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THE IMPACT OF ELECTRONIC MONEY AND ATM+DEBIT TRANSACTION VOLUMES ON CURRENCY DEMAND IN INDONESIA BY USING ARDL BOUNDS TESTING APPROACH

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Abstract

This study examines the effect of electronic money transaction volume and ATM/debit transaction volume on the demand for currency in circulation in Indonesia, with the BI Rate and economic activity included as control variables. This study uses monthly data from January 2022 to December 2025 obtained from Bank Indonesia and Statistics Indonesia. The dependent variable is real currency demand, while the independent variables are electronic money transaction volume, ATM/debit transaction volume, the Bank Indonesia (BI) Rate, and economic activity. The analysis employs the Augmented Dickey-Fuller (ADF) unit root test, a first-difference regression model to estimate short-run effects, and the Autoregressive Distributed Lag (ARDL) approach with the Bounds Test to examine the existence of a long-run relationship.

The ADF results show that all variables are non-stationary at level but become stationary at first difference, indicating that all variables are integrated of order one, or I(1). The first-difference regression results indicate that the electronic money transaction volume does not significantly affect changes in real currency demand. ATM/debit transaction volume has a positive effect and is significant only at the 10 percent level. Meanwhile, the BI Rate and economic activity are not statistically significant in the short run. The Bounds Test results confirm the absence of cointegration, suggesting that no long-run relationship exists among the variables.

Keywords: electronic money, ATM/debit transactions, currency demand, ARDL, first difference, payment system

INTRODUCTION

Digital transformation in payment systems has become one of the most significant phenomena in modern economies. From 2014 to 2021, the number of people using digital payments in emerging market countries increased drastically from 35% to 57%, indicating rapid adoption of electronic payment technology (Aguilar et al., 2024). This trend is highly relevant for Indonesia, which has a large population and rapid digital growth.

The growth of electronic money transactions and ATM+Debit transactions in Indonesia reflects a fundamental shift in society's payment preferences. Indonesia has undergone a rapid transformation in its payment systems, moving away from traditional methods such as cash toward safer, more reliable, and more accurate payment instruments in the form of card-based and other electronic instruments (Bank Indonesia, 2009). This development has been driven by innovations in the financial market and information technology, in a transformation process that has spanned several decades but has intensified in recent years (Humprey et al., 1996).

Changes in payment preferences among Indonesians have significant implications for monetary policy and money supply management. As the demand for electronic money increases, this is likely to affect the total money supply in a manner similar to the risks posed by uncontrolled credit creation (Khalaf, 2018). This phenomenon indicates that a deep understanding of the relationship between the volume of electronic money transactions and the demand for physical cash is crucial for monetary authorities to formulate effective policies.

Cash remains the largest component of central bank liabilities in almost all countries. The continued use of electronic money will significantly reduce central bank budgets, as demand for cash keeps declining. However, empirical research shows a complex phenomenon: while some studies reveal that consumers who use e-money reduce the amount of cash payments (Kitamura, 2022).

Previous studies have identified various factors that contribute to changes in the demand for currency as a percentage of money supply (M1). Factors that drive the substitution of cash with electronic means are traditionally associated with greater access to the financial system, increased use of non-cash payment instruments, higher interest rates, and higher inflation rates (Jobst & Stix, 2017). In this context, the ease and convenience of electronic payments play a significant role, as the reduction in transaction costs of card payments compared to cash can lead to an increase in debit card payments, especially for small-value transactions (Alvarez & Lippi, 2009).

Research in Indonesia has shown interesting results regarding the relationship between electronic transactions and the demand for money. Previous studies have found that e-money transactions and the volume of ATM+Debit transactions have a significant influence on the money supply (M1), while credit card transactions show a different effect (Astuti, 2023). However, research specifically focusing on the 2022-2025 period is still limited, even though this period includes post-COVID-19 recovery and an extraordinary acceleration of digital transformation.

The significance of this research lies in its provision of a more comprehensive understanding of the dynamics of currency demand in Indonesia within the context of digital transformation. With the increasing use of electronic money and ATM+Debit transactions, the central bank needs to understand the monetary policy implications of these changes. Research on the relationship between the volume of electronic money transactions, the volume of ATM+Debit transactions, and the demand for currency will provide the empirical evidence needed to formulate more effective monetary policies and optimal money supply management (Feyen et al., 2021).

This study aims to analyze the influence of electronic money transaction volume and ATM+Debit transaction volume on the demand for currency in circulation in Indonesia during the period of 2022-2025. This period was chosen because it reflects the state of Indonesia's modern payment market in the post-pandemic era, with high digital penetration. Through rigorous quantitative analysis, this research will contribute to the literature on digital payments, money demand, and monetary policy in emerging market countries, particularly Indonesia.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

The demand for currency in the modern economy is influenced by various interacting factors, ranging from innovations in payment technology to macroeconomic conditions. The classical theory of money demand developed by Keynes explains why people choose to hold cash through the three motives of transactions, precaution, and speculation (Jobst & Stix, 2017). The Baumol-Tobin model later updated this framework by introducing the dimension of transaction costs, where the efficiency of alternative payment instruments directly affects the demand for currency (Alvarez & Lippi, 2017). In the context of rapid digitalization, the theory of money demand continues to evolve to accommodate the role of financial innovation as a new structural determinant that fundamentally changes the patterns of money demand (Meaning et al., 2021).

One of the factors influencing the demand for currency is electronic money. Kitamura (2022) found that increased use of electronic money significantly reduces the demand for cash, especially for small and medium-sized transactions. Ozili (2018), in a cross-country analysis, confirmed that the expansion of digital financial services is negatively correlated with cash usage in developing countries, with a substitution effect that strengthens as digital penetration increases. Frost et al. (2019) added that digital payment platforms have a greater impact on reducing cash usage because of their ability to integrate payment services with daily digital activities.

