

Asynchronous Transmission of Global Uncertainty Across Credit Risk Channels

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Abstract

Global economic uncertainty has become an increasingly important source of financial vulnerability, particularly in emerging economies with bank-based financial systems. In Indonesia, aggregate indicators such as the Non-Performing Loan ratio have remained relatively stable despite heightened global uncertainty, potentially masking underlying changes in credit risk dynamics. This study argues that reliance on aggregate measures alone may be misleading, as credit risk is multidimensional and may respond heterogeneously to external shocks. To address this limitation, this study adopts a credit risk decomposition framework, separating total credit risk into inherent credit risk, driven by borrower fundamentals and macroeconomic conditions, and mispricing credit risk, arising from banks' lending behavior and risk assessment inefficiencies. Using quarterly data for 33 publicly listed Indonesian banks over the period 2010-2022, credit risk is decomposed through a Stochastic Frontier Analysis. The transmission of global uncertainty - proxied by the Global Economic Policy Uncertainty Index - is examined using a panel Feasible Generalized Least Squares approach. The results reveal an asynchronous transmission of global uncertainty across credit risk components. Rising global uncertainty significantly increases inherent credit risk, reflecting deteriorating borrower conditions, while simultaneously reducing mispricing credit risk, indicating more cautious bank behavior. These findings highlight the limitations of aggregate credit risk indicators and underscore the importance of a compositional approach to financial stability analysis, particularly in emerging economies exposed to global shocks.

Categories: International financial markets and institutions, International monetary system, Risk Management

Keywords: gepu, bank, credit risk, inherent risk, mispricing risk

JEL Classifications: E52, G21, C33

Introduction

Global economic uncertainty has become an increasingly influential force shaping financial stability, particularly in emerging and bank-based economies. Heightened uncertainty, arising from volatile global financial conditions, shifts in monetary policy in advanced economies, geopolitical tensions, and policy unpredictability, can weaken real economic activity, disrupt capital flows, and alter risk perceptions in domestic financial systems (Baker et al., 2016) (Bloom, 2016). For developing countries such as Indonesia, where financial intermediation relies heavily on the banking sector, these external shocks are transmitted primarily through credit markets, making credit risk a central channel of vulnerability (Borio, 2014) (Brunnermeier and Oehmke, 2013).

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In this context, the stability of the Non-Performing Loan (NPL) ratio is often interpreted as evidence of banking sector resilience. Indonesia provides a representative case. Despite repeated episodes of global financial stress and rising global policy uncertainty, aggregate NPL ratios have remained relatively stable and below regulatory thresholds for more than a decade. This pattern appears to suggest that Indonesian banks are resilient to global disruptions. Yet it remains questionable whether aggregate indicators alone are sufficient to capture the full picture of credit risk dynamics. A bank may report stable NPLs while simultaneously experiencing rising borrower default risk due to weakening macroeconomic conditions, offset by reduced mispricing risk from tighter lending standards. The net effect on aggregate NPLs could be negligible, yet the underlying risk profile may have shifted fundamentally. During periods of apparent financial calm, risks may not disappear but instead be reallocated across different sources, remaining undetected until adverse conditions intensify (Acharya, 2009), (Borio, 2014), and (Laeven and Valencia, 2018).

A key limitation of the existing literature lies in its treatment of credit risk as a homogeneous phenomenon. Most empirical studies implicitly assume that all non-performing loans respond uniformly to external shocks, including global uncertainty and monetary tightening. This assumption is particularly restrictive in emerging economies, as credit risk is generated through structurally different mechanisms. Some defaults arise from structural weaknesses in borrowers' balance sheets and adverse macroeconomic conditions, while others stem from banks' own lending behavior, such as lax screening, excessive risk-taking, or mispricing of credit during expansionary phases (Berger and DeYoung, 1997), (Dell'ariccia et al., 2017), and (Foos et al., 2010). When these distinct sources of risk move in opposite directions, aggregate NPL indicators may appear stable, even though the underlying risk structure is changing substantially.

This study departs from the aggregate approach by adopting a framework for credit risk decomposition, following the methodology proposed by Hughes and Moon (Hughes and Moon, 2022). Rather than focusing solely on total NPLs, this study separates credit risk into two structurally distinct components: inherent credit risk and mispricing credit risk. Inherent credit risk represents the minimum level of default risk that cannot be avoided and is driven by borrower fundamentals, macroeconomic conditions, and structural characteristics of the economy. In contrast, mispricing credit risk captures excess risk arising from banks' internal inefficiencies, inappropriate risk assessment, or overly aggressive lending behavior. This distinction enables a clearer identification of how different sources of credit risk evolve in response to external shocks.

Using this framework, the study examines how Global Economic Policy Uncertainty (GEPU) is transmitted to the Indonesian banking sector. Global uncertainty is expected to affect credit risk through multiple, potentially conflicting channels. On the one hand, heightened uncertainty reduces investment, weakens aggregate demand, and increases funding costs, thereby deteriorating borrowers' repayment capacity and increasing inherent credit risk (Basu and Bundick, 2017), (Bloom, 2016), and (Hantzsche, 2022). On the other hand, the same uncertainty may induce banks to behave more cautiously, tighten credit standards, and restrain risk-taking, thereby reducing mispricing credit risk through the risk-taking channel of financial intermediation (Adrian and Brunnermeier, 2016) (Borio and Zhu, 2012). Consequently, the transmission of global uncertainty to credit risk is unlikely to be uniform and may instead occur asynchronously across different risk components.

