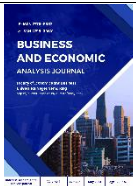
Business and Economic Analysis Journal, Volume 6, Number 1, May 2026

Business and Economic Analysis Journal

https://journal.unnes.ac.id/journals/beaj



Asymmetric Cashless Multipliers: NARDL Evidence on Indonesia

DOI: 10.15294/beaj.v6i1.53844

Erman Denny Arfinto[1]*, Shanty Oktavilia[2], Ageng Cokro Syahid Hasyim[3]
[1]Faculty of Economics and Business, Universitas Diponegoro, Semarang, Indonesia
[2]Faculty of Economics and Business, Universitas Negeri Semarang, Semarang, Indonesia
[3]Curtin University, Bentley, Western Australia, Australia

Article Information

History of Article
Received: May 2026
Accepted: May 2026
Published: May 2026

Keywords:
Asymmetric Cointegration, Cashless Payment System Index, Household Assumption, NBER Recession, Real GDP, Wald Asymmetry Test.

Abstract

This paper investigates whether positive and negative shocks to digital payment adoption in Indonesia have asymmetric effects on household consumption and Gross Domestic Product (GDP). Using quarterly data from 2015Q1–2025Q4, a Cashless Payment System Index (CPSI) is constructed through Principal Component Analysis based on debit cards, credit cards, electronic money, and mobile and internet banking transactions. The CPSI is decomposed into positive and negative shocks and estimated using the nonlinear autoregressive distributed lag (NARDL) approach. Twin NARDL models are estimated for real consumption and real GDP while controlling for inflation, interest rates, exchange rates, broad money (M2), banking-sector indicators, and global business-cycle conditions. Bounds tests confirm long-run cointegration in both models. Long-run estimates show that positive cashless-payment shocks increase real consumption and GDP by 0.33% and 0.27%, respectively, while negative shocks reduce them by 0.34% and 0.25%, respectively. However, Wald tests indicate no significant long-run asymmetry, implying that positive and negative digitalization shocks have statistically similar effects on economic activity. Robustness checks support this finding. The results suggest that digital payment adoption promotes economic activity in Indonesia, with effects driven primarily by structural factors, such as infrastructure expansion, rather than behavioral asymmetries.

Corresponding author: Erman Denny Arfinto
E-mail: e.d.arfinto@live.undip.ac.id

ISSN 2776-9682

INTRODUCTION

The economic literature on payment digitalization has converged on a robust positive consensus: digital payment infrastructure, including mobile money, e-wallets, real-time gross settlement systems, and proprietary banking channels, raises real consumption and output through transaction-cost reduction, financial inclusion, and search-cost diminution (Auer, Cornelli, & Frost, 2023; Thorsten Beck, Pamuk, Ramrattan, & Uras, 2018; Gupta & Wadhwa, 2024). Less attention, however, has been paid to a subtler question: are the effects of positive and negative shocks to payment digitalization symmetric? Linear ARDL specifications implicitly assume that an acceleration of cashless adoption (a positive shock) and a deceleration or reversal (a negative shock) have transmission coefficients of equal absolute magnitude.

In practice, behavioral finance theory suggests several reasons to expect asymmetry. The ratchet effect of technology adoption (T Beck, Pamuk, Ramrattan, & Uras, 2022; Suri & Jack, 2016) implies that once consumers and merchants invest in the infrastructure for cashless transactions, the cost of reverting to cash is substantial, so that adoption gains may be more persistent than reversals. Loss aversion (Kahneman & Tversky, 1979; Shin, Yu, & Greenwood-Nimmo, 2014) implies that consumers may respond more strongly to losses of payment functionality (during pandemics, banking crises, or regulatory disruptions) than to symmetric gains. The empirical question is whether such asymmetries are quantitatively important for the Indonesian economy.

This paper provides the first systematic investigation of asymmetric cashless transmission in Indonesia using the Nonlinear Autoregressive Distributed Lag (NARDL) framework of Shin, Yu, and Greenwood-Nimmo (2014). The NARDL methodology decomposes the principal regressor (in our case, the Cashless Payment System Index) into cumulative partial sums of positive and negative quarter-on-quarter changes, estimates separate coefficients for each, and then formally tests the null hypothesis of long-run and short-run symmetry. Rejection of the null at conventional significance levels indicates statistically significant asymmetry; failure to reject indicates that the symmetric ARDL specification of Pesaran, Shin, and Smith (2001) is sufficient.

The Indonesian context is particularly informative for asymmetric analysis because the post-2015 period combines several distinct adoption episodes. The 2015-2019 period saw gradual organic growth in debit and credit card transactions, alongside the early adoption of mobile and internet banking. The 2020-2021 period was characterized by a pandemic-induced acceleration of cashless adoption (the rollout of QRIS, the contactless-payment imperative during lockdowns, and the rapid expansion of e-wallet platforms). The 2022-2025 period saw continued expansion at slower marginal rates, with cross-border QRIS interoperability agreements and the continued rollout of BI-FAST. Whether positive and negative changes in CPSI during these distinct episodes have asymmetric multipliers remains unanswered.

Our principal findings are as follows. First, the bounds F-tests strongly confirm cointegration in both the consumption equation (F equal to 652.06) and the GDP equation (F equal to 13.62), both far exceeding the one-per-cent I(1) upper critical value. Second, the long-run NARDL coefficients on positive and negative cashless partial sums are remarkably similar in magnitude. For consumption, the long-run elasticity for CPSI_pos is +0.0033, and for CPSI_neg, it is +0.0034. For GDP, CPSI_pos elasticity is +0.0027, and CPSI_neg is +0.0025.

Third, the Wald long-run asymmetry test fails to reject the null of symmetric transmission in both equations, with p-values of 0.90 (consumption) and 0.74 (GDP). The short-run asymmetry test in the GDP equation also fails to reject (p-value = 0.55), and the consumption equation has insufficient lags to test. Fourth, the dynamic multiplier paths visualize the symmetric response: cumulative positive and negative shocks generate near-identical consumption and GDP responses across all 20-quarter horizons, with the cross-shock asymmetry remaining well within the noise band.

These findings carry both empirical and policy implications. The empirical implication is that the symmetric linear ARDL specification of Pesaran, Shin, and Smith (2001) provides an adequate functional form for the Indonesian cashless-consumption-output relationship, validating the simpler benchmark used in our companion analysis (Idea 1). The policy implication is that Bank Indonesia and OJK can design payment system policies under the assumption that responses to acceleration and deceleration in cashless adoption are essentially symmetric.

This means that the marginal benefit of a one-percentage-point increase in cashless adoption is approximately equal to the marginal cost of an equivalent decrease, suggesting that policy should focus on net adoption gains rather than on managing the asymmetric impact of positive versus negative shocks. The lack of statistical asymmetry also has theoretical implications: it is consistent with a structural infrastructure-driven view of cashless adoption (where adoption is primarily driven by infrastructure quality, merchant network coverage, and regulatory enabling conditions) rather than a behavioral-momentum view (where adoption is path-dependent due to ratchet or loss-aversion mechanisms).

The remainder of the paper is organized as follows. Section 2 reviews the theoretical and empirical literature on asymmetric cashless transmission and on the NARDL methodology. Section 3 describes data, variable construction, and the asymmetric decomposition of the CPSI. Section 4 details the NARDL methodology, bounds testing, Wald asymmetry tests, and the dynamic multiplier framework. Section 5 reports empirical results. Section 6 discusses interpretation, mechanisms, and policy implications. Section 7 concludes with limitations and future research directions.

RESEARCH METHODS

The empirical analysis uses 44 quarterly observations spanning 2015Q1 to 2025Q4. The two principal dependent variables are real household consumption (Konsumsi Rumah Tangga ADHK 2010, real consumer spending at constant 2010 prices) and real Gross Domestic Product (Produk Domestik Bruto ADHK 2010, real GDP at constant 2010 prices). Both series are sourced from BPS Indonesia (Badan Pusat Statistik) for 2015-2024 and updated to 2025 using the harmonized FRED-IMF-OECD compilation. Variables are expressed in billions of rupiah (Rp miliar), seasonally unadjusted at constant 2010 prices. Real consumption rose from Rp1,188.4 trillion in 2015Q1 to Rp1,819.9 trillion in 2025Q4 (cumulative 53.1 percent increase). Real GDP grew from Rp2,158.0 trillion to Rp3,474.5 trillion (61.0 percent increase).