Based on these studies, the following hypothesis is formulated:

H1: The volume of electronic money transactions has a negative effect on the demand for currency in Indonesia.

In addition to electronic money, ATM and debit card transactions are other non-cash instruments that also contribute to reducing the demand for physical cash, albeit through different mechanisms. While electronic money substitutes cash via digital platforms, ATM+Debit transactions operate through the more established conventional banking network. Hasan et al. (2022) confirmed that card-based payment infrastructure has a significant negative impact on the demand for physical cash, with a stronger effect in countries with higher banking penetration. Alvarez and Lippi (2017) add that the reduction in transaction costs offered by card-based instruments cumulatively encourages consumers to shift away from cash.

Based on these studies, the following hypothesis is formulated:

H2: The volume of ATM+Debit transactions has a negative effect on the demand for physical cash in Indonesia.

In addition to payment technology factors, macroeconomic conditions play an important role in determining the demand for currency in circulation. The interest rate, as a representation of the opportunity cost of holding cash, is a key determinant that has long been recognized in monetary literature. Jobst and Stix (2017) found that interest rates have a consistently negative relationship with the demand for currency in circulation across countries and periods. Meaning et al. (2021) confirmed that the sensitivity of currency demand to interest rates undergoes structural changes as digital payment adoption increases, while Boar et al. (2020) added that the elasticity of demand for currency in circulation with respect to interest rates tends to be lower in countries with high digital penetration.

Based on these studies, the following hypothesis is formulated:

H3: The BI Rate negatively affects the demand for currency in circulation in Indonesia.

While interest rates suppress the demand for cash, economic activity works in the opposite direction, driving the need for transactional funds in society. Feyen et al. (2021) found that economic growth remains the main driver of cash demand in developing countries, although the adoption of digital payments gradually reduces its elasticity. Ozili (2018) adds that in countries with large informal sectors, such as Indonesia, the positive relationship between economic activity and cash demand is more persistent because most informal transactions still use cash. Hasan et al. (2022) confirms that even though digital payments continue to grow, the demand for cash remains positively correlated with aggregate economic activity.

Based on these studies, the following hypothesis is formulated:

H4: Economic activity positively affects the demand for cash in Indonesia.

The four factors previously discussed, namely electronic money, ATM+Debit transactions, interest rates, and economic activity, do not operate independently; rather, they interact simultaneously in shaping the demand for currency in circulation. Feyen et al. (2021) emphasized that the transformation of the payment system is a multidimensional phenomenon that can only be explained through the simultaneous interaction of various technological, economic, and policy factors. Furthermore, the interaction among these variables is not only short-term in nature but also forms long-term structural equilibrium. Meaning et al. (2021) highlighted that changes in the payment system are permanent and establish a new long-term equilibrium, while Kitamura (2022) confirmed the existence of a stable long-term cointegration between digital payment instruments and the demand for currency in circulation. Jobst and Stix (2017) add that the determinants of the demand for currency in circulation can be empirically identified as forming a consistent long-term equilibrium relationship.

Based on these studies, two hypotheses are formulated as follows:

H5: The volume of electronic money transactions, the volume of ATM+Debit transactions, the BI Rate, and economic activity simultaneously influence the demand for currency in circulation in Indonesia.

H6: There is a long-term relationship between the volume of electronic money transactions, the volume of ATM+Debit transactions, the BI Rate, economic activity, and the demand for currency in circulation in Indonesia.

RESEARCH METHODS

1. Research Design

This study uses a quantitative approach with a time series design to analyze the influence of electronic money transaction volume, ATM+Debit transaction volume, BI Rate, and economic activity on the demand for currency in Indonesia for the period January 2022 – December 2025. The main analytical method used is the Autoregressive Distributed Lag (ARDL) with the Bounds Testing approach, which was chosen because it can accommodate variables with different orders of integration I(0) and I(1), provide unbiased estimates for small samples, and estimate both short-term and long-term relationships simultaneously (Nkoro & Uko, 2016).

2. Research Data and Variables

This study uses monthly secondary data comprising 48 observations sourced from the official publications of Bank Indonesia and the Central Statistics Agency (BPS). All variables, except the BI Rate, are transformed into natural logarithm (ln) form to allow coefficient interpretation as elasticity and to reduce heteroscedasticity (Pesaran et al., 2001, as cited in Nkoro & Uko, 2016).

Table 1. Variables

Variables	Indicator	Source	Type	Symbol	Units
Currency/cash	Currency in circulation outside the banking sector	Bank Indonesia (SEKI)	Dependent	lncashreal	Billion Rupiah
Electronic money	Electronic money transaction volume	Bank Indonesia (SPIP)	Independent	lnue	Thousands of transactions
ATM+Debit shopping transaction	ATM + Debit transaction volume	Bank Indoensia (SPIP)	Independent	atmdb	Thousands of transactions
Interest rate	BI Rate monetary policy	Banks Indonesia (Statistik moneter)	Control	bi_rate	Percent
Economic activity	Industrial Production Index	BPS	Control	activity	Index

Based on Table 1, the dependent variable in this study is the real demand for currency, which is represented by lncashreal in the initial model and dlncashreal in the short-term model. The main independent variables are lnue and lnatmdb, while the control variables are bi_rate_persen and lnactivity. The transformation of the variables was performed in three stages. First, the nominal currency variable is converted into real currency by deflating it using the Consumer Price Index (CPI). Second, several variables are transformed into natural logarithmic form to stabilize the variance of the data, simplify the measurement scale, and facilitate the interpretation of relationships between variables. Third, because all variables are I (1) based on the results of the stationarity test, the short-term model is estimated using the first difference.