This mechanism is closely aligned with the Financial Instability Hypothesis proposed by Hyman Minsky (Minsky, 1986) (Minsky, 1992). The hypothesis argues that periods of stability and optimism encourage risk-taking and credit mispricing, while periods of heightened uncertainty and financial stress induce more conservative behavior. During episodes of rising uncertainty, banks tend to retrench and adopt stricter lending practices, reducing mispricing risk, even as structural pressures on borrowers intensify and inherent credit risk rises. Despite its strong theoretical appeal, this asymmetric and asynchronous transmission mechanism has rarely been tested empirically using decomposed credit risk measures, particularly in developing and bank-based economies.

This study further considers the role of monetary policy in shaping the transmission of global uncertainty to credit risk. In developing economies, policy interest rates frequently respond to global financial conditions, either directly or indirectly. While tighter monetary policy may help curb excessive bank risk-taking, it can simultaneously amplify borrowers' debt-

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servicing burdens and weaken balance sheets, thereby increasing inherent credit risk (Borio, 2014) (Hantzsche, 2022). Ignoring this interaction risks overstating the stabilizing role of interest rate-based monetary policy during periods of heightened global uncertainty.

By focusing on Indonesia as a representative bank-based emerging economy, this study makes three main contributions. First, it provides new empirical evidence on how global uncertainty affects credit risk beyond aggregate indicators, highlighting the importance of a compositional perspective. Second, it demonstrates that global uncertainty is transmitted asynchronously across different components of credit risk, strengthening banking discipline while exacerbating structural vulnerabilities in the real sector. Third, it shows that interest rate-based monetary policy operates in an ambiguous and potentially pro-cyclical manner, underscoring the need for a more comprehensive policy framework that integrates monetary and macroprudential instruments.

Overall, this study argues that assessing financial stability in emerging economies requires moving beyond aggregate measures of credit risk. Understanding how global uncertainty reshapes the internal structure of credit risk is essential for designing effective and context-sensitive policy responses in an increasingly uncertain global environment.

Research Method

Decomposition of NPLs through a stochastic frontier approach

Following Hughes and Moon (Hughes and Moon, 2022), this study employs a Stochastic Frontier Analysis (SFA) to decompose bank credit risk into two structurally distinct components: inherent credit risk and mispricing credit risk. The central idea of this approach is that observed NPLs consist of a minimum, unavoidable level of risk determined by borrower fundamentals and macroeconomic conditions, and an excess component arising from inefficient or overly aggressive lending behavior by banks.

Formally, the stochastic frontier model follows Equation (1):

$$\text{NPL}_{it} = f(Z_{it}; \beta) + v_{it} + u_{it} \dots (1)$$

where NPL_{it} denotes the observed gross NPL ratio of bank i at time t , and $f(Z_{it}; \beta)$ represents the deterministic frontier function, capturing the minimum achievable level of NPLs given a set of bank-specific and macroeconomic characteristics Z_{it} . These controls include bank size (log of total assets), capital adequacy ratio (CAR), loan-to-deposit ratio (LDR), operational expense ratio (OER), policy interest rate, and economic growth.

The error term follows a composed structure. The symmetric component $v_{it} \sim \mathcal{N}(0, \sigma_v^2)$ captures random shocks and measurement errors beyond managerial control, while the one-sided component $u_{it} \geq 0$ reflects inefficiency in credit allocation and monitoring. Consistent with the standard SFA literature, the inefficiency term u_{it} is assumed to follow a half-normal distribution (Aigner et al., 1977) (Jondrow et al., 1982).

Within this framework, inherent credit risk is defined as the frontier level of NPLs, as shown in Equation (2):

$$\text{ICR}_{it} = f(Z_{it}; \beta) + v_{it} \dots (2)$$

This component reflects the minimum level of credit risk that persists even under best-practice lending behavior, driven by borrower fundamentals, macroeconomic conditions, and structural characteristics of the economy. In contrast, mispricing credit risk is measured as the excess risk above the frontier, as shown in Equation (3):

$$\text{MCR}_{it} = u_{it} \dots (3)$$

Mispricing credit risk therefore captures credit losses arising from errors in credit evaluation, monitoring failures, or overly aggressive risk-taking behavior by banks. The decomposition allows for a clear separation between structurally unavoidable credit risk and risk stemming from bank behavior.

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The stochastic frontier is estimated using maximum likelihood methods. Small negative values of estimated inherent risk may arise due to statistical noise; however, the analysis focuses on relative dynamics and cross-sectional variation rather than absolute levels, following standard practice in the SFA-based credit risk literature.

The half-normal distribution for the inefficiency term u_{it} follows standard practice in banking efficiency studies (Aigner et al., 1977) (Jondrow et al., 1982). It accommodates a mode at zero with strictly positive values, reflecting that most banks operate near best practice while some exhibit positive inefficiency. Alternative distributions (truncated normal or exponential) yield similar rank-order correlations.

A small number of bank-quarter observations yield slightly negative values for inherent credit risk. This occurs because the stochastic frontier allows the symmetric error term v_{it} to take negative values, which can push the estimated frontier residual below zero when the true inherent risk is near zero and statistical noise is present. Following Hughes and Moon (Hughes and Moon, 2022), these small negative values are not treated as economically meaningful but are retained because they preserve the relative ranking and covariance structure of the data. Truncating them at zero would introduce systematic bias. All main results are robust to excluding observations with negative inherent risk.

Model estimation

To identify the impact of global uncertainty on the credit risk behavior of Indonesian banks, this study employs the Feasible Generalized Least Squares (FGLS) approach within a panel data framework. This method is chosen for its ability to address common technical challenges often encountered in long-panel data, such as heteroskedasticity, serial autocorrelation, and cross-sectional dependence.

Unlike Ordinary Least Squares (OLS) or Fixed Effects (FE) estimators, which can yield inefficient results when classical assumptions are violated - FGLS allows for a comprehensive correction of the error term's covariance structure, resulting in more efficient and consistent parameter estimates. This is particularly important in the context of this study, as the dataset spans a long time period but includes a relatively small number of banking units (Hu and Zhu, 2025).

