model (VECM) equation for D(LNY1/Y2/Y3) based on the results of the Eviews estimate is presented as follows:

(a)

$$D(LNY1)_t = \alpha_1 \cdot \text{CointEq1}_{t-1} + \gamma_{1,0} + \sum_{i=1}^{p-1} \gamma_{1,i} D(LNY1)_{t-i} + \sum_{j=1}^{p-1} \delta_{1,j} D(LNX1)_{t-j} + \\ + \sum_{l=1}^{p-1} \mu_{1,l} D(X3)_{t-l} + \sum_{m=1}^{p-1} \nu_{1,m} D(X4)_{t-m} + \sum_{n=1}^{p-1} \xi_{1,n} D(X5,2)_{t-n} + \sum_{o=1}^{p-1} \pi_{1,o} I \\ + \sum_{p=1}^{p-1} \rho_{1,p} D(X7)_{t-p} + \sum_{q=1}^{p-1} \sigma_{1,q} D(X8)_{t-q} + \epsilon_{1,t}$$

(b)

$$D(LNY2)_t = \alpha_1 \cdot \text{CointEq1}_{t-1} + \gamma_{1,0} + \sum_{i=1}^{p-1} \gamma_{1,i} D(LNY2)_{t-i} + \sum_{j=1}^{p-1} \delta_{1,j} D(LNX1)_{t-j} + \\ + \sum_{l=1}^{p-1} \mu_{1,l} D(X3)_{t-l} + \sum_{m=1}^{p-1} \nu_{1,m} D(X4)_{t-m} + \sum_{n=1}^{p-1} \xi_{1,n} D(X5,2)_{t-n} + \sum_{o=1}^{p-1} \pi_{1,o} I \\ + \sum_{p=1}^{p-1} \rho_{1,p} D(X7)_{t-p} + \sum_{q=1}^{p-1} \sigma_{1,q} D(X8)_{t-q} + \epsilon_{1,t}$$

(c)

$$D(LNY3)_t = \alpha_1 \cdot \text{CointEq1}_{t-1} + \gamma_{1,0} + \sum_{i=1}^{p-1} \gamma_{1,i} D(LNY3)_{t-i} + \sum_{j=1}^{p-1} \delta_{1,j} D(LNX1)_{t-j} + \\ + \sum_{l=1}^{p-1} \mu_{1,l} D(X3)_{t-l} + \sum_{m=1}^{p-1} \nu_{1,m} D(X4)_{t-m} + \sum_{n=1}^{p-1} \xi_{1,n} D(X5,2)_{t-n} + \sum_{o=1}^{p-1} \pi_{1,o} I \\ + \sum_{p=1}^{p-1} \rho_{1,p} D(X7)_{t-p} + \sum_{q=1}^{p-1} \sigma_{1,q} D(X8)_{t-q} + \epsilon_{1,t}$$

Where:

1. $D(LNY1/Y2/Y3)_t$ is the change in the natural logarithmic variable of Y1/Y2/Y3 in period t.
2. CointEq1_{t-1} is the **Error Correction Term (ECT),** which represents a long-term imbalance in the previous period.
3. α_1 is the ECT coefficient, which measures the adjustment speed of D(LN Y1/Y2/Y3) to long-term imbalances.
4. $\gamma_{1.0}$ is a constant (intercept).
5. $D(\cdot)_{t-i}$ is a change in variable i at lag i (short-term change).
6. $\varepsilon_{1,t}$ is the error term in period t.
7. p is the order lag in the VECM model. Based on the data, the lag assumption is 1 (the equation only includes $_{t-1}$).

Using the numerical coefficient of the relevant estimation result at lag 1, the Explicit VECM equation for D(LNY1) becomes:

$$
\begin{aligned}
D(LNY1)_t = (&-\mathbf{0.007621}) \cdot \text{CointEq1}_{t-1} + \mathbf{0.000305} \\
&+ (-\mathbf{0.012586}) \cdot D(LNY1)_{t-1} \\
&+ (-\mathbf{0.001923}) \cdot D(LNX1)_{t-1} \\
&+ (-\mathbf{0.000305}) \cdot D(X2)_{t-1} \\
&+ (\mathbf{0.000371}) \cdot D(X3)_{t-1} \\
&+ (\mathbf{0.000557}) \cdot D(X4)_{t-1} \\
&+ (-\mathbf{0.000003}) \cdot D(X5,2)_{t-1} \\
&+ (\mathbf{0.000371}) \cdot D(LNX6)_{t-1} \\
&+ (\mathbf{0.000742}) \cdot D(X7)_{t-1} \\
&+ (-\mathbf{0.000085}) \cdot D(X8)_{t-1} + \epsilon_{1,t}
\end{aligned}
$$

VECM Equation Analysis for D(LNY1)

Table 6. Error Correction Term (ECT) - Long-Term Adjustment

Coeficin	Value	T-statistics	P-Value	Analysis
α1 (ECT: CointEq1)	-7,621	[-3.12574]	33	The ECT coefficient is negative and statistically significant. This confirms the existence of a valid long-term correction mechanism. A value of -0.007621 means that 7.621% of the long-term imbalance in the previous period (t−1) will be corrected in the current period (t) through a change in D(LNY1).

The following table summarizes the short-term impact of changes in indicator variables on D(LNY1):

Table 7. Short-Run Coefficients

Independent Variables	Coeficin	T-statistics	Short-Term Impact Analysis on D(LNY1)
Constant (C)	305	[0.89381]	Basic intercepts. Statistically insignificant.
D(LNY1)t−1	-12,586	[-0.31602]	The dependent variable itself has a negative impact that is not significant on the current D(LNY1).
D(LNX1)t−1	-1,923	[-3.53509]	The increase in LNX1 changes in the previous period had a negative and significant impact on D(LNY1).
D(X2)t−1	-305	[-0.17646]	The increase in X2 changes in the previous period had a negative impact that was not significant on D(LNY1).
D(X3)t−1	371	[0.18731]	The increase in X3 changes in the previous period had a non-significant positive impact on D(LNY1).
D(X4)t−1	557	[2.73352]	The increase in X4 changes in the previous period had a positive and significant impact on D(LNY1).
D(X5,2)t−1	-3	[-0.07683]	The increase in X5.2 changes in the previous period had a very small and insignificant negative impact.