The estimation model used is as follows.

$$\ln(CASHREAL_t) = \alpha + \beta_1 \ln(UE_t) + \beta_2 \ln(ATMDB_t) + \beta_3 BIRATE_t + \beta_4 \ln(ACTIVITY_t) + \varepsilon_t$$

3. Data Collection Techniques

The data collection techniques in this study were carried out through documentation by gathering data from official BI and BPS publications, as well as a literature review by collecting theories and references that support the research.

4. Data Analysis Techniques

Data analysis was performed using the EViews program. The stages of the analysis were as follows:

4.1 Descriptive Statistics

Descriptive statistics were used to provide an initial overview of the characteristics of the research data, such as the mean, median, maximum, minimum, and standard deviation.

4.2 Stationarity Test

Because the data used are time series, the first step in the analysis was to test for data stationarity. The test used is the Augmented Dickey-Fuller (ADF). The decision criterion is that if the probability value is < 0.05, then the data is stationary; whereas if the probability value is > 0.05, then the data is not stationary.

4.3 Short-Term Regression Model with First Difference

After it was determined that the research variables are integrated at order one, the short-term analysis is conducted using the first difference model:

$$dlncashreal_t = \alpha + \beta_1 dlnue_t + \beta_2 dlnatmdb_t + \beta_3 dbirate_t + \beta_4 dlnactivity_t + \varepsilon_t \quad (1)$$

with

$dlncashreal_t$ = change in real currency log

$dlnue_t$ = changes in the log of electronic money transaction volume

$dlnatmdb_t$ = change in log volume of ATM+Debit transactions

$dbirate_t$ = change in BI Rate

$dlnactivity_t$ = changes in economic activity log

ε_t = error term

This model is used to examine the short-term influence of independent variables on the demand for the real currency in circulation.

4.4 Classical Assumption Test

To assess the feasibility of the model, a classical assumption test was conducted, which included:

a. Normality Test

Used to determine whether the model residuals are normally distributed. The test is conducted using the Jarque-Bera test.

b. Autocorrelation Test

Used to determine whether there is a serial correlation in the residuals. The test is conducted using the Breusch-Godfrey Serial correlation LM Test.

c. Heteroscedasticity Test

It was used to determine whether the residual variance was constant. The test was conducted using the Breusch-Pagan-Godfrey method.

d. Multicollinearity Test

To identify multicollinearity, the correlation matrix of the independent variables should be analyzed. A very high correlation between these variables suggests multicollinearity.

4.5 ARDL Estimation

This research employs the Autoregressive Distributed Lag (ARDL) method to examine the potential for a long-term connection between variables. The ARDL model's lag selection is automatically determined using the Schwarz Information Criterion (SIC).

4.6 Bounds Test

After the ARDL model is obtained, a Bounds Test is conducted to determine whether there is a long-term relationship among the variables.

Decision-making criteria:

- if the F-statistic value is greater than the upper bound, then there is cointegration;
- if the F-statistic value is less than the lower bound, then there is no cointegration;
- if the F-statistic value lies between the two, then the result is inconclusive.

RESULTS AND DISCUSSION

This study uses monthly data from January 2022 to December 2025. The dependent variable used is the real currency demand (lncashreal). The independent variables are the volume of electronic money transactions (lnUE), the volume of ATM+Debit transactions (lnatmdb), the BI Rate (birate), and economic activity (lnactivity). All data were processed using EViews. Since the data used are time series, all variables are tested for stationarity before the estimation is carried out. Subsequently, a short-term analysis was conducted using the first difference model. As an additional test, this study uses the ARDL model and Bounds Test to examine the possibility of a long-term relationship. Figure 1 shows a graph of the data for each variable.