By using FGLS, the model can effectively capture the dynamic responses of credit risk - both in aggregate form and disaggregated into inherent and underpricing-related components - to fluctuations in global uncertainty, as measured by the GEPU Index, while also accounting for the complex variance structure within the banking sector panel data. The basic model follows equation (4).

$$\text{TCR}_{it} = \alpha_0 + \beta_1 \text{EU}_t + \gamma' \mathbf{Z}_{it} + \text{Bank FE} + e_{it} \dots (4)$$

With TCR representing the type of risk, α_0 is the constant, EU is economic uncertainty, $\mathbf{Z}_{it}$ represents the control variables, and e_{it} is the error term. This model also includes the bank FE.

Variable and data

Global uncertainty in this study is measured using the Index GEPU developed by Baker et al. (Baker et al., 2016). The GEPU Index is constructed from newspaper coverage in major economies (US, China, Eurozone, Japan, UK) and is therefore exogenous to the credit risk outcomes of individual Indonesian banks. This index is widely recognized as one of the primary proxies for capturing economic policy uncertainty across countries. Based on a textual analysis of media coverage from major economies, GEPU represents the systemic dimension of uncertainty that has global implications, particularly regarding the direction and consistency of economic policy. Unlike the Volatility Index (VIX), which primarily reflects short-term financial market volatility, GEPU is considered more relevant in the banking context as it captures macroeconomic uncertainty that directly influences investment behavior and credit risk-taking. Nonetheless, the VIX is also employed as an alternative proxy for global uncertainty.

Given Indonesia's open and externally sensitive economic structure, GEPU is adopted as the primary measure of global uncertainty in this study. To control for domestic macroeconomic conditions, economic growth is included as a variable representing real sector pressures that affect borrowers' capacity to meet credit obligations. In addition, exchange rate

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volatility is incorporated due to its role as a natural adjustment mechanism to external shocks. To capture policy responses, the study uses the policy interest rate as a key variable reflecting the stance of domestic monetary policy in the face of global pressures. Detailed operational definitions of all variables can be found in Table 7.

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Variables	Description
Global Economic Policy Uncertainty (GEPU)	An index that measures the level of global economic policy uncertainty based on textual analysis of media from major countries.
Credit risk (CR)	The total NPL ratio reflects the overall level of credit risk faced by the bank, without distinguishing the source of the risk.
Inherent credit risk (ICR)	Credit risk components that originate from the fundamental conditions of the debtor and external macroeconomic factors, regardless of the bank's internal efficiency.
Mispricing credit risk (MCR)	Credit risk that arises due to errors in assessment or underpricing by banks in the loan granting process.
Credit	Used as a measure of bank risk exposure. Larger credits reflect a higher scale of intermediation and may increase the potential for NPLs.
Asset	Represents the size and capacity of the bank
Loan to deposit ratio (LDR)	Measuring the aggressiveness of fund distribution. This ratio shows the extent to which the bank uses third party funds to distribute credit.
Capital Adequacy Ratio (CAR)	Describes the bank's capital capacity to absorb losses
Operating Expense Ratio (OER)	Used as an indicator of bank operational efficiency. High operational costs are often associated with weak governance and management quality.
Economic Growth (EG)	The growth rate of Gross Domestic Product (GDP) which reflects domestic macroeconomic conditions and the resilience of debtors in meeting their credit obligations.
Exchange Rate (ER)	Volatility of IDR exchange rate measured as the standard deviation of daily percentage changes over a rolling 4-quarter (88 trading days) window, then averaged across quarters.
Interest Rate (IR)	The policy interest rate set by the monetary authority is used as a signal of policy stance and a key determinant of the funding costs of borrowers and banks.
Volatility index (VIX)	An index that reflects expectations of short-term financial market volatility in the United States, often used as a proxy for global market uncertainty and investor risk sentiment.

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TABLE 1: Operational variable

NPL, Non-Performing Loan

This study uses quarterly data from 2010 to 2022, covering a cross-section of 33 publicly listed banks in Indonesia. Banking-related variables are obtained from the Indonesian Banking Statistics published by the Indonesian Financial Services Authority ([Indonesian Financial Services Authority, 2026](#)). Total loans refer to credit extended to non-bank third parties, and credit risk is measured using the gross NPL ratio. Data on interest rates, gross domestic product, and economic growth are sourced from Statistics Indonesia ([Statistics Indonesia, 2026](#)) (Badan Pusat Statistik, BPS). Global economic uncertainty is proxied by the GEPU Index ([GEPU Index, 2026](#)), while the VIX ([VIX, 2026](#)) data are retrieved from Investing.com.

Results And Discussion

Descriptive statistics

The characteristics of the variables used in the analysis are presented in Table 2. With a mean value of 1.857 and a standard deviation of 0.634, the GEPU Index indicates that global uncertainty remained moderate throughout the observation period while exhibiting significant variation over time. With an average credit risk of 0.029, the stability of Indonesian banking NPLs is evident. However, the decomposition results indicate very different fundamental dynamics.