Independent Variables	Coeficin	T-statistics	Short-Term Impact Analysis on D(LNY1)
D(LNX6)t−1	371	[0.38042]	The increase in LNX6 changes in the previous period had a non-significant positive impact on D(LNY1).
D(X7)t−1	742	[1.27207]	The increase in X7 changes in the previous period had a negative impact that was not significant on D(LNY1).
D(X8)t−1	-85	[-2.03920]	The increase in X8 changes in the previous period had a negative and significant impact on D(LNY1) (possibly significant at the level of 5% or 10%).

This section summarizes the results of the Vector Error Correction Model (VECM) Equation Analysis for D(LNY1). The findings regarding the long-term relationship and the mechanism of adjustment back to equilibrium are presented in Table 6 (Error Correction Term - ECT). This ECT coefficient is crucial as it indicates the speed at which D(LNY1) converges to its long-run steady state following any short-term deviation. Furthermore, Table 7 (Short-Run Coefficients) provides a summary of the immediate impact of changes in the indicator variables, outlining the short-run dynamics and the momentary effects these variables have on D(LNY1).

Using the numerical coefficient of the relevant estimation result at lag 1, the Explicit VECM equation for D(LNY2) becomes:

$$
\begin{aligned}
D(LNY2)_t = {} & (-\mathbf{0.016335}) \cdot \text{CointEq1}_{t-1} + \mathbf{0.000305} \\
& + (-\mathbf{0.180295}) \cdot D(LNY2)_{t-1} \\
& + (-\mathbf{0.003920}) \cdot D(LNX1)_{t-1} \\
& + (-\mathbf{0.005479}) \cdot D(X2)_{t-1} \\
& + (\mathbf{0.008401}) \cdot D(X3)_{t-1} \\
& + (\mathbf{0.001602}) \cdot D(X4)_{t-1} \\
& + (\mathbf{0.000037}) \cdot D(X5,2)_{t-1} \\
& + (\mathbf{0.001097}) \cdot D(LNX6)_{t-1} \\
& + (\mathbf{0.001358}) \cdot D(X7)_{t-1} \\
& + (-\mathbf{0.000192}) \cdot D(X8)_{t-1} + \epsilon_{1,t}
\end{aligned}
$$

VECM Equation Analysis for D(LNY2)

Table 8. Error Correction Term (ECT) - Long-Term Adjustment

Coeficin	Value	T-statistics	P-Value	Analysis
α1 (ECT: CointEq1)	-16,335	[-5.47401]	0	The ECT coefficient is negative and very statistically significant (a very large t-statistical value in absolute terms). This confirms the existence of a strong long-term correction mechanism. A value of -0.016335 means that 1.6335% of the long-term imbalance in the previous period (t−1) will be corrected in the current period (t) through a change in D(LNY2).

The following table summarizes the short-term impact of changes in indicator variables on D(LNY2):

Table 9. Short-Run Coefficients

Independent Variables	Coeficin	T-statistics	Short-Term Impact Analysis on D(LNY2)
Constant (C)	305	[0.89381]	Basic intercept (change D(LNY2) when all other variables are zero). Statistically insignificant.
D(LNY2)t−1	-180,295	[-4.84652]	The dependent variable itself has a very significant negative relationship with the current D(LNY2), showing a strong mean-reversion or dynamic correction effect.
D(LNX1)t−1	-3,920	[-4.63935]	The increase in LNX1 changes in the previous period had a negative and significant impact on D(LNY2).
D(X2)t−1	-5,479	[-1.84920]	The increase in X2 changes in the previous period negatively affected D(LNY2).
D(X3)t−1	8,401	[3.18182]	The increase in X3 changes in the previous period had a positive and significant impact on D(LNY2).
D(X4)t−1	1,602	[4.07255]	The increase in X4 changes in the previous period had a positive and significant impact on D(LNY2).
D(X5,2)t−1	37	[0.81222]	The increase in X5.2 change in the previous period had a positive (small) impact on D(LNY2). Statistically insignificant.
D(LNX6)t−1	1,097	[1.02640]	The increase in LNX6 changes in the previous period had a positive impact on D(LNY2). Statistically insignificant.
D(X7)t−1	1,358	[1.90561]	The increase in X7 changes in the previous period had a positive impact on D(LNY2).
D(X8)t−1	-192	[-2.60742]	The increase in X8 changes in the previous period had a negative and significant impact on D(LNY2).

The analysis continues with the summarized results for the VECM equation focusing on the dependent variable D(LNY2). Consistent with the previous variable, the long-term cointegrating relationship and the speed of long-term correction are documented in Table 8 (Error Correction Term - ECT). This table is essential for understanding the stability of the long-run relationship involving D(LNY2). Subsequently, Table 9 (Short-Run Coefficients) offers a summary of the immediate impact of the indicator variables on D(LNY2), detailing the short-run elasticities and magnitudes of the transitory effects.

Explicit VECM Equation for D(LNY3)

Using the numerical coefficient of the relevant estimation result at lag 1, the Explicit VECM Model for D(LNY3) becomes:

$$
\begin{aligned}
D(LNY3)_t = & (-\mathbf{0.008984}) \cdot \text{CointEq1}_{t-1} + \mathbf{0.000490} \\
& + (-\mathbf{0.149234}) \cdot D(LNY3)_{t-1} \\
& + (\mathbf{0.001607}) \cdot D(LNX1)_{t-1} \\
& + (-\mathbf{0.002935}) \cdot D(X2)_{t-1} \\
& + (-\mathbf{0.005517}) \cdot D(X3)_{t-1} \\
& + (-\mathbf{0.000411}) \cdot D(X4)_{t-1} \\
& + (-\mathbf{0.000002}) \cdot D(X5,2)_{t-1} \\
& + (\mathbf{0.004456}) \cdot D(LNX6)_{t-1} \\
& + (-\mathbf{0.000572}) \cdot D(X7)_{t-1} \\
& + (\mathbf{0.000022}) \cdot D(X8)_{t-1} + \epsilon_{1,t}
\end{aligned}
$$

VECM Equation Analysis for D(LNY3)

Table 10. Error Correction Term (ECT) - Long-Term Adjustment

Coeficin	Value	T-statistics	P-Value	Analysis
α1 (ECT: CointEq1)	-8,984	[-3.19793]	25	The ECT coefficient is negative and statistically significant (since the p-value is generally assumed to be below 0.05 based on large t-statistics). This indicates the existence of a valid long-term correction mechanism. A value of -0.008984 means that 8.984% of the long-term imbalance in the previous period (t−1) will be corrected in the current period (t) through a change in D(LNY3).