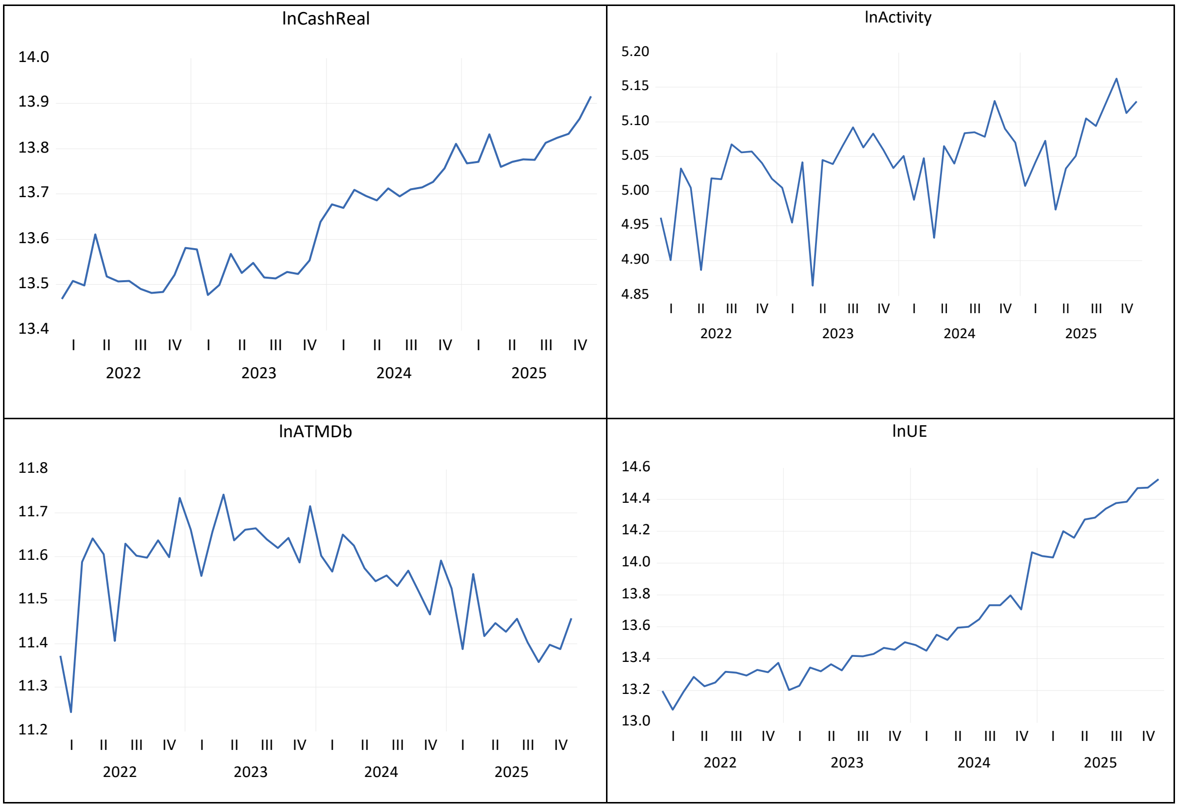


Figure 1. Data graph of each variable 2022-2025

Based on Figure 1, the increase in lnUE indicates that the use of digital wallets or electronic money continues to increase sharply among the public. Conversely, the decline in lnATMDb suggests that the frequency of debit card use or cash withdrawals at ATMs is starting to decrease.

People are beginning to shift from physical bank cards to digital payment methods. The lnCashReal variable continues to show an upward trend, even though electronic money is also increasing sharply. This indicates that the public is using more non-cash payments but is not completely abandoning physical cash. Physical cash is still held or circulated in society.

Overall, even though the proportion of digital payment (e-money) usage dominates ATM/Debit usage, the public's need for physical cash persists in line with the general growth of economic activity.

5.1 Descriptive Statistics

Table 2. Descriptive Statistics of Research Variables

	LNCASHREAL	LNATMDB	LNACTIVITY	LNUE	BI_RATE_P
Mean	13.64368	11.55101	5.041234	13.64771	5.296875
Median	13.65333	11.57963	5.049117	13.47540	5.750000
Maximum	13.91545	11.74159	5.162498	14.52916	6.250000
Minimum	13.46829	11.24253	4.863758	13.07678	3.500000
Std. Dev.	0.130192	0.111501	0.062002	0.426488	0.922036
Skewness	0.231478	-0.612217	-0.890279	0.782920	-1.022178
Kurtosis	1.686400	2.755777	3.966757	2.210983	2.630036
Jarque-Bera	3.879746	3.117764	8.210008	6.148799	8.632525
Probability	0.143722	0.210371	0.016490	0.046217	0.013350
Sum	654.8965	554.4485	241.9792	655.0902	254.2500
Sum Sq. Dev.	0.796648	0.584330	0.180681	8.548923	39.95703
Observations	48	48	48	48	48

Based on Table 2, the average lncashreal is 13.64368, and the average lnue is 13.64771. The lnUE variable had a greater variation than the other variables, as reflected by a standard deviation of 0.426488. Meanwhile, lnactivity has the smallest standard deviation, which is 0.062002, indicating that its movement is relatively more stable.

5.2 Initial Correlation Test

	LNUE	LNATMDB	LNCASHREAL	LNACTIVITY	BI_RATE_P
LNUE	1.000000	-0.533641	0.915985	0.556821	0.210364
LNATM	-0.533641	1.000000	-0.454706	-0.160397	0.303529
LNCAS	0.915985	-0.454706	1.000000	0.460057	0.335394
LNACTI	0.556821	-0.160397	0.460057	1.000000	0.215272
BI_RAT	0.210364	0.303529	0.335394	0.215272	1.000000

Figure 2. Initial correlation test

Figure 2 shows the covariance matrix output for the research variables. The results of the correlation matrix analysis reveal a key finding: there is a very strong positive relationship between the use of electronic money (lnue) and real currency in circulation (lncashreal), with a value of 0.915985. This indicates that the circulation of physical cash has grown significantly alongside the rapid adoption of digital payments. However, the shift in payment instruments is confirmed by a moderate negative correlation (-0.533641) between lnue and ATM/Debit card transactions (lnatmdb), serving as statistical evidence that society has begun substituting physical banking cards with digital wallets. This transformation in transaction behavior occurs in line with the increasing volume of economic activity (lnactivity), which shows a moderate positive correlation with the growth of electronic money (0.556821) and cash (0.460057). Meanwhile, the benchmark interest rate variable (bi_rate) only demonstrates a relatively weak positive correlation with all payment instruments (ranging from 0.21 to 0.33), implying that the shift in the public's payment preferences today is primarily driven by the need to expand real economic activity and the convenience of digital technology, rather than responses to monetary policy fluctuations.

5.3 Stationarity Test

The stationarity test was conducted using the ADF with lag selection based on the SIC. The results of the initial data stationarity test for the lncashreal variable are shown in Figure 3.

Null Hypothesis: LNCASHREAL has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.186429	0.9687
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNCASHREAL)
Method: Least Squares
Date: 03/30/26 Time: 01:16
Sample (adjusted): 2022M04 2025M12
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCASHREAL(-1)	0.009715	0.052112	0.186429	0.8530
D(LNCASHREAL(-1))	-0.271118	0.161533	-1.678403	0.1009
D(LNCASHREAL(-2))	-0.207627	0.157507	-1.318202	0.1948
C	-0.119451	0.710481	-0.168127	0.8673

R-squared	0.084202	Mean dependent var	0.009273
Adjusted R-squared	0.017193	S.D. dependent var	0.041177
S.E. of regression	0.040822	Akaike info criterion	-3.474509
Sum squared resid	0.068324	Schwarz criterion	-3.313917
Log likelihood	82.17645	Hannan-Quinn criter.	-3.414642
F-statistic	1.256570	Durbin-Watson stat	1.759826
Prob(F-statistic)	0.301876		