Variable(s)	Obs.	Mean	SD	Max	Min
Global Economic Policy Uncertainty (GEPU)	1,716	1.857	0.634	3.240	0.917
Credit risk (CR)	1,716	0.029	0.025	0.346	0.010
Inherent credit risk (ICR)	1,674	0.028	0.026	0.345	-0.002
Mispricing credit risk (MCR)	1,674	0.001	0.000	0.002	0.0008
Credit (million IDR)	1,716	9.30e+07	1.71e+08	1.00e+09	93506
Asset (million IDR)	1,716	1.47e+08	2.72e+08	1.80e+09	210037
Loan to deposit ratio (LDR)	1,716	0.808	0.252	2.104	0.000
Capital Adequacy Ratio (CAR)	1,716	0.222	0.455	16.990	0.001
Operating Expense Ratio (OER)	1,716	0.83	0.290	3.153	0.007
Economic Growth (EG)	1,716	0.045	0.028	0.111	-0.016
Exchange Rate (ER)	1,716	0.002	0.001	0.0005	0.000
Interest Rate (IR)	1,716	5.649	1.332	0.065	0.035
Volatility index (VIX)	1,716	3.256	0.1482	3.728	2.978

TABLE 2: Descriptive statistics

Source: Banking-related variables were obtained from the Indonesian Banking Statistics published by the Indonesian Financial Services Authority ([Indonesian Financial Services Authority, 2026](#)). Economic growth data were sourced from Statistics Indonesia ([Statistics Indonesia, 2026](#)). Global economic uncertainty is proxied by the GEPU Index ([GEPU Index, 2026](#)), while the VIX ([VIX, 2026](#)) data are retrieved from Investing.com.

With a mean value of 0.028 and a standard deviation of 0.026 inherent credit risk exhibits significant variation and is a major component of overall credit risk. This pattern indicates the borrower's sensitivity to macroeconomic factors, including funding costs, economic growth conditions, and exchange rate fluctuations. However, mispricing credit risk is

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very low, with a mean value of only 0.001 and very low dispersion. These results indicate that credit risk arising from bank misjudgments or inappropriate pricing behavior is relatively stable and well-controlled across the banking sample.

Bank-specific characteristics, such as total credits and total assets, exhibit significant heterogeneity, reflecting differences in operational scale across banks. The average LDR of around 0.808 indicates an active intermediation function. In contrast, differences in the capital adequacy and operating expense ratios indicate variations in capital strength and operational efficiency across institutions. Macroeconomic factors such as exchange rate fluctuations, interest rates, and economic growth exhibit relatively stable patterns over the sample period. However, they remain relevant as channels through which domestic and international disturbances flow into credit risk.

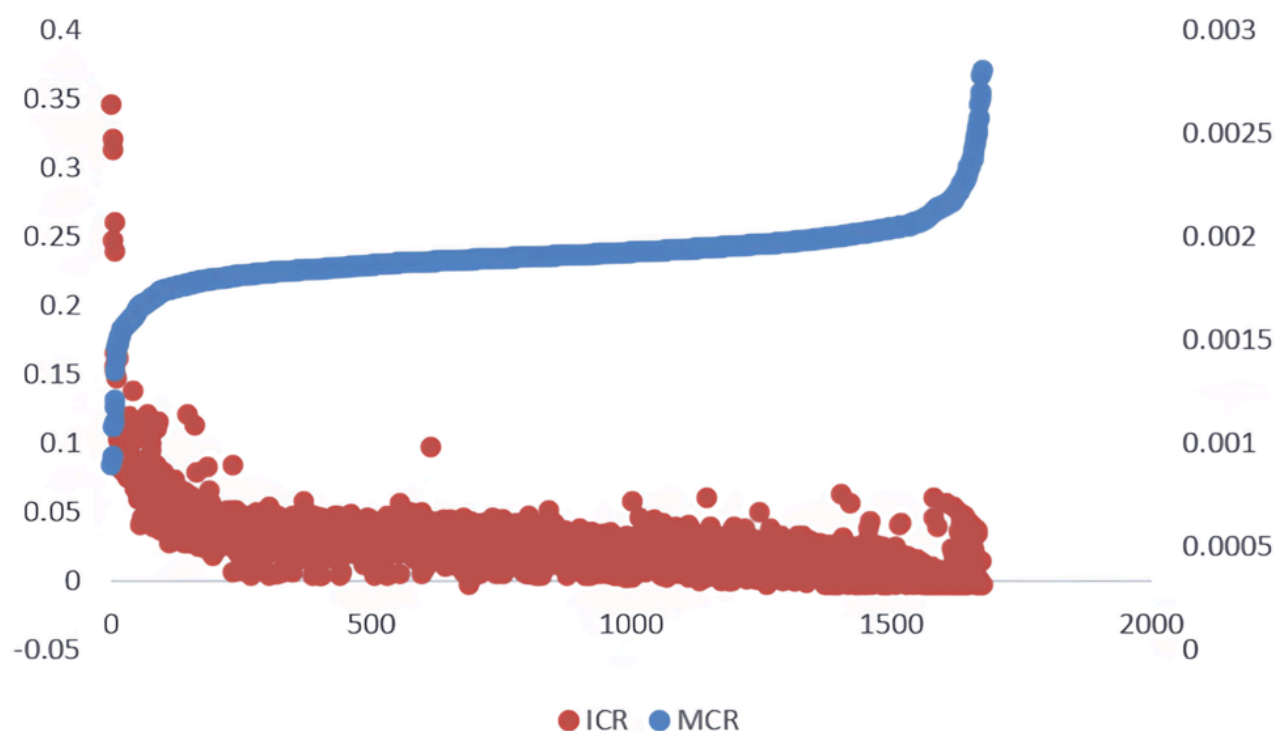


FIGURE 1: Credit risk structure

Note: The left vertical axis represents Inherent Credit Risk (ICR), while the right vertical axis represents Mispricing Credit Risk (MCR).

Figure 1 further illustrates the structure of credit risk by highlighting a pronounced distinction between inherent credit risk and mispricing-driven credit risk. Inherent risk is consistently higher and displays considerable variation over the observation period, while mispricing risk remains low and largely stable. This visual evidence supports the conclusion that credit risk in the Indonesian banking industry is primarily driven by structural elements related to borrower conditions rather than errors in credit allocation practices.