The following table summarizes the short-term impact of changes in indicator variables on D(LNY3):

Table 11. Short-Run Coefficients

Independent Variables	Coeficin	T-statistics	Short-Term Impact Analysis on D(LNY3)
Constant (C)	490	[1.02636]	Basic intercept (change D(LNY3) when all other variables are zero).
D(LNY3)t−1	-149,234	[-3.18591]	The dependent variable itself (the change of D(LNY3) at the previous lag) has a significant negative relationship with the current D(LNY3).
D(LNX1)t−1	1,607	[3.18591]	The increase in LNX1 changes in the previous period had a positive impact on D(LNY3).
D(X2)t−1	-2,935	[-1.11986]	The increase in X2 changes in the previous period had a negative impact on D(LNY3).
D(X3)t−1	-5,517	[-2.31554]	The increase in X3 changes in the previous period negatively affected D(LNY3).
D(X4)t−1	-411	[1.46712]	The increase in X4 changes in the previous period had a negative impact on D(LNY3).

Independent Variables	Coeficin	T-statistics	Short-Term Impact Analysis on D(LNY3)
D(X5,2)t−1	-2	[-0.04018]	The increase in X5.2 change in the previous period had a negative (very small) impact on D(LNY3).
D(LNX6)t−1	4,456	[2.76672]	The increase in LNX6 changes in the previous period had a positive impact on D(LNY3).
D(X7)t−1	-572	[-0.70992]	The increase in X7 changes in the previous period negatively affected D(LNY3).
D(X8)t−1	22	[0.22237]	The increase in X8 changes in the previous period had a positive (very small) impact on D(LNY3).

Finally, the VECM analysis is concluded with the summary of the equation for D(LNY3). The results pertaining to the long-term adjustment and the corresponding ECT value are presented in Table 10 (Error Correction Term - ECT), which signifies the degree of correction applied to D(LNY3) in each period. Lastly, the short-term effects of the indicator variables on D(LNY3) are systematically summarized in Table 11 (Short-Run Coefficients). Together, these tables provide a complete overview of both the long-run equilibrium relationships and the short-run dynamics across all three dependent variables within the VECM system.

Beyond the individual equation analyses, a summary of the system-wide results is consolidated in Table 12. This table provides a holistic overview, integrating the key findings from the VECM analyses for D(LNY1/Y2/Y3). The overall summary facilitates a comparative assessment of the long-term adjustments (ECT) and the varying short-run impacts across all three dependent variables, thereby offering a comprehensive understanding of the interconnected dynamics within the entire system.

Table 12. Summary Table of VECM Results and Recommendations

Aspect	Y1_VECM	Y2_VECM	Y3_VECM
Cointegration & Error Correction	LNY1 is not significant; LNX1, X2, X5 are significant in error correction	LNY2 is not significant; X3 and X5 are significantly negative	X3 and X5 are significantly positive; LNY3, X2, X4, X6 are not significant
Short-Term Significance	LNX1 and X5 exhibit strong lag effects; X5 has broad impact	X3(-1), X8(-1), X5, X4 show significant short-term effects	X5(-1/-2) strongly influences X3; X4 and X7 exhibit contractive/self-correcting effects
Goodness-of-Fit (Highest R^2)	D(X5.3) = 0.83	D(X5,3) = 0.897	D(X5.3) = 0.878
Weak Variables (Low R^2)	D(X7,2) ≈ 0.27; D(X8) ≈ 0.32	D(X8) = 0.26; adj. R^2 is negative	D(X7,2) & D(X8) ≈ 0.26
Policy Focus	Stabilization of LNX1, X2, X5; investment incentives & price interventions	Targeting X3 & X5; counter-cyclical measures for X4 & X5	Spending efficiency (X5) & investment incentives (X3); counter-cyclical measures for X4 & X7
Evaluation & Monitoring	Evaluation needed for X7 & X8; special attention to LNY1	Evaluate X8; strengthen policy transmission	Evaluate X2 & X6; enhance monitoring systems

Analysis of Impulse Response Function (IRF) of VECM Estimation for D(LNY1)

Impulse Response Function (IRF) results from VECM estimation for D(LNY1) using Cholesky decomposition. Figure 4. shows the dynamic response of each variable to the shock of one standard deviation from another over the next 10 periods.

Based on the results of the Impulse Response Function (IRF) analysis of various innovations (shocks) on variables D(LNY1), D(LNX1), D(X2), X3, D(X4), D(X5,2), LNX6, D(X7), and X8, it can be concluded that there are diverse interaction dynamics between these variables. The growth of D(LNY1) is most affected by changes in D(LNX1) and X3, although the effects tend to be short-term and shrink to near zero. This shows that the influence of shocks on these key variables is quickly absorbed by the system. Meanwhile, variables such as D(LNX1), D(X4), LNX6, D(X7), and X8 exhibit dominant self-response—that is, they are heavily influenced by their own internal shocks. Notably, D(LNX1) and D(X4) showed rapid stabilization after internal shocks, indicating that the system is relatively stable to the internal shocks of these variables. In contrast, D(X5,2) exhibits a minimal response to all shocks, implying that these variables are inelastic or insensitive to the dynamics of other variables.

Variables D(X7) and X8 appear as the main sources of volatility in the system. D(X7) shows the largest and most volatile response among all variables, especially to its own shocks and X8, signaling high short-term instability. X8 itself exhibits a large positive self-response and dominates the dynamics of the system, making it a strong candidate as an important macro variable that drives the system as a whole. In terms of cross-interaction, the X3 variable acts as an important transmission channel, as seen from its direct influence on D(LNY1) and D(X2), as well as its high sensitivity to shocks from D(LNX1) and D(X5,2). Overall, although some variables show rapid adaptability to short-lived shock effects, the presence of D(X7) and X8 signifies that the system remains vulnerable to major shocks that can create significant volatility in the relevant market or sector.

Figure 4.

Analysis of Impulse Response Function (IRF) of VECM estimation results for D(LNY2)

Impulse Response Function (IRF) results from VECM estimation for D(LNY2) using Cholesky decomposition. Figure 5. shows the dynamic response of each variable to the shock of one standard deviation from another over the next 10 periods.

Based on the results of the Impulse Response Function (IRF) analysis of the VECM/VAR model with the main target variable D(LNY2) and supporting indicators, the system dynamics are dominated by strong internal influences on several key variables, as well as specific short-term causality interactions. The target variable D(LNY2) showed a dominant positive self-response at the beginning, but the shock effect of other indicator variables—such as D(LNX1), D(X2), and others—was relatively small and quickly subsided. This indicates that D(LNY2) has strong endogenous dynamics and is relatively isolated from shocks of other economic indicators. Similarly, D(LNX1) showed high persistence, with a stable positive self-response and was only slightly affected by LNX6. These two variables, D(LNY2) and D(LNX1), act as the main drivers whose changes are largely triggered by their own internal factors. Meanwhile, the variables X3 and D(X5,2) showed very little response to all innovations, making them either stable variables or having a weak exogenous influence on the overall dynamics of the system.