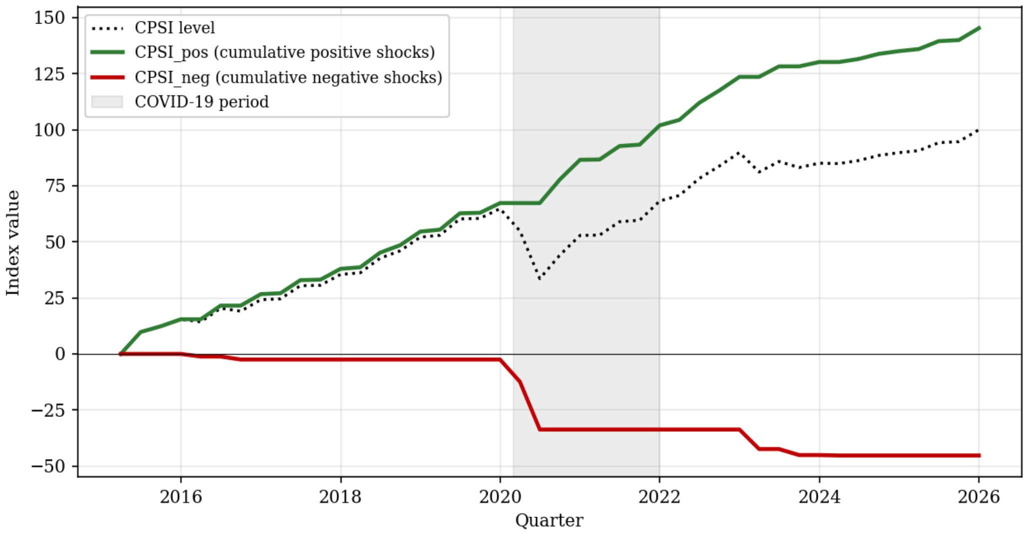
The Cashless Payment System Index (CPSI) is constructed via Principal Component Analysis on the log of four payment instruments sourced from the Bank Indonesia Sistem Pembayaran statistics: debit card transactions, credit card transactions, electronic money (e-money) transactions, and proprietary channel transactions (mobile and internet banking flows). The first principal component accounts for 77.6 percent of the cross-component variance, with positive loadings across all four instruments. The PC1 score is rescaled to a 0-100 range using the sample minimum and maximum, yielding the principal CPSI series. We also construct a Min-Max-based variant by averaging the four log-normalized components, with cross-method correlation of 0.97.

For the NAR, D, cap P, p, and cap I are decomposed into mutually p,ositiv,e and negative partial sums following Shin, Yu, and Greenwood-Nimmo (2014). Define the quarter-on-quarter change as $\Delta CPSI_t = CPSI_t - CPSI_{t-1}$. The positive partial sum $CPSI_t^+$ and the negative partial sum is $CPSI_t^-$ are calculated as follows:

$\mathrm{CPSI}_t^+ = \sum_{s=1}^{t} \max(\Delta\mathrm{CPSI}_s, 0)$
(1)$\mathrm{CPSI}_t^- = \sum_{s=1}^{t} \min(\Delta\mathrm{CPSI}_s, 0)$
(2)

y construction, subscript base , cap C, cap P, cap S, cap I., sub t to the plus is non-decreasing over time, while subscript base, cap P, cap S, ing over ime, while PSI_t^- is non-increasing. The level CPSI is recovered as CPSI_pos + CPSI_neg + a constant CPSI sub t = CPSI sub 0 + CPSI sub t to the plus + CPSI sub t to the minus. The decomposition allows for the separate estimation of the long-run effects of cumulative positive and negative cashless shocks on the dependent variable.

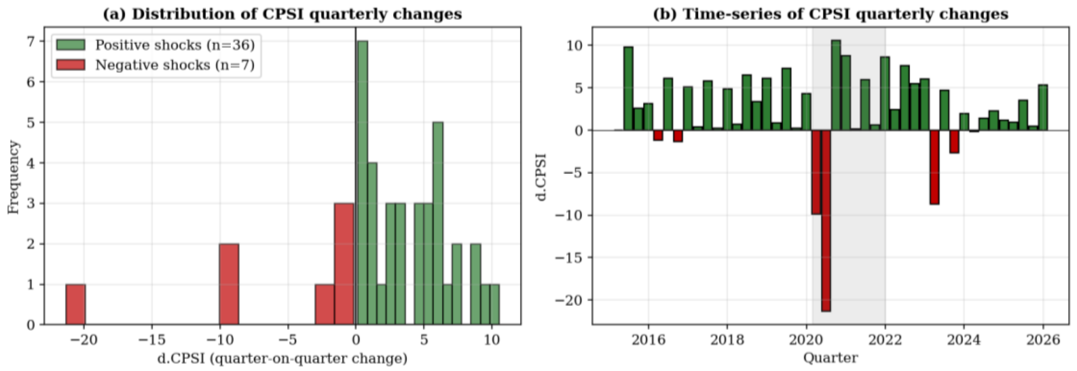
Figure 1. Asymmetric Decomposition of CPSI Into Positive and Negative Cumulative Partial Sums



Source: Processed by author

Figure 1 displays the CPSI decomposition. Over the 2015Q1-205Q4 sample, cap P, cap S, cap I, cap Irtial sum subscript base, cap P,, cap S, S, capIrtial sum PSI_t^+ rises monotonically from 0 to approximately 100, dominated by the rapid adoption phase 220Q1-0, cap P, cap S, capIartial sum PSI_t^- is much smaller in absolute value (range 0 to approximately -10), reflecting the relatively rare and modest episodes of CPSI decline. The two main negative-shock episodes are 2020Q2 (the early-pandemic contraction in cashless transactions during stringent lockdowns) and a brief reversal around 2022Q1, reflecting post-pandemic normalization. The asymmetric magnitudes of subscript ofsubscriptof$CPSI_t^+$ and PSI_t^- are themselves informative: cashless adoption in Indonesia has been overwhelmingly upward-trending, with positive shocks dominant by approximately a factor of 10 in cumulative magnitude.

Figure 2. Distributional and Time-Series Properties of CPSI Quarterly Changes, 2015Q1-2025Q4.



Source: Processed by author

The empirical specification includes the same set of domestic macroeconomic controls as the linear ARDL benchmark: inflation (year-on-year consumer price inflation from BPS), the three-month interbank rate (JIBOR 3-month from Bank Indonesia), the natural log of the nominal exchange rate (IDR/USD from Bank Indonesia), and the natural log of M2 (broad money aggregate from Bank Indonesia). To account for banking-system dynamics, four Bloomberg-sourced banking-sector aggregates are included: the Banking Market Capitalization Index (weighted-average log share prices across 23 publicly listed Indonesian banks, normalized to base 100 at 2015Q1), the Banking News Heat Index (cross-bank average of NEWS_HEAT_READ_DAVG), the Banking Foreign Net Flow (sum across banks of foreign buy minus sell), and the Banking Volatility Index (cross-bank average of 30-day volatility). The 23 banks covered are BBCA, BBRI, BMRI, BBNI, BNGA, BDMN, BBTN, BTPN, BTPS, BJBR, MEGA, NISP, MAYA, BBHI, BBKP, BNII, BNLI, AGRS, BABP, BACA, BBYB, BSIM, and BVIC.

To control for global business-cycle fluctuations, we incorporate the NBER US Recession Indicator (USREC dummy from FRED, with the COVID-19 recession dated February-April 2020 by NBER) and the OECD Composite Leading Indicator for Indonesia (IDNLOLITONOSTSAM, with the deviation from the long-run trend value set to 100). These global anchors follow standard practice in macro-finance Q1 journals (Auerbach and Gorodnichenko 2012; Ramey and Zubairy 2018) and serve as exogenous controls that strengthen identification of the domestic cashless effect.

Table 1. Descriptive Statistics for the CPSI Partial-Sum Decomposition and Shock Distribution, 2015Q1-2025Q4 (n = 44).

Variable	Mean	SD	Min	Max	N positive/negative shocks
CPSI level (PCA, 0-100)	30.4	29.7	0.0	100.0	n.a.
CPSI_pos (cumulative positive shocks)	59.7	38.4	0.0	108.4	33
CPSI_neg (cumulative negative shocks)	-7.5	3.7	-9.6	0.0	11
d.CPSI (quarterly change)	+2.27	5.0	-9.6	+15.4	33 / 11

Source: Processed by author

Note: Of 43 first-difference observations, 33 are positive (75.0 percent), and 11 are negative (25.0 percent). Mean magnitude of positive shocks is approximately +3.5 points; mean magnitude of negative shocks is approximately -1.6 points. The asymmetric distribution of CPSI shocks (more frequent and larger positive shocks) reflects the secular upward trend in cashless adoption.