Overall, Table 2 and Figure 1 demonstrate the critical importance of a decomposition approach for credit risk analysis. Although the aggregate NPL indicator shows stability, its internal components exhibit risk dynamics that are more sensitive to macroeconomic changes. These results suggest that financial stability policies should focus on structural risk channels rather than aggregate credit risk indicators.

Global uncertainty

The results of this study indicate that global uncertainty, as measured by the GEPU Index, significantly affects credit risk in the Indonesian banking sector. However, the decomposition analysis reveals that this effect is not uniform but differs markedly across distinct components of credit risk.

Table 3 shows that rising global uncertainty is consistently associated with higher aggregate credit risk, as reflected in an increase in total NPLs. This finding suggests that external pressures, such as uncertainty regarding economic policy direction in major economies, commodity price volatility, and fluctuations in global financial markets, are transmitted to the domestic banking sector and materialize in higher observed credit risk.

Table 4 provides further insight, indicating that the increase in aggregate credit risk associated with global uncertainty is primarily driven by rising inherent credit risk. These results suggest that adverse global conditions substantially weaken borrowers' financial positions through mechanisms such as higher funding costs, reduced export demand, and exchange rate depreciation. Such factors are structural in nature and largely beyond the direct control of banks. Consequently, the implementation of stricter lending standards or more conservative credit allocation alone is insufficient to fully mitigate these risks. The findings are consistent with studies emphasizing that certain forms of credit risk are systemic and unavoidable (Zuhroh and Rofik, 2024), and they support the concept of inherent credit risk proposed by Hughes and Moon (Hughes and Moon, 2022).

In contrast, Table 5 shows that credit risk arising from mispricing tends to decline as global uncertainty increases. In line with the behavioral risk-taking channel, heightened uncertainty induces banks to adopt more cautious lending behavior, tighten credit standards, reduce exposure to high-risk borrowers, and restrain aggressive credit expansion (Borio and Zhu, 2012) (Bruno and Shin, 2015). As a result, during periods of elevated global uncertainty, credit risk related to bank behavior becomes more contained, reflecting increased prudence in credit allocation rather than improvements in borrower fundamentals (Dell'ariccia et al., 2017).

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	1	2	3	4	5	6	7
GEPU	0.0054607*** (0.0008552)		0.0059968*** (0.0008367)	0.0048956*** (0.0009373)	0.0046447*** (0.0009399)	0.0033683*** (0.0010901)	0.0037173*** (0.0011154)
EG		0.0075542 (0.0154556)	0.0201426 (0.0153260)	0.0159129 (0.0143803)	0.0126505 (0.0144005)	0.0149096 (0.0143526)	0.0131535 (0.0143938)
Log(Credit)				0.011727*** (0.0027979)	0.0122611*** (0.0027989)	0.0127363*** (0.0028160)	0.0127418*** (0.0028142)
Log(Asset)				-0.011188*** (0.0028589)	-0.0118376** * (0.0028630)	-0.013038*** (0.0029321)	-0.0128369** * (0.0029334)
LDR				-0.0049831 (0.0032495)	-0.0000460 (0.0000325)	-0.0043912 (0.0032494)	-0.0000435 (0.0000325)
CAR				-0.0012804 (0.0011342)	-0.0013337 (0.0011319)	-0.0013574 (0.0011320)	-0.0013659 (0.0011313)
OER				0.0351217*** (0.0024281)	0.0352317*** (0.0024232)	0.0348897*** (0.0024242)	0.0350376*** (0.0024247)
ER					-0.7595328** * (0.2834295)		-0.4868108 (0.0617315)
IR						-0.142838*** (0.0523906)	-0.0951627 (0.3339377)
constant	0.021822*** (0.0034994)	0.0319533*** (0.0030898)	0.0204318*** (0.0034422)	-0.0057475 (0.0145567)	-0.0015896 (0.0146076)	0.0176999 (0.0168791)	0.0125388 (0.0172357)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
chi2(33)	575.70	502.82	569.54	912.95	924.12	912.95	927.84
Prob	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of obs	1,716	1,683	1,683	1,641	1,641	1,641	1,641
Number of groups	33	33	33	33	33	33	33

How to cite this article:

TABLE 3: Credit risk aggregate

Notes: The symbols ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively; and () represent standard errors. GEPU, Global Economic Policy Uncertainty; EG, Economic Growth; LDR, Loan to deposit ratio; CAR, Capital Adequacy Ratio; OER, Operating Expense Ratio; ER, Exchange Rate; IR, Interest Rate; FE, fixed effects

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	1	2	3	4	5	6	7
GEPU	0.0053773*** (0.0008593)		0.0058434*** (0.0008412)	0.0049120*** (0.0009435)	0.0046603*** (0.0009462)	0.0033859*** (0.0010974)	0.0037375*** (0.0011228)
EG		-0.0022400 (0.0155719)	0.0106160 (0.0154590)	0.0160967 (0.0144760)	0.0128243 (0.0144966)	0.0150942 (0.0144486)	0.0133248 (0.0144901)
Log(Credit)				0.0117757*** (0.0028165)	0.0123115*** (0.0028176)	0.0127842*** (0.0028349)	0.0127898*** (0.0028300)
Log(Asset)				-0.011254*** (0.0028780)	-0.011905*** (0.0028821)	-0.013102*** (0.0029517)	-0.0129001** * (0.0029531)
LDR				-0.0000502 (0.0000327)	-0.0000460 (0.0000327)	-0.0000440 (0.0000327)	-0.0000438 (0.0000327)
CAR				-0.0012807 (0.0011418)	-0.0013340 (0.0011395)	-0.0013577 (0.0011396)	-0.0013663 (0.0011389)
OER				0.0351836*** (0.0024396)	0.0352940*** (0.0024394)	0.0349518*** (0.0024404)	0.0351009*** (0.0024409)
ER					-0.761858*** (0.2853205)		-0.4904893 (0.0621444)
Interest rate						-0.142726*** (0.0527410)	-0.0946906 (0.0107925)
constant	0.0208285*** (0.0035606)	0.0310570*** (0.0031526)	0.0198105*** (0.0035037)	-0.0074365 (0.0146536)	-0.0032658 (0.0147050)	0.0159927 (0.0169920)	0.0107925 (0.0157925)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
chi2(33)	586.45	567.23	578.89	899.65	910.69	910.99	914.30
Prob	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of obs	1,674	1,641	1,641	1,641	1,641	1,641	1,641
Number of groups	33	33	33	33	33	33	33