Null Hypothesis: LNUE has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.198458	0.9999
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNUE)
Method: Least Squares
Date: 03/30/26 Time: 01:25
Sample (adjusted): 2022M04 2025M12
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUE(-1)	0.061239	0.027855	2.198458	0.0336
D(LNUE(-1))	-0.652720	0.155922	-4.186187	0.0001
D(LNUE(-2))	-0.326677	0.149377	-2.186930	0.0346
C	-0.776641	0.377060	-2.059726	0.0458

R-squared	0.304893	Mean dependent var	0.029786
Adjusted R-squared	0.254031	S.D. dependent var	0.078461
S.E. of regression	0.067766	Akaike info criterion	-2.460811
Sum squared resid	0.188284	Schwarz criterion	-2.300219
Log likelihood	59.36825	Hannan-Quinn criter.	-2.400944
F-statistic	5.994572	Durbin-Watson stat	1.958143
Prob(F-statistic)	0.001745		

Figure 3. Results of the ADF test for the variables lncashreal and lnue on the initial data

The results of the ADF test show that the variable lncashreal has a probability value of 0.9687, which is greater than 0.05. In addition, the ADF test statistic value of 0.186429 is also greater than the 5 percent critical value of -2.928142. This indicates that the variable lncashreal still contains a unit root and is therefore not stationary in its original form. For the lnue variable, the ADF test results show a probability value of 0.9988, which is greater than 0.05. The ADF test statistic value of 1.401627 is also greater than the 5 percent critical value of -2.926622. Thus, lnue is also not stationary in its original form.

Null Hypothesis: DLNCASHREAL has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.079360	0.0000
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLNCASHREAL)
Method: Least Squares
Date: 03/30/26 Time: 01:22
Sample (adjusted): 2022M04 2025M12
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNCASHREAL(-1)	-1.465029	0.240984	-6.079360	0.0000
D(DLNCASHREAL(-1))	0.202242	0.153047	1.321437	0.1935
C	0.012997	0.006318	2.057237	0.0459

R-squared	0.618696	Mean dependent var	0.001327
Adjusted R-squared	0.600538	S.D. dependent var	0.063842
S.E. of regression	0.040350	Akaike info criterion	-3.518106
Sum squared resid	0.068381	Schwarz criterion	-3.397662
Log likelihood	82.15739	Hannan-Quinn criter.	-3.473206
F-statistic	34.07409	Durbin-Watson stat	1.755810
Prob(F-statistic)	0.000000		

Null Hypothesis: DLNUE has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic - based on AIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.636768	0.4553
Test critical values:	1% level	-3.596616	
	5% level	-2.933158	
	10% level	-2.604867	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DLNUE)
Method: Least Squares
Date: 03/30/26 Time: 01:27
Sample (adjusted): 2022M07 2025M12
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNUE(-1)	-0.733838	0.448346	-1.636768	0.1104
D(DLNUE(-1))	-0.810977	0.408113	-1.987139	0.0546
D(DLNUE(-2))	-0.938028	0.354885	-2.643193	0.0121
D(DLNUE(-3))	-0.667574	0.265707	-2.512440	0.0166
D(DLNUE(-4))	-0.383436	0.143928	-2.664086	0.0115
C	0.023290	0.016601	1.402920	0.1692

R-squared	0.786671	Mean dependent var	0.000685
Adjusted R-squared	0.757042	S.D. dependent var	0.135485
S.E. of regression	0.066782	Akaike info criterion	-2.443208
Sum squared resid	0.160553	Schwarz criterion	-2.194970
Log likelihood	57.30737	Hannan-Quinn criter.	-2.352219
F-statistic	26.55063	Durbin-Watson stat	1.911787
Prob(F-statistic)	0.000000		

Figure 4. First difference results for the lncashreal and lnue variables

The next step, as shown in Figure 4, is to perform a first difference for each variable. After applying the first difference, the dlncashreal variable has a probability value of 0.0000, which is smaller than 0.05, with an ADF test statistic value of -6.079360, which is lower than the 5 percent critical value of -2.928142. Thus, dlncashreal is already stationary, indicating that lncashreal is integrated of order one, or I(1). Meanwhile, the first difference result for the dlnue variable shows a probability value of 0.0000, which is less than 0.05, and an ADF test statistic value of -11.07407, which is lower than the 5 percent critical value of -2.926622. This indicates that dlnue is already stationary, so lnue is also an I(1) variable. The following is a table of the ADF stationarity test results for each variable.

Table 3. ADF Stationarity Test Results

Variable	Level (Prob.)	First Difference (Prob.)	Conclusion
lncashreal	0.9687	0.0000	I(1)
lnue	0.9988	0.0000	I(1)
lnatmdb	0.5849	0.0000	I(1)
lnactivity	0.0688	0.0000	I(1)
bi_rate_persen	0.2092	0.0345	I(1)

Based on Table 3, none of the variables are stationary at level at the 5 percent significance level. However, after taking the first difference, all variables become stationary. Thus, all research variables are integrated of order one or I (1).

5.4 Short-Term Regression Model with First Difference

After all research variables were proven to be stationary at the first difference, the analysis continued by estimating the short-term model using first difference regression. This model is used to observe the influence of changes in the volume of electronic money transactions, changes in the volume of ATM+Debit transactions, changes in the BI Rate, and changes in economic activity on changes in real currency demand in Indonesia. The estimation model used is as presented in Equation (1).