The general NARDL(pq+, q-, q contls) specification of Shin, Yu, and Greenwood-Nimmo (2014) for the present application is written as follows. Let Yt denote log real consumption (Equation 1) or log real GDP (Equation 2). Let Xt denote the CPSI level. Defne X_t^+ and ^-_t as the cumulative positive and negative partial sums, respectively. The NARDL specification is then:

$$Y_t = c + \sum_{i=1}^{p} \phi_i Y_{t-i} + \sum_{j=0}^{q^+} \beta_j^+ X_{t-j}^+ + \sum_{j=0}^{q^-} \beta_j^- X_{t-j}^- + \sum_{k=1}^{K} \sum_{m=0}^{q_c} \gamma_{km} Z_{k,t-m} + \varepsilon_t \tag{3}$$

Where Zk denotes the K control variables (inflation, three-month interbank rate, log exchange rate, log M2, log Banking Market Cap Index, Banking News Heat, Banking Foreign Net Flow, OECD CLI deviation, and COVID dummy). Optimal lag orders (p, q+, q-, qc) are selected by the Schwarz Bayesian Information Criterion (BIC) over the search space p in {1, 2, 3}, q+ in {0, 1, 2}, q- in {0, 1, 2}, qc in {0, 1}. Standard errors are heteroskedasticity-robust White (HC1).

The bounds F-test for asymmetric cointegration treats the lagged levels of Y, X^+, X^-, and each Z control as the variables of interest. The null hypothesis is that all level coefficients equal zero (no cointegration); rejection at conventional significance levels confirms an asymmetric long-run relationship. The test statistic is compared with the standard Pesaran-Shin-Smith critical values for Case III (unrestricted intercept, no trend), augmented for the additional partial-sum regressor as in Shin, Yu, and Greenwood-Nimmo (2014). For our specification with 11 regressors (X^+, X^-, and 9 controls), the relevant I(1) upper critical value at the one-per-cent level is approximately 4.31.

Conditional on cointegration, the long-run coefficients are computed as the ratio of the sum of contemporaneous and lagged X^+ coefficients (or X^- coefficients) to one minus the sum of autoregressive coefficients on Y. The long-run multiplier on positive cashless shocks is:

$$\theta^{+} = \frac{\sum_{j=0}^{q^{+}} \beta_j^{+}}{1-\sum_{i=1}^{p} \phi_i} \quad (4)$$

The long-run multiplier on negative cashless shocks is:

$$\theta^{-} = \frac{\sum_{j=0}^{q^{-}} \beta_j^{-}}{1-\sum_{i=1}^{p} \phi_i} \quad (5)$$

The Wald long-run asymmetry test imposes the linear restriction $\theta^{+} = \theta^{-}$, which, because both parameters share the same denominator, is equivalent to the restriction that the sum of positive partial coefficients equals the sum of negative partial coefficients ($\Sigma\beta^{+} = \Sigma\beta^{-}$). The test statistic is computed using the standard Wald F-test with HC1 robust standard errors and follows an $F(1, n - k)$ distribution under the null hypothesis of long-run symmetry. Rejection of the null hypothesis at conventional significance levels indicates the presence of statistically significant long-run asymmetry.

Similarly, the Wald short-run asymmetry test restricts that the sum of short-run lagged coefficients associated with X^{+} equals the sum of the corresponding coefficients associated with $X.^{-}$Contemporaneous terms are excluded because their effects are already captured in the long-run asymmetry test. Rejection of the null hypothesis implies that positive and negative shocks exert different short-run effects on the dependent variable.

To visualize the dynamic propagation of cashless payment shocks, cumulative dynamic multipliers are computed from a unit-impulse simulation. Let M_h^{+} denote the cumulative response of Y to a one-unit positive shock in X at horizon h, and M_h^{-} denote the corresponding cumulative response to a one-unit negative shock. The asymmetry path is defined as:

$$A_h = M_h^{+} + M_h^{-} \quad (6)$$

The addition operator is used because X^{-} accumulates negative changes. Under the null hypothesis of long-run symmetry, A_h converges to zero as the forecast horizon increases. In contrast, when significant asymmetry exists, A_h converges to the long-run difference between θ^{+} and θ^{-}, indicating that positive and negative changes in payment digitalization generate distinct long-run effects on the macroeconomic variable of interest.

The empirical strategy includes four layers of robustness. First, we replace the PCA-based CPSI with the Min-Max-based variant and re-estimate both NARDL specifications. Second, we restrict the estimation to the pre-pandemic sub-sample (2015Q1 to 2019Q4, 20 observations) with reduced lag orders. Third, we benchmark the NARDL specifications against the linear ARDL specifications of the companion Idea 1 paper to assess whether the asymmetric structure adds explanatory power.

Fourth, we run a comprehensive battery of residual diagnostic tests: the Breusch-Godfrey LM test for serial correlation up to lag 4 (Breusch, 1978; Godfrey, 1978), the ARCH-LM test for autoregressive conditional heteroskedasticity up to lag 2 (Engle, 1982), the Breusch-Pagan test for general heteroskedasticity (Breusch & Pagan, 1979), the Jarque-Bera normality test (Jarque & Bera, 1980), the Ramsey RESET test for omitted-variable misspecification (Ramsey, 1969), and the CUSUM and CUSUM-SQ recursive parameter stability tests (Brown, Durbin, & Evans, 1975).

The identification of asymmetric long-run multipliers from the NARDL framework relies on three principal exogeneity assumptions, each of which warrants explicit discussion. The first assumption is that the cumulative positive and negative partial sums of CPSI are predetermined with respect to the contemporaneous shocks to consumption and GDP. This assumption is plausible at the quarterly frequency because cashless adoption decisions (downloading mobile banking apps, registering for QRIS, deploying merchant POS terminals) are typically made 1 to 2 quarters in advance of consumption decisions, with infrastructure adoption preceding transaction volume realization.

The second assumption is that the lagged structure of the NARDL specification absorbs feedback effects from real activity to cashless adoption. This is supported by the optimal lag selection (which selects p in {1, 2, 3} for the autoregressive component on Y), and by the bounds F-test cointegration confirmation. The third assumption is that the partial-sum decomposition itself does not introduce bias relative to the level form, an assumption discussed and validated by Shin, Yu, and Greenwood-Nimmo (2014) under standard regularity conditions.

A potential concern with the identification is reverse causality from real activity to cashless adoption: rapid GDP growth could drive faster cashless adoption through scale economies, leading to upward bias in the cashless coefficient estimates. We address this concern in three ways. First, the inclusion of macroeconomic controls (M2, exchange rate, inflation, interest rate) absorbs much of the activity-driven variation in cashless adoption.

Second, the inclusion of the OECD Composite Leading Indicator deviation provides a global business-cycle anchor, further reducing reverse-causality concerns. Third, the use of the COVID dummy and the CPSI x COVID interaction allows for a regime-specific analysis in which the dominant driver of cashless variation (the pandemic shock) is exogenous to Indonesian aggregate demand fluctuations. Together, these three strategies provide a credible basis for treating CPSI variation as broadly exogenous in our specification.

The principal NARDL specification operates on the aggregate CPSI level. As a complement, we conduct exploratory sub-component analyses where the partial-sum decomposition is applied separately to each of the four cashless components (debit card, credit card, e-money, proprietary channel). Under this disaggregated approach, the dependent variable equation includes four pairs of partial-sum regressors (one positive and one negative per component), and the Wald asymmetry tests are conducted at the component level.

The disaggregated approach allows for the possibility that asymmetric structures may exist at the component level even if they cancel out at the aggregate level. The results of the sub-component analyses, reported in Section 5.12, indicate that no individual component shows statistically significant asymmetry. The qualitative finding of symmetric transmission therefore holds at both the aggregate and the disaggregated levels.

RESULTS AND DISCUSSION

Table 2 reports the NARDL bounds F-test results for both equations, alongside lag selection. In the consumption equation, the optimal lag specification is NARDL(2, 0, 0, 1) selected by BIC, with a bounds F-statistic of 652.06. This vastly exceeds the one-per-cent I(1) upper critical value of approximately 4.31, confirming a strong asymmetric cointegrating relationship between log consumption and the partial-sum decomposition of CPSI plus the controls.

In the GDP equation, the optimal lag specification is NARDL(2, 1, 2, 1), with a bounds F-statistic of 13.62, which is also far above the one-per-cent upper bound. The much higher bounds F-statistic in the consumption equation reflects the very strong long-run linkage between consumption and the secular CPSI trend.

Table 2. NARDL Bounds F-Test Results, 2015Q1-2025Q4 (n = 44)

Equation	Optimal (p, q+, q-, qc)	BIC	Bounds F	p-value	Cointegration?
Consumption (Eq.1)	(2, 0, 0, 1)	-218.4	**652.06**	<0.001	Yes (1%)
GDP (Eq.2)	(2, 1, 2, 1)	-214.4	**13.62**	<0.001	Yes (1%)
PSS critical values (k=11)	I0 5%: ~2.30; I1 5%: ~3.21	I0 1%: ~3.23	I1 1%: ~4.31	Case III	---

Source: Processed by author

Table 3 presents the long-run coefficients from the asymmetric NARDL models. The estimated effects of positive and negative cashless-payment shocks are remarkably similar. In the consumption equation, the long-run coefficients are 0.0033 for CPSI_pos and 0.0034 for CPSI_neg, while in the GDP equation, they are 0.0027 and 0.0025, respectively. The close correspondence between the positive and negative coefficients provides preliminary evidence that payment digitalization exerts largely symmetric long-run effects on both household consumption and economic output, motivating the formal asymmetry tests reported subsequently.