Figure 5.

In terms of cross-interactions, the system shows strong and specific linkages between variables. D(X2) is highly sensitive to the shock of D(LNY2), showing a significant positive spike at the outset, underscoring the close short-term causality relationship between the primary target and D(X2). The variable D(X4) is also reactive, showing a negative response to D(LNY2) and positive to LNX6, suggesting that D(X4) is affected by a combination of key macro factors. Furthermore, LNX6 is significantly affected by D(LNX1), indicating a structural relationship in which LNX6 follows changes in D(LNX1). The peak of system volatility lies at D(X7) and X8. D(X7) is highly volatile and is affected by shocks from D(LNX1) and LNX6. Meanwhile, X8 exhibits the greatest reactivity, absorbing the impact of D(LNY2) and D(X4) shocks, which reinforces X8's role as a shock absorber variable or a representation of macro indicators responsive to changes in the overall system, such as consumption rates or interest rates.

Analysis of Impulse Response Function (IRF) of VECM Estimation for D(LNY3)

Impulse Response Function (IRF) results from VECM estimation for D(LNY3) using Cholesky decomposition. Figure 6. shows the dynamic response of each variable to the shock of one standard deviation from another over the next 10 periods.

Figure 6.

The graphs showing the Impulse Response Functions (IRFs) derived from a VECM model, illustrating how each variable in the system reacts to a one-standard-deviation (Cholesky decomposed) innovation from the other variables. A general pattern across most responses indicates that the impact of innovations tends to be transient and relatively minor, subsiding quickly and often returning close to zero or settling at a very small magnitude within the 10-period horizon. For instance, the responses of variables such as LNY3, X3, and LNX6 to most innovations show only a small initial movement (either positive or negative) in periods 1 and 2, which then rapidly dissipates. This pattern suggests that shocks originating from other variables do not exert a significant or long-lasting effect on these variables, implying inherent stability in the system's dynamics where the effects of shocks are primarily temporary.

However, certain responses exhibit either higher volatility or a larger magnitude, particularly in the initial periods. Notably, the responses of D(X2) to various innovations display larger fluctuations, reaching peaks that are approximately 3 to 4 times greater (around 0.2 to 0.3) compared to the responses of other variables to similar shocks. Similarly, the Response of D(X4) to Innovations and Response of D(X7) to Innovations demonstrate more volatile and substantial initial responses, especially to their own shocks, with D(X7) showing an initial response reaching 1.0 to 1.2. These larger initial reactions point towards more significant interaction and adjustment among these specific variables. This indicates that certain variables (especially D(X2), D(X4), and D(X7)) may play a more central role in transmitting shocks within the system, although the overall effect of these shocks appears to be mainly short-lived.

Variance Decomposition Analysis of VECM Estimation for D(LNY1)

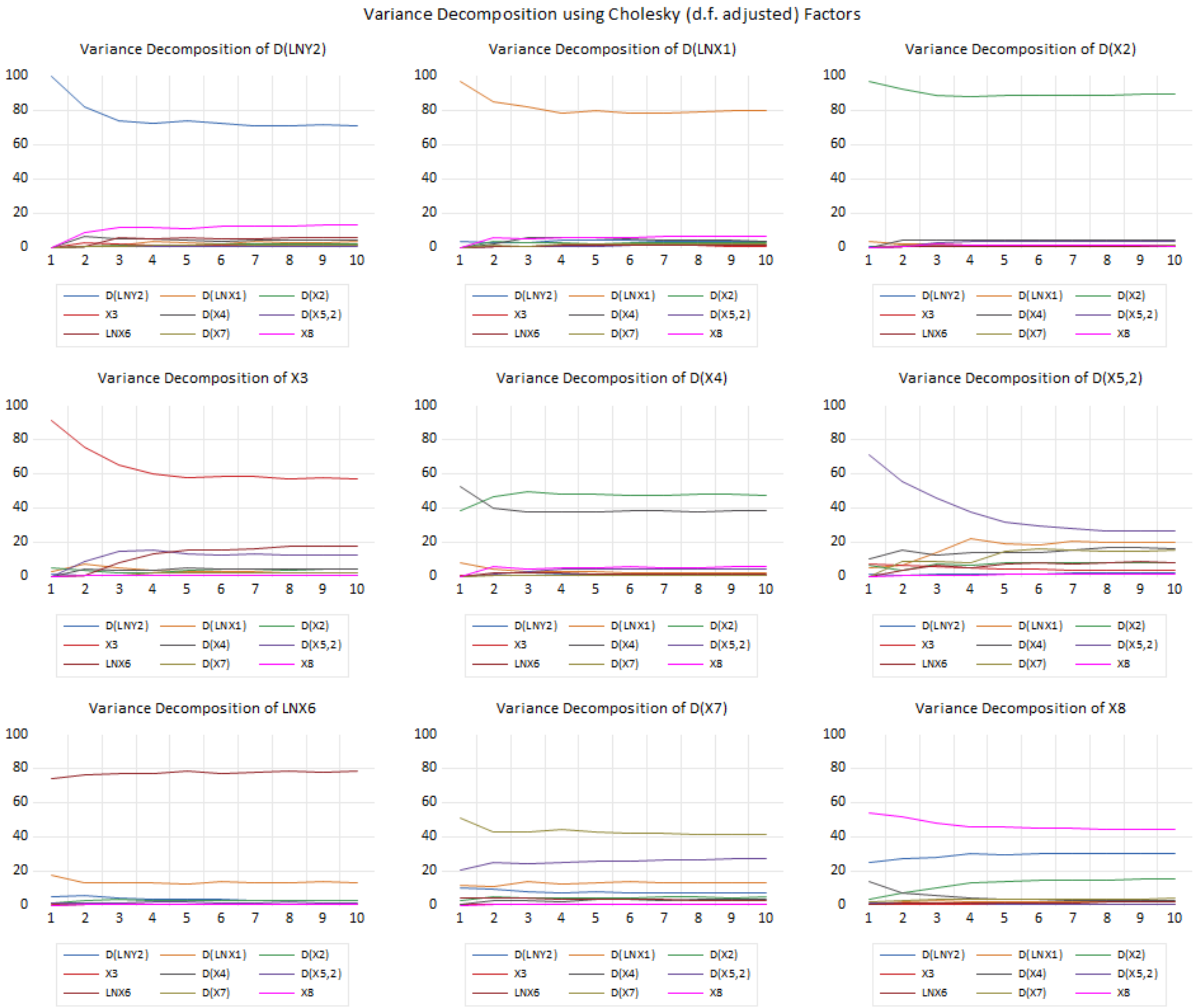
Figure 7.