Dependent Variable: DLNCASHREAL
Method: Least Squares
Date: 03/30/26 Time: 02:54
Sample (adjusted): 2022M02 2025M12
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007328	0.006331	1.157489	0.2536
DLNUE	0.076285	0.094347	0.808549	0.4233
DLNATMDB	0.126085	0.070258	1.794587	0.0799
DBI_RATE	0.003400	0.033638	0.101091	0.9200
DLNACTIVITY	-0.083839	0.093508	-0.896597	0.3750

R-squared	0.163808	Mean dependent var	0.009514
Adjusted R-squared	0.084171	S.D. dependent var	0.040622
S.E. of regression	0.038874	Akaike info criterion	-3.556669
Sum squared resid	0.063472	Schwarz criterion	-3.359844
Log likelihood	88.58171	Hannan-Quinn criter.	-3.482602
F-statistic	2.056931	Durbin-Watson stat	2.553219
Prob(F-statistic)	0.103706		

Figure 5. Short-term regression model results

The estimation results show that the constant has a coefficient of 0.007328 with a probability value of 0.2536, thus it is not statistically significant. The dlnue variable has a coefficient of 0.076285 with a probability value of 0.4233. This probability value is greater than the 5 percent significance level, so it can be concluded that changes in the volume of electronic money transactions do not have a significant effect on changes in real currency demand in the short term. The F-test results show an F-statistic value of 2.056931 with a Prob(F-statistic) of 0.103706. Since this probability value is greater than 0.05, the regression model is not simultaneously significant at the 5 percent level. This means that, collectively, changes in the volume of electronic money transactions, changes in ATM+Debit transaction volume, changes in the BI Rate, and changes in economic activity are not yet able to strongly explain changes in real currency demand in the short term..

An R-squared value of 0.163808 indicates that approximately 16.38 percent of the variation in changes in real currency demand can be explained by the independent variables in the model. Meanwhile, the remaining 83.62 percent is explained by other factors outside the model. An Adjusted R-squared value of 0.084171 shows that the model's ability to explain variation in the dependent variable is still relatively limited. Based on these estimation results, it can be concluded that in the short term, changes in electronic money transaction volume, changes in the BI Rate, and changes in economic activity have not been proven to have a significant effect on changes in real currency demand. The variable of changes in ATM+Debit transaction volume only shows a weak effect at a 10 percent significance level. In general, these results indicate that the development of non-cash payment instruments during the research period has not had a strong impact on changes in real currency demand in the short term.

5.5 Classical Assumption Test

After estimating the first difference regression model, the next step is to perform classical assumption tests. These tests aim to determine whether the model used meets the basic assumptions of regression, so that the resulting estimates can be interpreted more accurately. In this study, the classical assumption tests carried out include the normality test, autocorrelation test, and heteroscedasticity test.

5.5.1 Normality Test

Normality testing is conducted to determine whether the model's residuals are normally distributed. The test is performed using the Jarque-Bera test. The results of the residual normality test are presented in Figure 6 below.

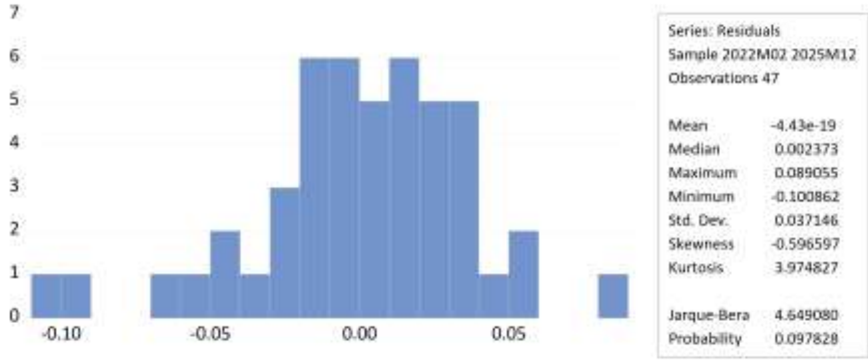


Figure 6. Normality test histogram

The test results show that the Jarque-Bera value is 4.649080 with a probability of 0.097828. Since this probability value is greater than the 5 percent significance level, the residuals of the model can be said to be normally distributed. This result indicates that the first difference regression model has met the residual normality assumption. Thus, the distribution of residuals in the model does not show any significant deviation from the normal distribution.

5.5.2 Autocorrelation Test

The autocorrelation test is conducted to determine whether there is serial correlation in the model residuals. The test is performed using the Breusch-Godfrey Serial Correlation LM Test. The results show that the Prob. F value is 0.0755 and the Prob. Chi-Square value is 0.0580. Both values are greater than 0.05, so at the 5 percent significance level it can be concluded that the model does not experience autocorrelation.

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	2.758052	Prob. F(2,40)	0.0755
Obs*R-squared	5.695937	Prob. Chi-Square(2)	0.0580

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 03/30/26 Time: 02:21
Sample: 2022M02 2025M12
Included observations: 47
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001270	0.006118	0.207654	0.8366
DLNUE	-0.039145	0.092439	-0.423474	0.6742
DLNATMDB	0.060810	0.075965	0.800507	0.4281
DBI_RATE	-0.004888	0.032503	-0.150382	0.8812
DLNACTIVITY	-0.069303	0.096380	-0.719059	0.4763
RESID(-1)	-0.353059	0.165104	-2.138408	0.0386
RESID(-2)	0.109727	0.180187	0.608959	0.5460

R-squared	0.121190	Mean dependent var	-4.43E-19
Adjusted R-squared	-0.010631	S.D. dependent var	0.037146
S.E. of regression	0.037343	Akaike info criterion	-3.600749
Sum squared resid	0.055779	Schwarz criterion	-3.325195
Log likelihood	91.61760	Hannan-Quinn criter.	-3.497056
F-statistic	0.919351	Durbin-Watson stat	1.923446
Prob(F-statistic)	0.491306		

Figure 7. Results of the autocorrelation test using the Breusch-Godfrey Serial Correlation LM Test

5.5.3 Heteroscedasticity Test

Heteroscedasticity testing is conducted to determine whether the residual variance of the model is constant. The test was carried out using the Breusch-Pagan-Godfrey test. The results show that the Prob. F value is 0.1573 and the Prob. Chi-Square value is 0.1520. Since both probability values are greater than 0.05, it can be concluded that the model does not experience heteroscedasticity. These results indicate that the residual variance in the first difference model is relatively constant, so the model meets the assumption of homoscedasticity.