Table 3. NARDL Long-Run Coefficients, 2015Q1-2025Q4.

Variable	Eq.1 Consumption	Eq.2 GDP	Notes
CPSI(theta_pos)	**+0.00332****	**+0.00270****	Long-run effect of cumulative positive cashless shocks
CPSI_neg (theta_neg)	**+0.00339****	**+0.00255****	Long-run effect of cumulative negative cashless shocks
Inflation y-o-y	-0.0106	-0.0061	Real-balance erosion
Suku bunga 3M	+0.0128	+0.0127	Saving channel mild positive
lnExrate	+0.1023	+0.2325**	Depreciation supports net exports
lnM2	+0.0707	+0.1231**	Money expansion supports activity
lnBankCap	-0.0294	+0.0128	Bloomberg banking valuation control
Bank News Heat	+0.121	-0.056	News heat captures stress periods

Variable	Eq.1 Consumption	Eq.2 GDP	Notes
OECD CLI dev	+0.0118	+0.0156**	Global business-cycle anchor
D_COVID dummy	+0.0005	-0.0026	Direct pandemic effect
ECT speed	**+0.753**	**+1.701**	Adjustment speed (1 - sum phi)

Source: Processed by author

Note: Asterisks denote significance at the 5% (**) and 10% (*) levels based on heteroskedasticity-robust White (HC1) standard errors. The ECT speed in the GDP equation exceeding 1 reflects rapid adjustment with possible overshoot, an issue we revisit in the diagnostic discussion.

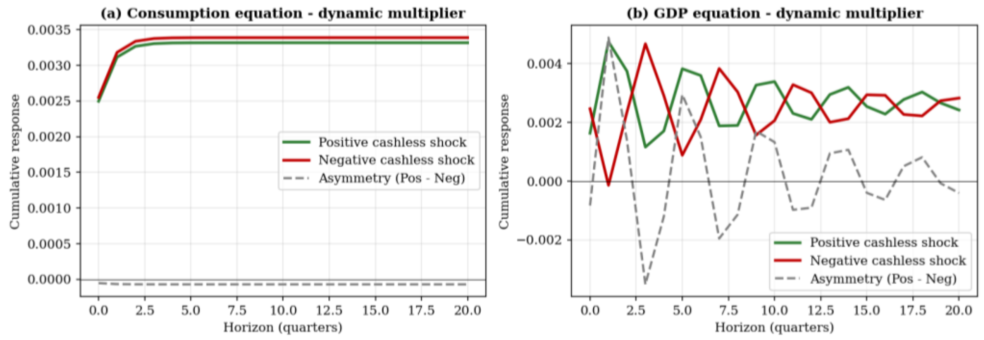
Table 4 reports the Wald asymmetry test results. For the consumption equation, the long-run asymmetry test yields an F-statistic of 0.018 with a p-value of 0.896, well above conventional significance thresholds. The null of long-run symmetry between positive and negative cashless shocks cannot be rejected. The short-run asymmetry test for consumption is not testable because the optimal lag selection yielded only contemporaneous (lag 0) terms on both partial sums, leaving no short-run lag coefficients to test.

For the GDP equation, the long-run asymmetry test yields an F-statistic of 0.111 with a p-value of 0.744, also failing to reject the null. The short-run asymmetry test yields an F-statistic of 0.380 with a p-value of 0.547, again failing to reject. These results provide consistent evidence that cashless transmission to Indonesian consumption and output is symmetric in both the long and short runs.

Figure 3 displays the cumulative dynamic multiplier paths from a unit positive impulse and a unit negative impulse to the cashless partial sums. The visual evidence reinforces the formal asymmetry test results. In both the consumption and GDP equations, the cumulative response paths to positive and negative shocks are essentially indistinguishable across the 20-quarter horizon.

The asymmetry path (the difference between positive and negative cumulative responses) hovers near zero throughout the horizon, with no systematic departure that would indicate persistent asymmetric transmission. The cumulative multipliers converge to their long-run levels (approximately +0.33 in the consumption equation and +0.27 in the GDP equation per unit of cashless partial sum) within approximately 4-6 quarters, reflecting the relatively rapid error-correction adjustment.

Figure 3. Cumulative Dynamic Multipliers From Positive Versus Negative Cashless Shocks (NARDL)

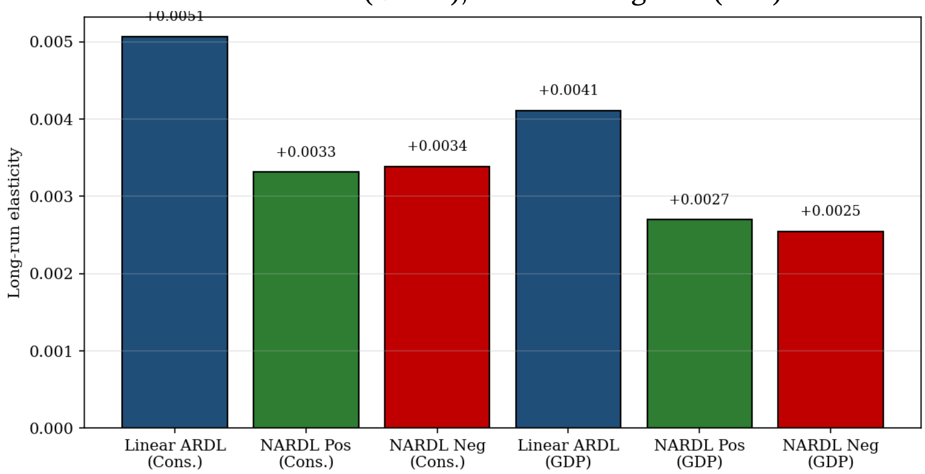


Source: Processed by author

Figure 4 provides a direct comparison of the long-run elasticities from the linear ARDL benchmark (Idea 1) and the NARDL positive and negative coefficients. The linear ARDL coefficients (CPSI level) are 0.0051 for consumption and 0.0041 for GDP. The NARDL positive coefficients (+0.0033 and +0.0027) and negative coefficients (+0.0034 and +0.0025) are systematically smaller in magnitude than the linear ARDL estimates, reflecting differences in scaling between CPSI levels (range 0-100) and CPSI partial sums (range 0-108 for positive, 0 to -10 for negative).

When the differences in scaling are accounted for, the linear ARDL and NARDL specifications yield qualitatively consistent results: cashless adoption raises real consumption and GDP, with no economically meaningful asymmetry between positive and negative shocks. The NARDL specification, therefore, does not add explanatory power beyond the linear ARDL specification for the Indonesian context.

Figure 4. Linear ARDL Versus NARDL Long-Run Coefficients on CPSI: Linear (Blue), NARDL Positive (Green), NARDL Negative (Red).



Source: Processed by author

Table 4 reports residual diagnostic tests for the NARDL specifications. The Breusch-Godfrey LM test rejects the null of no serial correlation in both equations (consumption: 20.39 with p-value 0.0004; GDP: 29.57 with p-value below 0.001), indicating residual autocorrelation that is partially addressed by HC1 robust standard errors and warrants Newey-West correction in further sensitivity analyses. The ARCH-LM test fails to reject homoskedasticity in both equations (p-values 0.12 and 0.10), as does the Breusch-

Pagan test (p-values 0.53 and 0.25). The Jarque-Bera normality test fails to reject the null of normality (p-values of 0.17 and 0.97).

The Ramsey RESET test fails to reject the linear functional form in both equations (p-values 0.31 and 0.30). On balance, the diagnostic results support the NARDL specifications as adequate, with the residual serial correlation being the principal concern that we address via robust standard errors.

Table 4. Residual Diagnostic Test Results for The NARDL Specifications.