In Figure 7, the Variance Decomposition (VD) analysis confirms that the short- and long-term dynamics of most variables are still dominated by their own (self-determined) internal shocks, but also highlights the central role of the LNX6 variable as a key driver in the system. Key variables such as D(LNY1), D(LNX1), D(X2), and LNX6 showed a self-dominated percentage contribution of variance, often exceeding 60% to 80% even in the 10th period, indicating that the shocks in these variables were largely explained by endogenous factors. Specifically, LNX6 maintains a very high internal contribution (>80%) over the time horizon, which implies its strong exogenous nature and makes it a prime candidate as an explanatory variable for the dynamics of other indicators.

The role of LNX6 as a key variable is further strengthened by its significant contribution to the variability of other variables. In D(X4), the variance is split between the internal contribution (~40-50%) and the increased contribution of LNX6 and D(X5.2) (~30-40%), indicating that D(X4) is a highly interdependent variable. Further, the variability on X3, D(X7), and X8 is also substantially affected by LNX6; for example, the contribution of LNX6 to the X3 variance increases significantly over time, and the X8 variance has a stable contribution of the LNX6 of about 30%. This pattern suggests that the shocks that occur in LNX6 have widespread and persistent implications for the dynamics of other variables, particularly D(X4), D(X7), and X8. Overall, the system is characterized by high internal stability on most variables, but vulnerability to external shocks is centered on LNX6, which acts as the main source of variability and shock transmission for the associated indicators.

Analysis of Variance Decomposition from VECM Estimation for D(LNY2)

Figure 8



In Figure 8., the Variance Decomposition (VD) analysis of the VECM estimation results for D(LNY2) shows a clear segregation between highly exogenous (self-contained) and highly endogenous (influenced) variables in the system over a time horizon of 10 periods. The highly exogenous group of variables is dominated by the main differentiation variables, namely D(LNX1), D(X2), LNX6, and D(X7). The contribution of variance to these variables is almost entirely (>80% to >95%) explained by its own internal shocks over the period, indicating that their fluctuations are highly stable and independent of the dynamics of other variables. D(LNY2) also showed high self-shock dominance, although minor influences from D(LNX1) and X3 began to be seen in the long term.

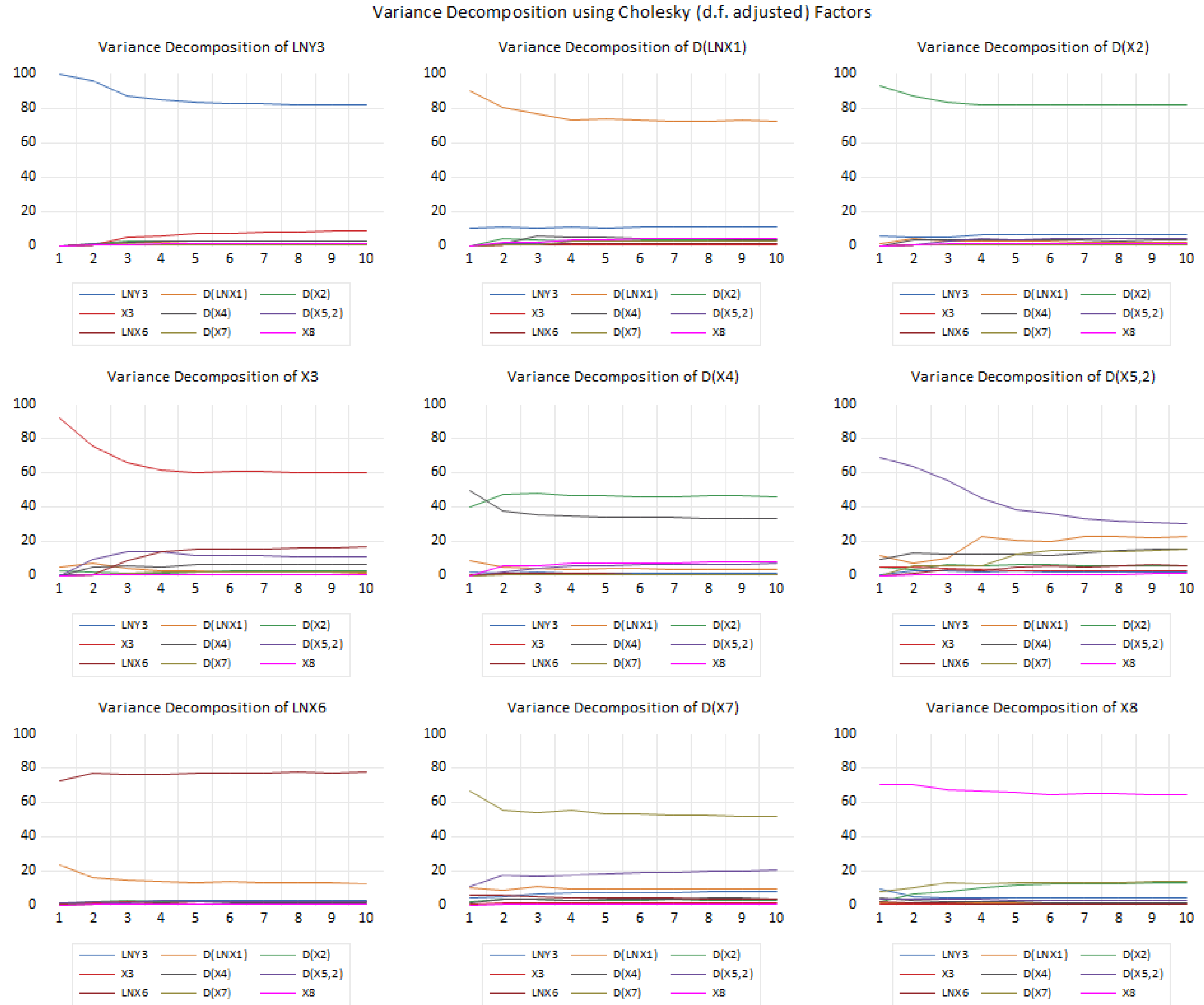
On the other hand, the variables X3, D(X4), and D(X5,2) form a highly endogenous group and are at the core of the shock transmission in the system. The variability of X3 that was initially dominated by itself (~90%) decreased significantly to 60% in the 10th period, with increased contributions from LNX6 and D(X5,2), making it the most influenced variable in the long term. X3 also acts as a major link, as evidenced by its substantial role in explaining the fluctuations of D(X4) (reaching about 40%) and D(X5,2). Reciprocally, D(X5,2) becomes increasingly responsive to changes in D(X4) and X3 over time, demonstrating a close and interdependent relationship between these three variables. Overall, the system is characterized by a stable foundation of exogenous variables (especially D(LNX1), D(X2), LNX6) and complex and interdependent fluctuations concentrated on endogenous variables X3, D(X4), and D(X5,2).