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TABLE 4: Inherent credit risk

Notes: The symbols ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively; and () represent standard errors. GEPU, Global Economic Policy Uncertainty; EG, Economic Growth; LDR, Loan to deposit ratio; CAR, Capital Adequacy Ratio; OER, Operating Expense Ratio; ER, Exchange Rate; IR, Interest Rate; FE, fixed effects

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	1	2	3	4	5	6	7
GEPU	-4.48e-06 (5.54e-06)		-7.32e-06 (5.56e-06)	-0.0000164** (6.63e-06)	-0.000015** (6.66e-06)	-0.0000176** (7.72e-06)	-0.0000202** (7.90e-06)
EG		-0.0001679* (0.0001015)	-0.000184* (0.0001022)	-0.0001837* (0.0001017)	-0.000173* (0.0001020)	-0.0001845* (0.0001017)	-0.0001713* (0.0001020)
Log(Credit)				-0.0000488** (0.0000198)	-0.0000504** (0.0000198)	-0.000048** (0.0000200)	-0.000048** (0.0000199)
Log(Asset)				0.0000661*** (0.0000202)	0.0000681*** (0.0000203)	0.0000646*** (0.0000208)	0.0000631*** (0.0000208)
LDR				3.81e-07* (2.30e-07)	3.70e-07 (2.30e-07)	3.86e-07* (2.30e-07)	3.82e-07 (2.30e-07)
CAR				3.48e-07 (8.02e-06)	5.11e-07 (8.02e-06)	2.87e-07 (8.02e-06)	3.51e-07 (8.01e-06)
OER				-0.000061*** (0.0000172)	-0.000062*** (0.0000172)	-0.0000621** * (0.0000172)	-0.000063*** (0.0000172)
ER				0.0023254 (0.0020072)		0.0036784 (0.0023657)	
Interest rate						-0.0001119 (0.0003712)	-0.0004721 (0.0004373)
constant	0.0019203*** (0.0000230)	0.0019151*** (0.0000206)	0.0019291*** (0.0000232)	0.0016889*** (0.0001029)	0.0016762*** (0.0001034)	0.0017073*** (0.0001196)	0.0017463*** (0.0001221)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
chi2(33)	586.45	567.23	578.89	899.65	910.69	910.99	914.30
Prob	61.13	82.75	84.57	110.36	111.80	110.46	113.04
Number of obs	1,674	1,641	1,641	1,641	1,641	1,641	1,641
Number of groups	33	33	33	33	33	33	33

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TABLE 5: Mispricing credit risk

Notes: The symbols ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively; and () represent standard errors. GEPU, Global Economic Policy Uncertainty; EG, Economic Growth; LDR, Loan to deposit ratio; CAR, Capital Adequacy Ratio; OER, Operating Expense Ratio; ER, Exchange Rate; FE, fixed effects

Monetary policy response to external shocks

This study further examines the interaction between policy interest rates and GEPU. When monetary authorities adjust interest rates in response to rising global uncertainty and external financial stress, this interaction reflects a policy response mechanism through which global shocks are transmitted to the domestic financial system (Bank for International Settlements, 2019) (Borio, 2014). Global uncertainty and monetary policy jointly influence bank balance sheets and borrower conditions, thereby shaping multiple dimensions of credit risk. Table 6 presents empirical evidence illustrating how this interaction affects aggregate credit risk, inherent credit risk, and credit mispricing risk.

	Credit risk	Inherent credit risk	Mispricing credit risk
GEPU	-0.0027424 (0.0037716)	-0.0027730 (0.0037969)	0.0000312 (0.0000267)
EG	0.0119735 (0.0144447)	0.0121346 (0.0145412)	-0.0001611 (0.0001023)
IR	-0.33664*** (0.1259173)	-0.33807*** (0.1267594)	0.0014350 (0.0008919)
GEPU X IR	0.1150182* (0.0679667)	0.1159363* (0.0684212)	-0.0009181* (0.0004814)
constant	0.0245009 (0.0173366)	0.0228479 (0.0174525)	0.001653*** (0.0001228)
Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
chi2(33)	928.99	915.45	114.34
Prob	0.0000		
Number of obs.	1,641	1,641	1,641
Number of groups	33	33	33

TABLE 6: Monetary interaction

Notes: The symbols ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively; and () represent standard errors. GEPU, Global Economic Policy Uncertainty; EG, Economic Growth; IR, Interest Rate; FE, fixed effects; NPL, Non-Performing Loan

First, when total NPLs are used as the dependent variable, the interaction between policy interest rates and GEPU is statistically significant and associated with an increase in aggregate credit risk. These results indicate that financial stress on borrowers intensifies when global uncertainty rises and central banks maintain or raise policy interest rates. Under

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tighter liquidity conditions, higher funding costs, and declining business profitability, debt servicing becomes more difficult, leading to an increase in NPLs (Bloom, 2016).