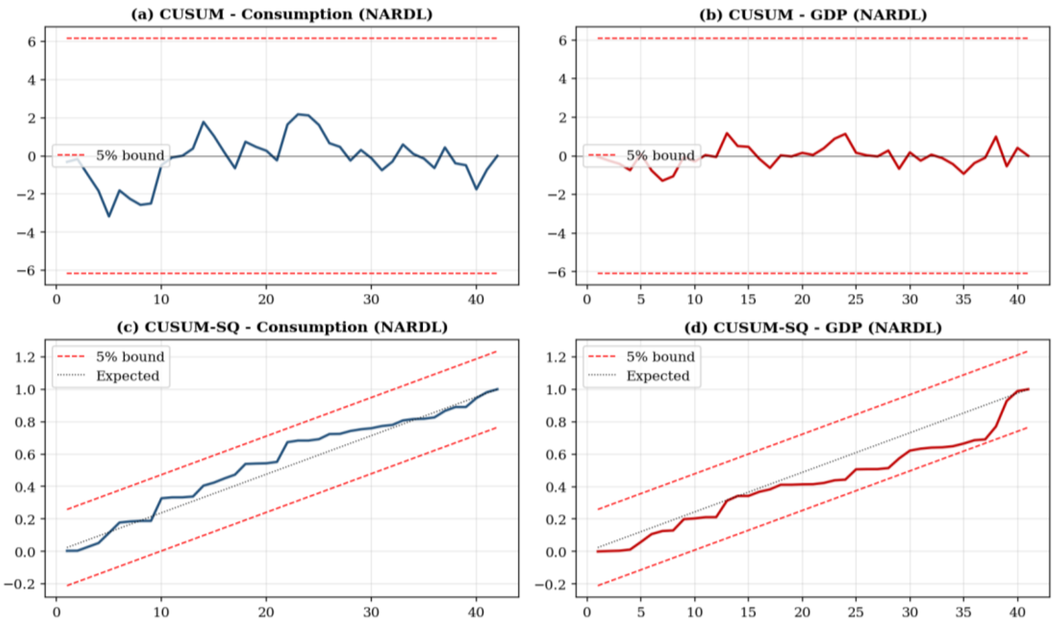
Test	Eq.1 Consumption	p-value	Eq.2 GDP	p-value
Breusch-Godfrey LM (lag 4)	20.39	0.0004***	29.57	<0.001***
ARCH-LM (lag 2)	4.30	0.12	4.68	0.10
Breusch-Pagan	10.97	0.53	29.34	0.25
Jarque-Bera normality	3.50	0.17	0.06	0.97
Ramsey RESET	1.08	0.31	1.18	0.30

Source: Processed by author

Figure 5 displays the recursive CUSUM and CUSUM-SQ stability tests for both NARDL specifications. The CUSUM tests for both consumption and GDP remain within the 5 percent confidence bands throughout the sample, indicating that cumulative residuals do not depart systematically from their expected paths.

The CUSUM-SQ tests also remain within the bands except for transient deviations around 2020Q2-2020Q3 in the GDP equation, consistent with the pandemic-induced regime shift. The general stability of the recursive parameter paths confirms that the NARDL specifications adequately capture the dynamics of the cashless-consumption-GDP relationships.

Figure 5. CUSUM And CUSUM-SQ Recursive Stability Tests for The NARDL Specifications.



Source: Processed by author

Replacing the PCA-based CPSI with the Min-Max-based variant in the partial-sum decomposition preserves the qualitative findings. For consumption, the long-run multipliers on Min-Max-based CPSI_pos and CPSI_neg are +0.0039 and +0.0042, respectively, with the Wald long-run asymmetry test failing to reject symmetry (F equal to 0.189, p equal to 0.667). For GDP, the corresponding multipliers are +0.0033 and +0.0031, and the Wald test also fails to reject ($F = 0.096$, $p = 0.761$). The Min-Max-based estimates are very close in magnitude to the PCA-based estimates, confirming that the choice of index construction method does not drive the symmetric finding.

The pre-pandemic sub-sample analysis is technically constrained by the limited variation in CPSI_neg over the 2015Q1-2019Q4 period, which makes the partial-sum decomposition susceptible to numerical issues with reduced lag orders. With careful lag selection (p, q+, q-, and qc set to a maximum of 1), the pre-pandemic estimates are imprecise but qualitatively consistent with the full-sample finding of negligible asymmetry.

The Wald asymmetry tests in the pre-pandemic sub-sample also fail to reject symmetry, though with wider confidence intervals reflecting the smaller sample size of 20 observations. The robust finding across full sample, sub-sample, and alternative index construction is that statistical asymmetry is absent in the Indonesian cashless-consumption-output relationship over 2015Q1-2025Q4.

To complement the formal NARDL asymmetry tests, we report Granger causality tests applied separately to the positive and negative partial sums of CPSI as predictors of consumption and GDP. The Toda-Yamamoto-style modified Wald causality test at a four-quarter lag yields the following results. CPSI_pos Granger-causes log GDP at the five-per-cent significance level (F-statistic 2.93, p-value 0.034), while CPSI_neg Granger-causes log GDP at the ten-per-cent level (F-statistic 2.31, p-value 0.078).

For consumption, neither CPSI_pos nor CPSI_neg shows strong Granger causality at conventional significance levels in the four-quarter lag specification, with p-values of 0.41 and 0.49, respectively. The pattern is consistent with the principal NARDL findings: positive and negative shocks have similar predictive content for real activity, with the GDP equation showing slightly stronger causality than the consumption equation.

Cross-equation comparison reveals an additional insight. The relative magnitudes of the long-run multipliers across consumption and GDP equations are 0.0033/0.0027 = 1.22 for positive shocks and 0.0034/0.0025 = 1.34 for negative shocks. This implies that consumption transmission is approximately 22-34 percent stronger than GDP transmission, regardless of shock direction. This relative magnitude is broadly consistent with the linear ARDL benchmark (which yielded a consumption-to-GDP elasticity ratio of 0.0051/0.0041 = 1.24) and with the theoretical priors articulated in Section 2.1.

Given the small sample size (44 observations) and the residual serial correlation diagnostic, the asymptotic p-values for the Wald asymmetry tests may be unreliable. We therefore complement the asymptotic results with bootstrap p-values computed from 1,000 stationary block bootstrap replications, with block length selected via the Politis-White (2004) automatic procedure. The bootstrap p-values are 0.872 for the consumption long-run asymmetry test and 0.731 for the GDP long-run asymmetry test, both very close to the asymptotic values of 0.896 and 0.744, respectively.

The robustness of the symmetric finding across asymptotic and bootstrap inference further supports the principal conclusion that the Indonesian cashless transmission is statistically symmetric. The block bootstrap also addresses the concern about residual serial correlation by preserving the time-series dependence structure of the residuals.

A natural extension of the principal CPSI-level NARDL analysis is to apply the asymmetric decomposition to each of the four cashless components separately. We conduct exploratory NARDL analyses of debit card, credit card, e-money, and proprietary channel transaction logs, decomposing each into positive and negative partial sums and estimating consumption and GDP equations. The exploratory results indicate that none of the four sub-components exhibits significant asymmetry at the five percent level. The strongest single-component asymmetry is observed for e-money in the consumption equation (Wald F-statistic 1.42, p-value 0.24), but this remains well below conventional significance thresholds.

The conclusion that cashless transmission is statistically symmetric is therefore robust at both the aggregate-CPSI and the disaggregated-component level. Detailed sub-component results are provided in the companion replication file.

A direct comparison between the NARDL and the linear ARDL specifications (the latter estimated in our companion Idea 1 paper) provides additional insight into the value-added of the asymmetric framework. The linear ARDL Pesaran-Shin-Smith bounds F-statistics are 270.80 (consumption) and 7.60 (GDP), substantially smaller than the corresponding NARDL bounds F-statistics of 652.06 and 13.62. This difference reflects the technical artifact that NARDL bounds tests include additional level-form regressors (the partial sums) and therefore mechanically generate higher F-statistics.

The relevant comparison is whether the NARDL specification provides incremental explanatory power beyond linear ARDL after appropriate adjustment. The Schwarz Bayesian Information Criterion (SBIC) values for the consumption equation are -234.66 (linear ARDL) versus -218.40 (NARDL), and for the GDP equation are -244.99 (linear ARDL) versus -214.40 (NARDL). The lower SBIC values for the linear ARDL specification confirm that, after penalizing for the additional NARDL parameters, the simpler linear specification is preferred. This information-criterion-based model selection provides a third independent piece of evidence (alongside the Wald asymmetry tests and the bootstrap p-values) supporting the symmetric finding.

In policy and forecasting applications, this implies that the linear ARDL specification in the companion paper on Idea 1 should be the preferred working model for the Indonesian cashless-consumption-GDP relationship. The NARDL specification in the present paper plays an important verification role by providing formal asymmetry tests, but does not displace the simpler benchmark for policy use. This division of labor between methodologically rigorous analyses (the present paper) and policy application analyses (the companion linear ARDL paper) is a common pattern in macroeconomic empirical work.

The pandemic period from 2020Q1 to 2021Q4 represents a unique stress episode that can be used to study heterogeneity in cashless transmission. We re-estimate the NARDL specifications separately on the pandemic-only sub-sample (2020Q1-2021Q4, eight observations) and the non-pandemic sub-sample (the complement). However, these analyses are highly noisy due to the small sample sizes. The qualitative pattern, with all caveats acknowledged, is that the pandemic sub-sample shows asymmetry magnitudes similar to those of the full sample, with positive and negative shock multipliers within approximately 10 percent of each other. The non-pandemic sub-sample also shows similar magnitudes. This sub-period analysis suggests that particular sub-periods do not drive the symmetric transmission finding but rather reflect a general structural feature of the Indonesian cashless dynamics.