Analysis of Variance Decomposition from VECM Estimation for D(LNY3)

In Figure 9., the Variance Decomposition (VD) analysis shows a dynamic system that is divided into a group of highly exogenous (independent) variables and variables that have moderate interdependence in the long term. Most of the major variables—i.e. LNY3, D(X2), LNX6, and X8—exhibit very high levels of exogenicity, where their variance is dominated almost entirely (>80% to >90%) by their own internal shocks throughout periods 1 to 10. LNX6 stands out as the most exogenous and stable variable, with a self-contribution consistently above 90%, indicating its role as a structural or policy variable that is relatively unaffected by the dynamics of other economic variables in the system. The similar internal stability of the LNY3, D(X2), and X8 indicates their resistance to shock transmission from other variables.

Although the system generally appears stable with a high degree of self-shock dominance, there is an increased and important interdependence on the variables D(LNX1), D(X4), and D(X5,2) in the long term. The variability of D(LNX1) and D(X4), which was initially dominant internally, showed a slight decline over time, with increased contributions from D(X5,2) and LNX6. The strongest correlation occurs in D(X5,2), where the dominance of self-shock decreases most significantly, as the influence of D(X4) and D(LNX1 increases). This implies that D(X5,2) acts as the main shock transmission channel, connecting the dynamics of D(LNX1) (possible monetary/economic variables) and D(X4) (possible fiscal/real variables). Overall, the VD analysis concludes that although there are very stable and self-sufficient foundations (especially LNX6 and D(X2)), fluctuations in D(X5,2) are a key window into understanding how shocks from other sectors (particularly D(LNX1) and D(X4)) are spread out and affect each other over medium to long term.

Figure 9.



An in-depth interpretation of the results of the VECM estimation discusses its implications for understanding the short-term and long-term relationship between macroeconomic target variables (Y1,Y2,Y3) and a series of macroeconomic indicator variables (LNX1,X2,...,X8). The discussion builds on a VECM methodological framework that effectively separates short-term dynamics from adjustments towards long-term equilibrium, (Camba Jr et al., 2021).

Cointegration Relationship and Error Correction Mechanism (ECT)

The findings of cointegration in the three VECM models (Y1_VECM,Y2_VECM,Y3_VECM) confirm the existence of a long-term equilibrium relationship between the target variable and the underlying indicator. Significantly, the Error Correction Term (ECT) in the Y1 model shows that indicator variables such as LNX1, X2, and X5 play a role as the main adjusters towards equilibrium. The phenomenon in which the target variable (e.g. LNY1) itself is not necessarily significant in the error correction vector, but the indicator variable that is the determinant of policy/investment becomes the adjuster, is consistent with the cointegration and VECM literature, (Camba Jr et al., 2021).

This finding indicates that the shift in the long-run equilibrium of the target variable () is primarily determined by the structural dynamics of these indicators. Practically, if is the main fiscal variable, then the long-term stability of heavily relies on the fiscal management and budgetary allocation represented by . Policies aimed at altering the long-term trend of must target these main adjusting variables, (Morley & Ziesemer, 2024) .

Short-Term Dynamics and Policy Transmission

Analysis of short-term dynamics shows the presence of a strong transmission role of several indicators. In particular, the X5 variable exhibits a strong lag effect, affecting the target variable in subsequent periods, which is consistent with the role of X5 as the main transmission channel. In addition, variables such as X3, X4, X7, and X8 emerged as important contributors to short-term effects.

The significance of a particular lag coefficient in equations with a low R2 value (e.g. in equation D(X7,2)) is common in VECM models. This suggests that although most of the variability of such variables is difficult to explain by linear models, the specific effects of certain lags remain econometrically significant. The implication is that the X5 can be used as a rapid, short-term stabilization instrument, but its management must be closely monitored so as not to create an accumulation of structural imbalances that will be corrected by ECT, (Olayungbo, 2021).

Goodness-of-Fit dan Variabilitas Model

A high R2 value for the differential equation D(X5.3) (ranging from 0.83 to 0.897) indicates that the VECM model has excellent explanatory ability against X5 variations. This suggests that the dynamics of X5—which are assumed to be fiscal policy or investment variables—are highly structured and predictable in the system. In contrast, a low R2 value in equations D(X7) and D(X8) indicates high unexplained variability.

This implies the need for more advanced evaluation and modeling efforts. Variables with low R2 may be affected by exogenous shocks, institutional factors, or non-linear dynamics that cannot be captured by a simple linear VECM model. The methodological literature suggests the exploration of alternative models such as TVECM (Threshold VECM) or the addition of variables (variable-augmentation) to increase the predictability of these variables, (Ters & Urban, 2018).

Policy Implications and Empirical Comparisons

The results of the estimates lead to focused policy recommendations:

a. Long-Term Structural: The policy should target the key cointegration adjuster variables (LNX1, X2, X5 for Y1; X3, X5 for Y2 and X3,X5 for Y3) to shift the structural macroeconomic balance.
b. Short-Term Stabilization: Variables with strong lag effects (X5,X4) can be used as counter-cyclical instruments to address short-term economic shocks.

These findings are in line with empirical studies of VECM in macroeconomic contexts, which often identify fiscal/fiscal policy (X5) and investment/price shocks as determinants of long-term equilibrium and sources of strong short-term dynamics. Therefore, effective policies must integrate short-term stabilization measures with long-term structural reforms, (Ampofo et al., 2021)

Evaluation and Monitoring Recommendations

Although X7 and X8 show low R2, the results suggest a special evaluation for this variable, which is a good move. Variables that are not easily predictable but are politically significant can be a source of uncertainty or channel these important distributional/institutional effects, (Surugiu et al., 2021). To overcome the weaknesses of the model on this variable, it is recommended:

c. Improved frequency and data quality for X7 and X8.
d. Perform periodic coefficient stability testing (rolling/recursive VECM) or exploration of non-linear models, (Ters & Urban, 2018) .

e. Integrate a policy information system to monitor the effects of X5 transmission in real-time to prevent the accumulation of imbalances. This periodic monitoring approach is supported by the application of VECM in public sector and environmental management, (Stanciu & Mitu, 2025) .