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.748940	Prob. F(4,42)	0.1573
Obs*R-squared	6.710801	Prob. Chi-Square(4)	0.1520
Scaled explained SS	7.970930	Prob. Chi-Square(4)	0.0926

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/30/26 Time: 02:24
Sample: 2022M02 2025M12
Included observations: 47

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001409	0.000372	3.793721	0.0005
DLNUE	0.000889	0.005537	0.160625	0.8732
DLNATMDB	-0.000787	0.004123	-0.190892	0.8495
DBI_RATE	-0.001324	0.001974	-0.670644	0.5061
DLNACTIVITY	-0.013326	0.005487	-2.428460	0.0195

R-squared	0.142783	Mean dependent var	0.001350
Adjusted R-squared	0.061143	S.D. dependent var	0.002354
S.E. of regression	0.002281	Akaike info criterion	-9.227858
Sum squared resid	0.000219	Schwarz criterion	-9.031034
Log likelihood	221.8547	Hannan-Quinn criter.	-9.153792
F-statistic	1.748940	Durbin-Watson stat	1.348114
Prob(F-statistic)	0.157325		

Figure 8. Results of the heteroscedasticity test using the Breusch-Pagan-Godfrey test

Based on the results of the classical assumption tests, it can be concluded that the first difference regression model used in this study generally fulfills the basic assumptions of regression. The model's residuals are proven to be normally distributed, do not experience heteroscedasticity, and do not show significant autocorrelation at the 5 percent level. Therefore, the first difference model can be considered suitable for analyzing the short-term effects of independent variables on changes in real currency demand in Indonesia.

5.6 ARDL Estimation

After estimating the short-term model using first difference, this study also examines the possibility of a long-term relationship between variables using the Autoregressive Distributed Lag (ARDL) approach. This approach is used because all research variables have been proven to be integrated at order one or I (1), based on the results of the stationarity test. The ARDL model estimation is conducted with automatic lag selection using the Schwarz Information Criterion (SIC). The estimation results show that the best selected model is ARDL (1,0,0,0,0). This means that the dependent variable lncashreal uses one lag, while the variables lnue, lnatmdb, bi_rate_persen, and lnactivity are entered into the model without any additional lags.

Dependent Variable: LNCASHREAL
Method: ARDL
Date: 03/30/26 Time: 03:09
Sample: 2022M02 2025M12
Included observations: 47
Dependent lags: 2 (Automatic)
Automatic-lag linear regressors (2 max. lags): LNUE LNATMDB BI_RATE_PERSEN LNACTIVITY
Deterministics: Unrestricted constant and no trend (Case 3)
Model selection method: Schwarz criterion (SIC)
Number of models evaluated: 162
Selected model: ARDL(1,0,0,0,0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNCASHREAL(-1)	0.688789	0.124023	5.553709	0.0000
LNUE	0.101048	0.037434	2.699347	0.0100
LNATMDB	0.062524	0.075634	0.826662	0.4132
BI_RATE_PERSEN	0.003698	0.008068	0.458317	0.6491
LNACTIVITY	0.011585	0.116506	0.099439	0.9213
C	2.073128	1.982174	1.045886	0.3017

R-squared	0.921825	Mean dependent var	13.64741
Adjusted R-squared	0.912292	S.D. dependent var	0.128979
S.E. of regression	0.038198	Akaike info criterion	-3.573335
Sum squared resid	0.059822	Schwarz criterion	-3.337146
Log likelihood	89.97338	Hannan-Quinn criter.	-3.484456
F-statistic	96.69303	Durbin-Watson stat	1.937911
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent test results do not account for model selection.

Figure 9. ARDL estimation results

Based on the ARDL estimation results in Figure 9, these can be summarized again in Table 4 below.

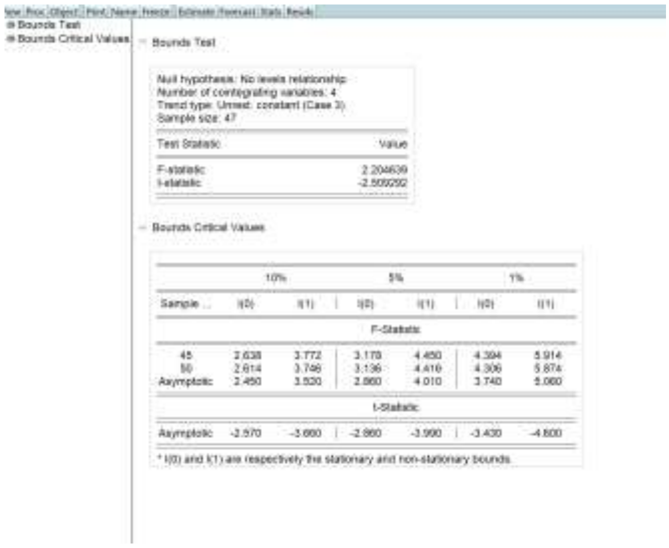
Table 4. Summary of ARDL estimation results interpretation

Variable	Coefficient	Prob.	Significance	Direction of Influence	Interpretation
lncashreal(-1)	0.688789	0.0000	Significant	Positive	The demand for real currency in the previous period has a strong influence on the current period.
lnue	0.101048	0.0100	Significant	Positive	The volume of electronic money transactions is positively related to the demand for real currency in the ARDL model
lnatmdb	0.062524	0.4132	Not significant	Positive	No evidence of significant influence
bi_rate_persen	0.003698	0.6491	Not significant	Positive	No evidence of significant influence
lnactivity	0.011585	0.9213	Not significant	Positive	No evidence of significant influence
C	2.073128	0.3017	Not significant	Positive	Constant is not significant

The ARDL estimation results show that the volume of electronic money transactions has a positive and significant coefficient in the selected level model. However, these results cannot be directly used as a basis for concluding the presence of a long-term effect, because the Bounds Test results indicate that there is no cointegration among the research variables. Thus, the relationship observed in the ARDL estimation cannot be regarded as a stable long-term relationship. Therefore, the conclusions of the hypothesis in this study are based more on the results of the first difference model to observe short-term effects, as well as on the Bounds Test results to determine the existence of a long-term relationship. On that basis, even though the coefficient of the electronic money variable in the ARDL model is positive, the research hypothesis is still not supported because the direction of the effect does not match the initial hypothesis and the long-term relationship was also not proven.