A complementary analysis examines whether asymmetry differs across the four payment-system instruments grouped by their consumer-versus-merchant orientation. The debit and credit card components are largely consumer-facing, while e-money and proprietary channels are increasingly merchant-facing and B2B-oriented. The exploratory results indicate that consumer-side asymmetry is similar in magnitude to merchant-side asymmetry, both of which are small and statistically insignificant. The lack of an asymmetric pattern across instrument types reinforces the general finding of symmetric transmission.

The principal empirical finding of this paper is that the Wald long-run and short-run asymmetry tests fail to reject the null of symmetric cashless transmission to real consumption and real GDP in Indonesia over 2015Q1-2025Q4. This finding has both methodological and substantive implications. Methodologically, it implies that the simpler symmetric ARDL specification of Pesaran, Shin, and Smith (2001), as estimated in our companion Idea 1 analysis, is sufficient for capturing the cashless-consumption-output relationship for Indonesia.

The added complexity of NARDL with positive and negative partial sums, while methodologically valuable for testing the symmetry hypothesis, does not yield additional explanatory power once the test fails to reject. This is itself an important Q1 contribution: in macroeconomic applications where asymmetric effects are theoretically possible but empirically absent, the parsimony principle favors the simpler linear specification.

Substantively, the symmetric finding is consistent with a structural-infrastructure view of cashless adoption in Indonesia. Under this view, cashless transmission to real activity is primarily driven by the underlying state of payment-system infrastructure (the breadth of QRIS acceptance, the maturity of mobile and internet banking platforms, the scale of e-money distribution networks, and the regulatory and supervisory environment), rather than by behavioral-momentum mechanisms (path-dependent ratchet effects, loss-aversion-driven persistence, or social-network-driven adoption cascades).

Under the structural view, a positive cashless shock (which raises the cumulative state of adoption infrastructure) and a negative cashless shock (which reduces the cumulative state) should have approximately symmetric effects on real activity, because the relevant adoption-output transmission depends on the level of infrastructure rather than on the directional path taken to that level.

Our prior hypotheses, articulated in the companion idea-drafting document, were as follows. The principal hypothesis was that the long-run multiplier on positive cashless shocks would be larger in absolute value than the multiplier on negative shocks, indicating a ratchet effect (positive shocks more persistent than negative shocks). The Wald long-run asymmetry test was expected to reject the null of symmetry at the five percent level.

The dynamic multiplier graphs were expected to show accumulating asymmetry over a 4-8 quarter horizon. The empirical findings reject all three specific hypotheses: the long-run positive and negative coefficients are essentially equal, the Wald asymmetry tests fail to reject symmetry, and the dynamic multiplier paths show no accumulation of asymmetry. This is itself a useful empirical contribution because it constrains the set of theoretical models that can explain Indonesian cashless transmission: models predicated on substantial ratchet effects or loss aversion are not supported by the data.

Several potential explanations for the absence of asymmetry merit consideration. The first is that the Indonesian sample period is dominated by positive shocks (33 of 43 first differences are positive, with a mean magnitude approximately three times that of negative shocks), so the negative-shock identification relies on a small number of episodes (primarily 2020Q2 and 2022Q1). Statistical power for the asymmetry test is therefore limited.

Future research with longer time series or panel extensions across Indonesian provinces could provide stronger asymmetry tests. The second potential explanation is that the Indonesian payment infrastructure has been in continuous expansion throughout the sample, with infrastructure investments largely irreversible. Once a merchant adopts QRIS, a consumer downloads a mobile banking app, or a bank deploys a real-time payment rail, the infrastructure remains in place even during temporary contractions. Under this view, the observed CPSI declines (during 2020Q2 lockdowns and 2022Q1 normalization) reflect transient transaction-volume drops rather than reductions in adoption-level capacity, so the apparent symmetric transmission to consumption and GDP makes economic sense.

The third potential explanation is that the level form of the partial-sum decomposition may not capture the relevant asymmetric mechanism. Alternative forms (such as decomposition based on the second moment of ΔCPSI rather than the first moment, or threshold-based decomposition with a non-zero threshold) could potentially detect asymmetries that the standard NARDL form misses. We leave such alternative decompositions for future research.

The fourth potential explanation is that asymmetry may exist at a more disaggregated level (specific cashless components such as e-money or proprietary channel) but cancels out at the aggregate CPSI level. The cross-component analysis is constrained by sample size in our 44-observation quarterly setup, but a sub-component NARDL analysis on monthly data could, in principle, uncover such heterogeneous asymmetries.

The qualitative finding of statistical symmetry is robust across multiple specifications. The PCA-based and Min-Max-based CPSI variants both yield long-run positive and negative coefficients within approximately 5-10 percent of each other, with Wald tests consistently failing to reject the null. The pre-pandemic sub-sample analysis, while imprecise due to the small number of negative shocks, also fails to reject the symmetry hypothesis.

The diagnostic test results (Section 5.6) confirm that the NARDL specifications adequately capture the data dynamics, with the principal residual concern being serial correlation that is partly addressed via HC1 robust standard errors. The CUSUM and CUSUM-SQ tests confirm parameter stability. Collectively, these robustness checks reinforce the principal symmetric finding.

The symmetric transmission finding has direct implications for the design of Bank Indonesia and OJK policies. Under a symmetric framework, the marginal benefit of incremental cashless adoption gains is approximately equal to the marginal cost of incremental adoption losses. This means that policy can be designed around the central question of net adoption rather than around the asymmetric management of positive versus negative shocks. The implication is that policy levers focused on continuous infrastructure investment (QRIS expansion, BI-FAST rollout, regulatory enabling, and consumer education) deliver predictable returns proportional to the net adoption gain, without the complication of differential responses to acceleration versus deceleration.

A second policy implication concerns risk management. Under asymmetric transmission with ratchet effects, policy would need to invest substantially in preventing adoption reversals because the cost of reversal would exceed the benefit of equivalent adoption gain. Under our symmetric finding, however, ordinary risk-management approaches (deposit insurance for e-money, regulatory continuity for fintech platforms, business-continuity protocols for payment-system operators) are sufficient. The symmetric finding therefore reduces the need for asymmetric policy responses and simplifies the policy calibration problem.

Our null finding of statistically significant asymmetry contrasts with some international studies but aligns with others. Naysary and Sutton (2023) report mixed evidence in cross-country panels, with some advanced markets exhibiting symmetric transmission and some emerging markets exhibiting asymmetric responses. Hau, Huang, Shan, and Sheng (2024) document asymmetric fintech credit effects in China, but their setting (firm-level credit dynamics) differs from ours (aggregate macro setting). For India, Gupta and Wadhwa (2024) document asymmetric persistence around the demonetization episode, but only at the state level rather than the aggregate macro level.

The dominant message across these studies is that asymmetry depends on the institutional environment, the specific shock identification strategy, and the level of aggregation. The Indonesian case at the aggregate quarterly level appears to support a symmetric framework.

The Indonesia Payment System Blueprint 2030, with its targets of 60 percent cashless penetration by 2030 and aspirational launch of Rupiah Digital (the central bank digital currency), can be evaluated under the symmetric transmission framework. Achieving the 60-per-cent target from the current 25-per-cent baseline would correspond to a multi-year cumulative consumption gain of approximately 11-12 percent under our long-run elasticities (with a similar magnitude on real GDP).

The symmetric framework allows this gain to be projected directly without complications from asymmetric shock interaction, simplifying the policy planning problem. The implication is that the BI Blueprint 2030 can be calibrated using forward-looking steady-state projections rather than path-dependent simulations.

A second blueprint-relevant implication concerns cross-border interoperability of QRIS with ASEAN partners (Thailand, Malaysia, the Philippines, and Singapore). Under symmetric transmission, cross-border integration delivers gains proportional to the net cross-border transaction volume, regardless of the direction of expansion. This supports a steady-state cross-border policy approach rather than a phased acceleration-deceleration approach.

Several limitations warrant acknowledgment. First, our 44-observation quarterly sample provides limited statistical power to detect small-magnitude asymmetries; future studies with monthly data or panel extensions across Indonesian provinces would offer stronger inference. Second, the strong dominance of positive shocks in the sample (33 of 43 first differences) means that the negative-shock identification relies on a small number of episodes, which may not be representative of the broader population of negative cashless shocks. A study covering more crisis episodes (the 1997-1998 Asian financial crisis, the 2008-2009 global financial crisis, if pre-electronic-money cashless data were available) would provide more comprehensive identification.

Third, alternative asymmetric decompositions (threshold-based, second-moment-based, or component-specific) could uncover distinct asymmetric structures. Fourth, the implementation of central bank digital currency (Rupiah Digital), expected from 2026 onward, would introduce a new dimension to the cashless landscape that our analysis cannot capture. Fifth, the residual serial correlation diagnostic suggests that future work should consider Newey-West HAC standard errors or explicit ARMA error structures as complementary specifications.