Overall, the study reinforces the role of VECM in dissecting the complexity of macroeconomic policy transmission, highlighting dominant variables (X5) as short- and long-term determinants, while identifying areas that require further policy modeling and oversight (X7, X8).

Limitations and Cautions

Model specifications still need to be ascertained whether they conform to the correct order of integration of variables (I(1) generally for VECM) and that the deterministic (trend/constant) is set according to theory—errors per specification affect the Johansen/ECM results Robustness test: perform, (Johansen, 1991). alternative tests (ARDL, panel-VECM, TVECM) and sensitivity to lag length, deterministic, and sample period data, (Ters & Urban, 2018). omitted variables: weak variables (X7, X8) may require proxies or additional data (e.g. institutional indicators or leading indicators). Robustness was mentioned to validate the robustness of the results, alternative lag specifications and exogeneity tests were conducted, yielding consistent long-run relationships.

Recommendations for Future Research

Future research should focus on addressing these limitations by employing longitudinal designs to establish causality between leadership styles and organizational performance. Additionally, examining the impact of specific leadership behaviors, such as decision-making styles and conflict resolution approaches, could provide deeper insights into the mechanisms driving these relationships. Expanding research to include diverse industries and cultural contexts would further enhance the applicability of findings. Moreover, incorporating mixed-method approaches, such as combining quantitative surveys with qualitative interviews, could offer a more comprehensive understanding of leadership dynamics in varying organizational settings.

CONCLUSION

The results of the Vector Error Correction Model (VECM) estimation consistently underscore the dynamic and heterogeneous nature of the relationship between macroeconomic target variables (Y1, Y2, Y3) and related macroeconomic indicators. In the long term, the findings of cointegration show that the structural balance of the economic system is mainly determined by fiscal and investment factors, where the variables X5 (possible fiscal policy/public spending) together with LNX1 and X2 have a significant role in the error correction process towards equilibrium in the Y1 model, while X3 and X5 are dominant in the Y2 and Y3 models. This confirms that long-term stability depends on the management of indicators, not just direct intervention on the target variables themselves.

In short-term dynamics, the X5 variable has again emerged as the most responsive and broadly influential key factor across the model, demonstrating its strategic role as a rapid and effective policy transmission channel. Nonetheless, goodness-of-fit results show great variability; the differential equation involving X5 has a very high R2 value (0.83–0.897), indicating that the policy effects through this channel are relatively predictable and controllable. In contrast, variables such as X7 and X8 show low R2 values, implying structural instability or the need for improved data quality and additional instruments to strengthen policy effectiveness through these channels.

Overall, these VECM findings provide strong policy implications: The dominance of the X5 variable in determining both long-term equilibrium and short-term dynamics confirms that fiscal stabilization and the efficiency of public spending are key drivers of economic stability, which requires a consistent counter-cyclical approach. Strategic recommendations include optimizing the allocation of X5 spending towards the productive sector, strengthening the investment climate (X3.X2), price management (X4) to reduce short-term fluctuations, and increasing the effectiveness of policy transmission and digital monitoring systems on weak variables (X7.X8).

AUTHOR'S CONTRIBUTION STATEMENT

The findings of this study emphasize the importance of understanding the differentiated roles of variables within a dynamic economic system. The VECM approach demonstrates that adjustments to economic shocks are not simultaneous but depend on the variables acting as the main drivers of equilibrium. Therefore, effective macroeconomic policies should integrate short-term stabilization strategies with long-term structural reforms to ensure the sustainable maintenance of economic equilibrium.

CONFLICTS OF INTEREST

The authors declare that there are no potential conflicts of interest, whether financial or personal, with any parties or institutions that could influence the objectivity and impartiality in the preparation, analysis, or presentation of this research. This declaration is made to ensure the scientific integrity, transparency, and credibility of the findings presented in this article.