Second, the findings reveal a strong relationship between global uncertainty, higher interest rates, and inherent credit risk. In this context, inherent credit risk reflects default risk arising from borrowers' fundamental economic vulnerabilities, including declining income, rising production costs, and adverse real-sector shocks. Elevated interest rates combined with heightened global uncertainty weaken real economic resilience, thereby increasing the likelihood of structural defaults that are largely beyond banks' direct control (Basu and Bundick, 2017) (Hantzsche, 2022).

Conversely, the third finding indicates that credit risk mispricing declines when global uncertainty and monetary tightening occur simultaneously. Banks respond to increased uncertainty and tighter financial conditions by adopting more conservative lending behavior, consistent with the risk-taking channel of monetary transmission. Credit standards are tightened, default risk assessments become more stringent, and aggressive credit expansion is restrained.

This pattern directly aligns with Minsky's Financial Instability Hypothesis. Minsky (Minsky, 1986 (Minsky, 1992) argued that during periods of stability and optimism, financial systems transition from "hedge" (safe) to "speculative" and ultimately "Ponzi" (fragile) financing structures, driven by declining risk perception and rising credit mispricing. Conversely, when uncertainty heightens or financial conditions tighten, the system undergoes a forced retrenchment: banks and borrowers become more cautious, risk-taking is suppressed, and credit mispricing contracts. Our empirical finding of declining mispricing credit risk under global uncertainty and monetary tightening provides direct quantitative evidence of this Minskyan "stability-begets-instability, instability-begets-stability" dynamic - but with a critical refinement: the retrenchment applies primarily to bank behavior (mispricing risk), not to borrower fundamentals (inherent risk), which move independently.

In this setting, monetary tightening functions as a disciplinary mechanism that reduces credit risk originating from banks' internal decision-making processes, consistent with Minsky's prediction that external shocks or policy tightening can interrupt speculative lending cycles before they culminate in systemic crisis.

However, the reduction in mispricing credit risk does not offset the concurrent increase in inherent credit risk. As a result, overall credit risk remains elevated. These findings suggest that interest rate-based monetary policy faces important limitations during periods of heightened global uncertainty. While higher interest rates may curb excessive risk-taking and reduce credit mispricing, they simultaneously exacerbate borrowers' structural vulnerabilities and amplify inherent credit risk (Borio and Lowe, 2002) (Minsky et al., 1992). When monetary policy is confronted with externally driven uncertainty shocks, this interaction exposes its potentially pro-cyclical nature.

Overall, these results indicate that monetary policy alone is insufficient to ensure financial system stability under conditions of high global uncertainty. Due to the dominance of inherent credit risk, interest rate adjustments tend to operate in a pro-cyclical manner. Maintaining financial stability therefore requires a policy mix that combines interest rate instruments with more flexible and targeted macroprudential measures. Such a framework enables authorities to restrain excessive bank risk-taking during periods of stability while mitigating systemic stress when global uncertainty intensifies.

Bank-specific determinants of credit risk

Loan Growth

Credit growth exhibits a positive and statistically significant effect on credit risk in both the aggregate and inherent risk models. This finding indicates that higher credit expansion tends to increase banks' exposure to risk, particularly when credit growth is not accompanied by adequate borrower screening and credit quality assessment. Rapid credit expansion is typically pro cyclical and increases the probability of default, especially during periods of heightened external stress. This result is consistent with the existing literature, which documents that credit booms are frequently followed by rising credit risk and greater systemic vulnerability (Schularick and Taylor, 2012).

Bank Size

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Bank size, measured by total assets, shows a negative relationship with credit risk, suggesting that larger banks exhibit greater resilience to risk. Larger institutions generally benefit from broader portfolio diversification, more advanced risk management systems, and more stable access to funding sources. These characteristics enable them to better withstand external shocks and deterioration in asset quality. This finding is consistent with the too big to fail argument and supports the literature emphasizing the role of scale efficiency in enhancing banking sector stability (Barth and Wihlborg, 2016) (Blatter and Fuster, 2022).

Liquidity

The loan to deposit ratio has a positive effect on credit risk. A higher loan to deposit ratio reflects more aggressive lending behavior and a reduction in liquidity buffers. As liquidity capacity declines, banks become more vulnerable to funding pressures, particularly during periods of elevated global uncertainty. Moreover, higher loan to deposit ratios are often associated with credit expansion toward riskier borrower segments, which increases the likelihood of NPLs.

Capital Adequacy Ratio

The capital adequacy ratio exhibits a negative association with credit risk, indicating that stronger capital positions play a critical role in mitigating potential credit losses. Banks with higher capital buffers possess greater capacity to absorb shocks and support more prudent lending behavior. This result underscores the importance of capital resilience in maintaining banking system stability and aligns with the literature highlighting the stabilizing role of capital buffers in managing credit risk.

Operational Efficiency

The operating expense ratio has a positive and statistically significant effect on all measures of credit risk. A higher operating expense ratio reflects greater operating costs relative to revenue, signaling internal inefficiencies within banks. Such inefficiencies are often linked to weaker risk monitoring and credit assessment processes, which increase the likelihood of misjudging borrower quality. This finding suggests that credit risk is not solely driven by external macroeconomic conditions but also emerges from internal weaknesses in bank management and governance.

Robustness Test

This study uses the Two-Stage Least Squares (2SLS) method as shown in Table 7 to overcome potential endogeneity problems, especially related to credit distribution variables. It is possible that credit distributed in the current period is influenced by the level of credit risk in the previous period, so that the relationship between the two becomes simultaneous. To overcome this, Return on Asset is used as an instrumental variable, because it is considered to affect credit distribution without being directly correlated with the error term in the credit risk equation.