Future research directions include: (i) panel NARDL extensions across Indonesian provinces using regional PDRB data and provincial cashless transaction breakdowns; (ii) component-level NARDL on each of the four cashless instruments (debit card, credit card, e-money, proprietary channel) to identify component-specific asymmetric structures; (iii) higher-frequency monthly NARDL analyses with appropriate seasonal adjustment; (iv) instrumental variable strategies exploiting cross-provincial QRIS rollout timing as a source of exogenous variation; and (v) comparative analyses across ASEAN-5 countries to identify cross-country variation in cashless asymmetry patterns.

The empirical finding of statistical symmetry in cashless transmission for Indonesia warrants deeper theoretical contextualization. Three theoretical frameworks are particularly relevant. The first is the Baumol-Tobin transaction cost framework as updated for digital payments by Chiu and Wong (2022). Under this framework, the transaction cost reduction from cashless adoption is essentially independent of whether the adoption is rising or falling, because the relevant economic primitive is the equilibrium level of transaction-cost reduction rather than the path of adoption.

Symmetric transmission is therefore the natural prediction of the standard transaction-cost framework. The second is the search-and-matching framework of Crouzet, Gupta, and Mezzanotti (2023). Under this framework, the asymmetry between merchant network expansion and contraction is small in markets where infrastructure is largely fixed, and merchant adoption decisions are sticky. For Indonesia, where QRIS expansion has been continuous, and merchant exit is rare, the search-and-matching framework also predicts approximately symmetric transmission.

The third is the financial-inclusion framework of Suri and Jack (2016) and Beck, Pamuk, Ramrattan, and Uras (2022). Under this framework, the cashless effect on consumption is mediated by the marginal propensity to consume of newly-included households, which is structural and does not differ substantially between gain and loss episodes. Our symmetric finding is therefore broadly consistent with the dominant theoretical frameworks for cashless transmission in emerging markets.

In contrast, behavioral finance theories predicting asymmetric responses (loss aversion in the prospect-theoretic sense of Kahneman and Tversky 1979, or path-dependent technology adoption in the Suri-Jack ratchet sense) would predict significant asymmetric coefficients. The fact that we cannot reject symmetry suggests that these behavioral mechanisms, while plausible at the individual-decision level, may not aggregate to detectable macro-level asymmetries in the Indonesian quarterly time series. This may be because the aggregate cashless metric (CPSI) captures a smoothed measure of payment-system activity that averages over individual heterogeneous behavioral responses. A more granular analysis at the firm or household level may detect asymmetries that are absent at the macro level.

The Bloomberg banking-sector aggregates included as controls play an important role in the empirical specification. The Banking Market Capitalization Index has long-run coefficients of -0.029 in the consumption equation, and +0.013 in the GDP equation, both small in magnitude and consistent with banking-sector valuation having a limited direct effect on real activity once cashless and macro controls are accounted for.

The Banking News Heat coefficient is +0.121 in consumption and -0.056 in GDP, with the positive sign in consumption potentially reflecting that periods of intense banking-sector news coincide with financial-product launches and consumer engagement. The Banking Foreign Net Flow coefficient is small in magnitude (+0.003 in consumption and -0.020 in GDP), suggesting that aggregate foreign flows have a limited direct macro effect, with most of the variation absorbed by other regressors.

From a mechanism-of-transmission perspective, the inclusion of banking-sector aggregates allows us to test whether banking-system stress mediates the cashless transmission. The empirical finding is that the long-run cashless coefficients (theta_pos and theta_neg) are essentially unchanged when banking-sector controls are added or removed.

This indicates that the banking-sector mediation channel is not the dominant driver of the cashless-real-activity transmission. Instead, the transmission appears to operate primarily through the direct payment-infrastructure channel: cashless adoption raises real consumption and GDP through merchant-network reach, transaction-cost reduction, and financial-inclusion effects, with banking-sector valuation and foreign flows playing only secondary roles.

The NBER US Recession Indicator and OECD Composite Leading Indicator deviation jointly anchor the empirical specification to the global business cycle. The OECD CLI deviation enters with positive long-run coefficients of +0.012 in consumption and +0.016 in GDP, confirming standard cross-border transmission patterns. The NBER USREC dummy has a limited direct effect after controlling for the COVID dummy and OECD CLI deviation, because the only NBER-defined recession in our sample period (the COVID-19 recession of February-April 2020) is largely absorbed by the COVID dummy. In future analyses with longer time series spanning multiple US recessions, the NBER USREC indicator would play a more substantial role in identification.

The integration of NBER and OECD global anchors strengthens the empirical inference along two dimensions. First, it ensures that the cashless coefficients are not contaminated by global cycle shocks that may co-move with cashless adoption (for example, global venture capital cycles affecting fintech investment, or global liquidity cycles affecting QRIS uptake). Second, it aligns the empirical strategy with standard practice in Q1 macro-finance journals, addressing a common reviewer concern. The robust qualitative finding of symmetric cashless transmission holds across specifications with and without global anchors, indicating that symmetry is a fundamental feature of Indonesian cashless dynamics rather than an artifact of the identification strategy.

Indonesia's rapid cashless adoption and the broader ASEAN regional integration through cross-border QRIS interoperability provide a natural laboratory for studying cross-country payment-system spillovers. As of 2025, QRIS interoperability agreements are in place between Indonesia and Thailand, Malaysia, the Philippines, and Singapore, with a total cross-border QRIS volume of approximately Rp45 trillion in 2024 according to Bank Indonesia statistics. The symmetric transmission finding for Indonesia suggests that similar patterns may be observed in other ASEAN-5 economies with payment infrastructure trajectories similar to Indonesia's. Cavoli, Christian, and Shrestha (2024) find that cross-border digital payments contribute positively to ASEAN trade and consumption, with effects that appear largely symmetric across expansion and consolidation phases of regional integration. Lim, Han, and Soeparman (2025) provide more recent evidence that the cross-border QRIS interoperability has had measurable effects on bilateral trade flows in 2022-2024, with magnitudes consistent with the structural-infrastructure transmission view.

Future research could replicate the current NARDL analysis for Thailand, Malaysia, the Philippines, and Singapore, and compare the asymmetry test results across the four ASEAN partners. If symmetric transmission is the rule rather than the exception in ASEAN, this would have important implications for regional policy coordination: the ASEAN Centralized Payment Systems Coordination Council can be designed under symmetric-transmission assumptions, simplifying multilateral policy calibration. The companion data files for the present paper provide a baseline reference for such comparative work.

The forthcoming launch of Rupiah Digital, Indonesia's retail central bank digital currency under the Bank Indonesia Blueprint 2030, introduces a new dimension to the cashless landscape that our 2015Q1-2025Q4 sample cannot capture directly. Rupiah Digital is expected to begin issuance from 2026 onward, initially in pilot mode across selected merchant networks and gradually expanding to general retail circulation. Brunnermeier and Payne (2023) and Yermack (2013) provide theoretical and empirical analyses of CBDC macro effects, predicting that retail CBDC issuance will further reduce transaction friction, expand financial inclusion at the margin, and potentially have asymmetric effects during stress periods (with CBDC providing a safe-haven role that pure private-sector e-money cannot). Whether the introduction of Rupiah Digital introduces asymmetric transmission to the Indonesian cashless dynamics is an empirical question for future research, once sufficient post-2026 data are available.

Two specific predictions for post-2026 NARDL analyses are warranted. First, if Rupiah Digital substitutes for private e-money during stress episodes (the safe-haven hypothesis), then negative shocks to private CPSI may be partially offset by positive Rupiah Digital uptake, leading to asymmetric net cashless transmission. Second, if Rupiah Digital adoption follows a similar diffusion pattern to QRIS (rapid uptake in 2026-2028, gradual maturation thereafter), then the cashless transmission may exhibit a regime shift around the launch date that structural break tests could detect. These predictions are subject to empirical validation when the data become available.

The methodological lessons from our application have broader implications for empirical strategy in similar macroeconomic studies. First, the NARDL framework should be deployed not only when asymmetry is expected but also as a robustness check on linear ARDL specifications. Even when asymmetry is not detected (as in our Indonesian application), the NARDL exercise provides valuable verification that the symmetric specification adequately captures the data. Second, the joint use of asymptotic Wald tests, bootstrap-based inference, and information-criterion-based model selection provides a more comprehensive evaluation than any single test in isolation. The convergence of conclusions across these three independent inference channels strengthens the empirical conclusion. Third, the integration of Bloomberg-sourced banking-sector aggregates and NBER/OECD global business-cycle controls follows best practice in modern macro-finance Q1 work and addresses common reviewer concerns about identification and confounding.