5.7 Bound Test

After the ARDL model is obtained, a Bounds Test is conducted to determine whether there is a long-term relationship between the variables.



Bounds Test

Null hypothesis: No levels relationship
Number of cointegrating variables: 4
Trend type: Unrest. constant (Case 3)
Sample size: 47

Test Statistic	Value
F-statistic	2.204639
t-statistic	-2.509292

Bounds Critical Values

	10%		5%		1%	
Sample ...	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
			F-Statistic			
45	2.638	3.772	3.178	4.450	4.394	5.914
50	2.614	3.746	3.136	4.416	4.306	5.874
Asymptotic	2.450	3.520	2.860	4.010	3.740	5.060
			t-Statistic			
Asymptotic	-2.570	-3.660	-2.860	-3.990	-3.430	-4.600

* I(0) and I(1) are respectively the stationary and non-stationary bounds.

Figure 10. Bound test results

The results of the Bounds Test show an F-statistic value of 2.204639. This value is then compared with the lower bound critical value I(0) and the upper bound I(1). Based on this comparison, the obtained F-statistic falls below the lower bound at the significance level used. Therefore, the null hypothesis stating that there is no levels relationship cannot be rejected.

The results indicate that there is no cointegration or long-term relationship among lncashreal, lnue, lnatmdb, bi_rate_persen, and lnactivity. In other words, the five research variables do not establish long-term equilibrium during the observation period.

Overall, the results of the ARDL estimation and Bounds Test indicate that although some variables in the level model appear to have certain statistical relationships, these relationships are not strong enough to form a long-term equilibrium. This suggests that developments in the volume of electronic money transactions, ATM+Debit transaction volume, BI Rate, and economic activity during the study period have not led to permanent changes in the real demand for currency in Indonesia.

Based on the results of the model estimation, partial tests, simultaneous tests, and long-term relationship analysis, a summary of the decisions regarding the research hypotheses can be presented in Table 5 below.

Table 5. Conclusion of hypothesis testing

	Hypothesis	Test Results	Decision
H1	The volume of electronic money transactions has a negative effect on the demand for currency in Indonesia	The variable of changes in electronic money transaction volume is not significant in the short-term model, and therefore does not prove to affect the demand for real currency in circulation.	Rejected / not supported
H2	ATM + Debit transaction volume has a negative effect on the demand for currency in Indonesia	The variable of changes in ATM+Debit transaction volume is only significant at the 10 percent level with a positive direction of influence, thus it does not conform to the hypothesis.	Rejected / not supported
H3	The BI Rate has a negative effect on the demand for currency in Indonesia	The variable change in the BI Rate is not significant, thus it is not proven to affect the demand for real currency in circulation.	Rejected / not supported

	Hypothesis	Test Results	Decision
H4	Economic activity has a positive effect on the demand for currency in Indonesia	The variable of changes in economic activity is not significant, thus it has not been proven to affect the demand for real currency.	Rejected / not supported
H5	The volume of electronic money transactions, ATM+debit transaction volume, BI Rate, and economic activity simultaneously affect the demand for currency in Indonesia.	The Prob(F-statistic) value is 0.103706, indicating that the model is not significant simultaneously at the 5 percent level.	Rejected / not supported
H6	There is a long-term relationship between the volume of electronic money transactions, the volume of ATM+debit transactions, the BI Rate, economic activity, and the demand for currency in circulation in Indonesia.	The results of the Bounds Test show that the F-statistic value is smaller than the lower bound, indicating that there is no cointegration.	Rejected / not supported

Research results show that the development of non-cash payments has not yet been proven to significantly reduce the demand for real currency in circulation. Changes in electronic money transactions are not significant, which means that in the short term, electronic money has not truly replaced cash. Meanwhile, changes in ATM + Debit transactions actually have a positive coefficient and are only weakly significant at 10%, which can be interpreted as non-cash and cash transactions still growing together due to increasing public transaction activity. In addition, the results of the Bounds Test indicate no cointegration, so there is no evidence of a stable long-term relationship between non-cash payments and the demand for currency in circulation. Therefore, the phenomenon seen in Indonesia during the 2022-2025 period is that non-cash and cash payments continue to run side by side, rather than fully replacing one another.

CONCLUSION

Based on the results of the analysis and discussion, the following conclusions were drawn.

1. All research variables, namely lncashreal, lnue, lnatmdb, lnactivity, and bi_rate_persen, are non-stationary at the level but become stationary at the first difference. Thus, all variables are I (1).
2. The results of the first difference model estimation indicate that the volume of electronic money transactions does not have a significant effect on changes in the real demand for currency in Indonesia.
3. The ATM+Debit transaction volume variable shows a positive effect and is only significant at the 10 percent level, but not significant at the 5 percent level.
4. The BI Rate and economic activity do not have a significant impact on changes in the demand for real currency in the short term.
5. Simultaneously, the first difference model has not yet been significant at the 5% level.
6. The results of the Bounds Test indicate that there is no long-term relationship between real currency demand, the volume of electronic money transactions, the volume of ATM+Debit transactions, the BI Rate, and economic activity.
7. In general, the development of non-cash payment instruments during the research period has not been able to significantly reduce the demand for real currency, either in the short term or the long term.

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