	Credit risk	Inherent credit risk	Mispricing credit risk
GEPU	0.0033702*** (0.0011072)	0.0033877*** (0.0011141)	-0.0000174* (9.93e-06)
EG	0.0157828 (0.0146233)	0.0159037 (0.0147147)	-0.0001209 (0.0001311)
Log(Credit)	0.0214066* (0.0118647)	0.0208228* (0.0119388)	0.0005838* (0.0000000)
constant	0.0198680 (0.0200736)	0.0180077 (0.0201990)	0.0018603*** (0.0001800)
Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
chi2(33)	3882.54	3397.15	180935.35
Prob	0.0000	0.0000	0.0000
Number of obs	1,607	1,641	1,641
Number of groups	33	33	33

TABLE 7: Result of 2SLS

Notes: The symbols ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively; and () represent standard errors. 2SLS, Two-Stage Least Squares. GEPU, Global Economic Policy Uncertainty; EG, Economic Growth; FE, fixed effects

The 2SLS estimation results confirm that the impact of global uncertainty, as measured by the GEPU Index, on credit risk remains robust even after accounting for potential endogeneity. In addition, as a robustness check, the study also utilizes the VIX as an alternative proxy for global uncertainty. The results, reported in Table 8, reveal estimation patterns consistent with those obtained using GEPU, thereby reinforcing the validity of the study's core findings.

	Credit risk	Inherent credit risk	Mispricing credit risk
VIX	0.0069864** (0.0033475)	0.0070324** (0.0033699)	-0.000046* (0.0000237)
EG	0.0096360 (0.0143496)	0.0097908 (0.0144455)	-0.0001548 (0.0001015)
Log(Credit)	0.0134326*** (0.0028404)	0.0134852*** (0.0028594)	-0.0000526*** (0.0000201)
Log(Asset)	-0.012693*** (0.0029349)	-0.012757*** (0.0029545)	0.0000637*** (0.0000208)
LDR	-0.0000474 (0.0000326)	-0.0000478 (0.0000328)	4.09e-07*** (2.31e-07)
CAR	-0.0014214 (0.0011339)	-0.0014221 (0.0011415)	6.72e-07 (8.02e-06)
OER	0.0353679 (0.0024222)	0.0354325*** (0.0024384)	-0.000064*** (0.0000171)
Interest rate	-0.216711*** (0.0452352)	-0.216971*** (0.0455374)	0.0002603 (0.0003201)
constant	-0.0095119 (0.0204189)	-0.0113939 (0.0205553)	0.001882*** (0.0001445)
Bank FE	Yes	Yes	Yes
chi2(33)	916.45	903.00	108.97
Prob	0.0000	0.0000	0.0000
Number of obs	1,641	1,641	1,641
Number of groups	33	33	33

TABLE 8: Result of VIX

Notes: The symbols ***, **, and * indicate significance levels at 1%, 5%, and 10%, respectively; and () represent standard errors. VIX, Volatility Index; EG, Economic Growth; LDR, Loan to deposit ratio; CAR, Capital Adequacy Ratio; OER, Operating Expense Ratio; FE, fixed effects

Limitations of the study

Although this study provides new empirical evidence regarding the asynchronous transmission of global uncertainty to the credit risk structure of Indonesian banks, the SFA approach used to decompose credit risk is highly dependent on model specification and inefficiency distribution assumptions. Consequently, estimates for inherent credit risk and mispricing credit risk may be sensitive to the choice of variables and functional forms. Furthermore, the scope of this research is limited to a single country with a bank-based financial system; therefore, these findings may not be fully generalizable to countries with more market-based financial structures or different levels of institutional development. Finally, while this study controls for various macroeconomic factors and bank characteristics, it remains possible that institutional factors, microprudential regulations, and granular debtor characteristics are not fully captured within the aggregate banking data.

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Conclusions

Aggregate credit risk indicators, such as the NPL ratio, are insufficient to capture the structural complexity of risks faced by banks, especially in an increasingly stressed world. This study demonstrates that global uncertainty has an asymmetric impact on the credit risk structure in the Indonesian banking sector, separating non-performing loans into inherent credit risk and mispricing-related credit risk.

Empirical findings indicate that inherent credit risk, which comprises risks driven by borrower fundamentals and macroeconomic pressures beyond the bank's control, increases significantly with increasing global uncertainty. Conversely, credit risk arising from mispricing decreases with rising global uncertainty, indicating more prudent bank behavior, as evidenced by controlled credit expansion. The results suggest that external pressures enhance banking discipline while amplifying structural vulnerabilities in the real sector.

Furthermore, this study finds that interest rate-based monetary policy tends to increase the transmission of inherent credit risk during periods of heightened global uncertainty. Higher interest rates mitigate excessive bank risk-taking but also increase financing pressures on borrowers, increasing the likelihood of structural defaults. These results suggest that a monetary policy framework that relies too heavily on interest rate instruments faces significant limitations and can be pro-cyclical due to inherent credit risk.

These results have significant policy implications. They suggest that financial stability management must shift from a focus on aggregate indicators to a more detailed understanding of the types of credit risks present. Changing interest rates is not sufficient to maintain banking system stability amid high global uncertainty. Instead, to provide an effective policy response, monetary policy must be combined with more flexible and context-specific macroprudential instruments. This approach reduces structural pressures on the real economy while minimizing behavioral risks in the banking sector, supporting financial system stability.

Appendices

The datasets used in this study are publicly available. Banking-level data were obtained from the Indonesian Financial Services Authority (OJK), while macroeconomic variables were sourced from Statistics Indonesia (BPS). Global Economic Policy Uncertainty (GEPU) data were retrieved from policyuncertainty.com, and VIX data from investing.com. All variables used in the empirical analysis are reported in the manuscript. Raw bank-level datasets are available from the corresponding author upon reasonable request.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Data Availability Statements

The datasets (and/or code) supporting this study are available from the corresponding author upon reasonable request.

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