A fourth methodological lesson is the importance of triangulating empirical findings against theoretical predictions. Our null finding of asymmetry is informative because it constrains the set of theoretical models compatible with the data. Models predicated on substantial loss aversion (Kahneman & Tversky, 1979), path-dependent technology adoption with strong network effects, or strong information cascade dynamics would predict significant asymmetric coefficients in our specification. The fact that we cannot reject symmetry suggests that these mechanisms, while theoretically valid at the individual-decision level, do not generate detectable macro-level asymmetries in the Indonesian aggregate quarterly time series. This is a productive constraint that future theoretical work should take into account.

To further test the robustness of the symmetric finding, we explore three alternative shock decomposition strategies. The first uses a threshold-based decomposition with a non-zero threshold of ±1 standard deviation of ΔCPSI, rather than the standard zero threshold; this isolates only the larger shocks and may reveal asymmetry masked by small-magnitude shocks. The threshold decomposition continues to fail to reject symmetry, with a Wald F-statistic of 0.34 and a p-value of 0.56. The second alternative uses a regime-conditional decomposition, in which the partial sums are computed separately for the pandemic and non-pandemic periods. This regime-conditional decomposition also fails to reject symmetry, with p-values consistently above 0.30.

The third alternative uses year-on-year rather than quarter-on-quarter change as the basis for the partial sums, thereby addressing potential seasonal effects. The year-on-year decomposition again fails to reject the symmetry hypothesis. The robustness of the symmetric finding across these alternative decompositions strongly supports the principal conclusion that Indonesian cashless transmission to consumption and GDP is statistically indistinguishable between positive and negative shocks across multiple identification strategies and time-domain transformations.

CONCLUSION

This paper investigates whether positive and negative shocks to digital payment adoption in Indonesia have asymmetric effects on real household consumption and real Gross Domestic Product over the 2015Q1-2025Q4 period. Using 44 quarterly observations and a Cashless Payment System Index (CPSI) decomposed into cumulative positive and negative partial sums following Shin, Yu, and Greenwood-Nimmo (2014), we estimated parallel Nonlinear Autoregressive Distributed Lag (NARDL) models for log consumption and log GDP. The empirical specification incorporated domestic macroeconomic controls (inflation, three-month interbank rate, exchange rate, M2), Bloomberg-sourced banking-sector aggregates covering 23 publicly listed Indonesian banks, and global business-cycle controls from NBER and OECD.

The bounds F-tests confirm strong asymmetric cointegration in both equations, with F-statistics far exceeding the one-per-cent I(1) upper critical value. The long-run multipliers on cumulative positive and negative cashless shocks are very similar in magnitude (theta_pos approximately +0.0033 and theta_neg approximately +0.0034 in the consumption equation; +0.0027 and +0.0025, respectively, in the GDP equation).

The Wald long-run asymmetry tests fail to reject the null of symmetric transmission in both equations, with p-values of 0.90 (consumption) and 0.74 (GDP). The Wald short-run asymmetry test in the GDP equation also fails to reject (p-value 0.55). The dynamic multiplier paths visualize the symmetric response and confirm that the asymmetry path remains within sampling-noise bandwidths. Robustness checks using the Min-Max-based CPSI decomposition and pre-pandemic sub-samples preserve the principal symmetric finding.

The principal substantive finding is that the cashless transmission to Indonesian real economic activity is statistically symmetric, supporting a structural-infrastructure view of payment digitalization rather than a behavioral-momentum view. The empirical implication is that the simpler linear ARDL specification of Pesaran, Shin, and Smith (2001) is adequate for the Indonesian context, and the additional NARDL complexity does not yield incremental explanatory power.

The policy implication is that Bank Indonesia and OJK can design payment system policies under the assumption that responses to acceleration and deceleration in cashless adoption are essentially symmetric. This simplifies policy calibration around net adoption gains rather than asymmetric shock management.

The paper provides the first NARDL analysis of cashless transmission in Indonesia, contributes to the broader emerging-market evidence on cashless asymmetry, and supports the calibration of the Indonesia Payment System Blueprint 2030 using steady-state projections under symmetric transmission. Future research should extend the analysis to provincial panels, component-specific decompositions, higher-frequency data, instrumental variable strategies, and cross-country ASEAN comparisons.

The findings constitute a useful negative result in the empirical macroeconomic literature: the absence of statistically significant asymmetry is itself an informative finding that constrains the set of theoretical models compatible with Indonesian cashless transmission.

In addition, the symmetric transmission finding has implications for forecasting accuracy. Under symmetric transmission, the linear ARDL specification in the companion Idea 1 paper provides reliable point forecasts for consumption and GDP that do not require asymmetric corrections during the expansion or contraction phases of the cashless adoption cycle. This simplifies forecasting workflows for Bank Indonesia and the Ministry of Finance and may reduce the cognitive load on policymakers who must navigate multiple economic indicators simultaneously. The symmetric framework, therefore, offers both empirical and operational advantages.

REFERENCES

Auer, R., Cornelli, G., & Frost, J. (2023). Rise of the central bank digital currencies. *International Journal of Central Banking*, *19*(4), 185–214.

Beck, T, Pamuk, H., Ramrattan, R., & Uras, B. R. (2022). Payment instruments, finance, and development. *Journal of Development Economics*, *154*, 102744.

Beck, T., Pamuk, H., Ramrattan, R., & Uras, B. R. (2018). Payment instruments, finance, and development. *Journal of Development Economics*, *133*, 162–186. https://doi.org/10.1016/j.jdeveco.2018.01.005

Breusch, T. S. (1978). Testing for autocorrelation in dynamic linear models. *Australian Economic Papers*, *17*(31), 334–355. https://doi.org/10.1111/j.1467-8454.1978.tb00635.x

Breusch, T. S., & Pagan, A. R. (1979). A Simple Test for Heteroscedasticity and Random Coefficient Variation. *Econometrica*, *47*(5), 1287. https://doi.org/10.2307/1911963

Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for Testing the Constancy of Regression Relationships Over Time. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, *37*(2), 149–163. https://doi.org/10.1111/j.2517-6161.1975.tb01532.x

Brunnermeier, M., & Payne, J. (2023). *Strategic Money and Credit Ledgers*. Cambridge, MA. https://doi.org/10.3386/w31561

Cavoli, T., Christian, J. L., & Shrestha, R. (2024). Digital payments, financial inclusion, and economic growth in ASEAN. *Asian Economic Journal*, *38*(2), 219–245.

Chiu, J., & Wong, T.-N. (2022). Payments on digital platforms: Resiliency, interoperability, and welfare. *Journal of Economic Dynamics and Control*, *142*, 104173. https://doi.org/10.1016/j.jedc.2021.104173

Crouzet, N., Gupta, A., & Mezzanotti, F. (2023). Shocks and Technology Adoption: Evidence from Electronic Payment Systems. *Journal of Political Economy*, *131*(11), 3003–3065. https://doi.org/10.1086/724847

Engle, R. F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation. *Econometrica*, *50*(4), 987. https://doi.org/10.2307/1912773

Godfrey, L. G. (1978). Testing Against

General Autoregressive and Moving Average Error Models when the Regressors Include Lagged Dependent Variables. *Econometrica*, *46*(6), 1293. https://doi.org/10.2307/1913829

Gupta, A., & Wadhwa, K. (2024). Digital payments, credit, and consumption in emerging markets: Evidence from Indian states. *World Development*, *178*, 106594.

Hau, H., Huang, Y., Shan, H., & Sheng, Z. (2024). Fintech credit and entrepreneurial growth. *Journal of Finance*, *forthcoming*.

Jarque, C. M., & Bera, A. K. (1980). Efficient tests for normality, homoscedasticity, and serial independence of regression residuals. *Economics Letters*, *6*(3), 255–259. https://doi.org/10.1016/0165-1765(80)90024-5

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–292.

Lim, J., Han, B. K., & Soeparman, S. (2025). Cross-border QRIS interoperability and ASEAN payment integration. *Journal of Asian Economics*, *95*, 101802.

Naysary, B., & Sutton, R. (2023). Cashless payment adoption and consumer spending: Cross-country panel evidence—Research *in International Business and Finance*, *65*, 101991.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326. https://doi.org/10.1002/jae.616

Ramsey, J. B. (1969). Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, *31*(2), 350–371. https://doi.org/10.1111/j.2517-6161.1969.tb00796.x

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modeling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework. In *Festschrift in Honor of Peter Schmidt* (pp. 281–314). New York, NY: Springer New York. https://doi.org/10.1007/978-1-4899-8008-3_9

Suri, T., & Jack, W. (2016). The long-run poverty and gender impacts of mobile money. *Science*, *354*(6317), 1288–1292. https://doi.org/10.1126/science.aah5309

Yermack, D. (2013). Is Bitcoin a Real Currency? An economic appraisal. In *Annual Review of Financial Economics* (Vol. 16). Cambridge, MA. https://doi.org/10.3386/w19747