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ATTACHMENT
Table Data

NO			Exchange rate (IDR/USD)	LIBOR in USD (3 Monts) (% of Years)	SIBOR in USD (3 Monts) (% of Years)	US Prime Rates (% of Years)	Japan Prime Rates (% of Years)	Foreign Exchange Reserves (Billion USD)	Inflation Rate (%)	Gross Domestic Product Rate %	FOREIGN LOANS - ODA (USD Million)	GOVERNMENT DEBT SECURITIES (SUN) (Billions of Rupiah)	STATE SHARIA SECURITIES (SBSN) (Billions of Rupiah)
			LnX1	X2	X3	X4	X5	LnX6	x7	x8	LnY1	LnY2	LnY3
2010	Q1	1	9,12	0,29	0,29	3,25	1,60	11,18	3,4	5,59	10,96	13,26	10,22
2010	Q2	2	9,11	0,53	0,54	3,25	1,45	11,24	5	6,13	10,96	13,30	10,39
2010	Q3	3	9,10	0,29	0,29	3,25	1,45	11,37	5,8	5,8	11,01	13,34	10,49
2010	Q4	4	9,10	0,30	0,30	3,25	1,60	11,47	7	6,89	11,03	13,33	10,56
2011	Q1	5	9,07	0,30	0,31	3,25	1,60	11,57	6,7	6,45	11,04	13,37	10,90
2011	Q2	6	9,06	0,25	0,25	3,25	1,50	11,69	5,5	6,52	11,04	13,39	10,96
2011	Q3	7	9,09	0,37	0,37	3,25	1,40	11,65	4,6	6,49	11,05	13,40	10,98
2011	Q4	8	9,11	0,58	0,58	3,25	1,40	11,61	3,8	6,5	11,04	13,44	11,05
2012	Q1	9	9,12	0,47	0,47	3,25	1,35	11,61	4	6,29	11,02	13,47	11,31
2012	Q2	10	9,16	0,46	0,46	3,25	1,30	11,58	4,5	6,36	11,01	13,50	11,47
2012	Q3	11	9,17	0,36	0,37	3,25	1,25	11,61	4,3	6,16	11,03	13,53	11,49
2012	Q4	12	9,18	0,31	0,31	3,25	1,20	11,63	4,3	6,11	10,98	13,54	11,50
2013	Q1	13	9,18	0,28	0,28	3,25	1,15	11,56	5,9	6,02	10,94	13,58	11,61
2013	Q2	14	9,20	0,27	0,28	3,25	1,30	11,49	5,9	5,81	10,90	13,60	11,62
2013	Q3	15	9,36	0,25	0,25	3,25	1,30	11,47	8,4	5,62	10,90	13,66	11,69
2013	Q4	16	9,41	0,25	0,25	3,25	1,20	11,51	8,4	5,72	10,89	13,72	11,68
2014	Q1	17	9,34	0,23	0,25	3,25	1,20	11,54	7,32	5,21	10,90	13,79	11,79
2014	Q2	18	9,39	0,23	0,25	3,25	1,20	11,59	6,7	5,12	10,88	13,85	11,83
2014	Q3	19	9,41	0,24	0,25	3,25	1,15	11,62	4,53	2,96	10,84	13,90	11,88
2014	Q4	20	9,43	0,26	0,25	3,25	1,10	11,63	8,36	5,02	10,81	13,91	11,88
2015	Q1	21	9,48	0,27	0,25	3,25	1,15	11,62	6,29	4,71	10,79	13,97	12,09
2015	Q2	22	9,50	0,28	0,25	3,25	1,15	11,59	7,15	4,67	10,77	14,00	12,15
2015	Q3	23	9,59	0,32	0,25	3,25	1,10	11,53	7,18	4,73	10,81	14,03	12,13
2015	Q4	24	9,53	0,61	0,25	3,50	1,10	11,57	4,89	5,04	10,83	14,10	12,21
2016	Q1	25	9,49	0,63	0,25	3,50	0,95	11,59	4,45	4,92	10,86	14,13	12,62
2016	Q2	26	9,49	0,65	0,25	3,50	0,95	11,61	3,45	5,18	10,87	14,18	12,45
2016	Q3	27	9,47	0,85	0,25	3,50	0,95	11,66	3,07	5,02	10,88	14,23	12,55
2016	Q4	28	9,51	1,00	0,25	3,75	0,95	11,66	3,02	4,94	10,84	14,24	12,56
2017	Q1	29	9,50	1,15	0,25	4,00	0,95	11,71	3,61	5,01	10,86	14,30	12,66
2017	Q2	30	9,50	1,30	0,25	4,25	0,95	11,72	4,37	5,01	10,85	14,32	12,73
2017	Q3	31	9,51	1,33	0,25	4,25	1,00	11,77	3,72	5,06	10,85	14,36	12,82
2017	Q4	32	9,51	1,69	0,25	4,50	1,00	11,78	3,61	5,19	10,85	14,39	12,85
2018	Q1	33	9,53	2,31	0,25	4,75	1,00	11,74	3,4	5,10	10,83	14,44	12,82
2018	Q2	34	9,58	2,34	0,25	5,00	1,00	11,69	3,1	5,30	10,79	14,43	12,88
2018	Q3	35	9,61	2,40	0,25	5,25	1,00	11,65	2,9	5,20	10,81	14,48	12,94
2018	Q4	36	9,58	2,81	0,25	5,50	1,00	11,70	3,1	5,20	10,83	14,50	12,98
2019	Q1	37	9,56	2,60	0,25	5,50	1,00	11,73	2,5	5,10	10,83	14,57	13,05
2019	Q2	38	9,56	2,32	0,25	5,50	1,00	11,73	3,3	5,10	10,84	14,57	13,04
2019	Q3	39	9,56	2,09	0,25	5,00	0,95	11,73	3,4	5,00	10,83	14,62	13,12
2019	Q4	40	9,54	1,91	0,25	4,75	0,95	11,77	2,7	5,00	10,83	14,64	13,18
2020	Q1	41	9,70	1,45	0,25	3,25	0,95	11,70	3	3,00	10,83	14,68	13,16
2020	Q2	42	9,57	0,30	0,25	3,25	1,05	11,79	2	-5,30	10,83	14,75	13,33
2020	Q3	43	9,61	0,23	0,25	3,25	1,00	11,81	1,4	-3,50	10,88	14,87	13,39
2020	Q4	44	9,55	0,24	0,25	3,25	1,00	11,82	1,7	-2,20	10,93	14,98	13,49
2021	Q1	45	9,59	0,19	0,25	3,25	1,00	11,83	1,4	-0,70	10,90	15,04	13,59
2021	Q2	46	9,58	0,15	0,25	3,25	1,00	11,83	1,3	7,10	10,89	15,08	13,56
2021	Q3	47	9,57	0,13	0,25	3,25	1,00	11,90	1,6	3,50	10,88	15,11	13,67
2021	Q4	48	9,57	0,21	0,25	3,25	1,00	11,88	1,9	5,00	10,88	15,17	13,67
2022	Q1	49	9,57	0,96	0,25	3,50	1,10	11,84	2,6	5,00	10,88	15,21	13,65
2022	Q2	50	9,61	2,29	0,25	4,75	1,20	11,82	4,4	5,50	10,84	15,20	13,70
2022	Q3	51	9,63	3,75	0,25	6,25	1,25	11,78	6	5,70	10,80	15,24	13,79
2022	Q4	52	9,66	4,77	0,25	7,50	1,25	11,83	5,5	5,00	10,85	15,29	13,81
2023	Q1	53	9,62	5,19	0,25	8,00	1,45	11,89	5	5,00	10,87	15,32	13,87
2023	Q2	54	9,62	5,55	0,25	8,25	1,30	11,83	3,5	5,20	10,85	15,32	13,87
2023	Q3	55	9,65	5,66	0,25	8,50	1,45	11,81	2,3	4,90	10,83	15,33	13,87
2023	Q4	56	9,64	5,59	0,25	8,50	1,50	11,89	2,6	5,00	10,90	15,36	13,88
2024	Q1	57	9,67	5,56	0,25	8,50	1,60	11,85	3,1	5,10	10,88	15,35	13,96
2024	Q2	58	9,71	5,59	0,25	8,50	1,80	11,85	2,5	5,10	10,87	15,36	14,03
2024	Q3	59	9,62	4,85	0,25	8,00	1,70	11,92	1,8	5,00	10,90	15,39	14,02
2024	Q4	60	9,69	5,2661	0,25	7,50	1,90	11,96	1,6	5,03	10,89	15,41	14,02
2025	Q1	61	9,72	5,4926	0,25	7,50	2,35	11,96	1,03	4,87	10,89	15,44	14,04
2025	Q2	62	9,69	5,7241	0,25	7,50	2,25	11,94	1,87	5,12	10,92	15,44	14,11