

The Effect of Digital Payments on Currency in Circulation Mediated by Digital Financial Inclusion

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Keywords:	Abstract
QRIS, electronic money, APMK, currency in circulation, Digital Financial Inclusion, ARDL	The rapid growth of digital payment systems has transformed Indonesia's payment behavior; however, currency in circulation remains substantial despite the increasing adoption of cashless instruments. This study aims to examine the effect of digital payments, represented by Quick Response Code Indonesian Standard (QRIS), electronic money, and card-based payment instruments (APMK), on currency in circulation, both directly and indirectly through Digital Financial Inclusion as a mediating variable. This study employs a quantitative approach with a causal associative design using monthly time-series data from January 2020 to December 2025, consisting of 72 observations obtained from Bank Indonesia publications. The data were analyzed using the Autoregressive Distributed Lag (ARDL) model, Error Correction Model (ECM), and Sobel test to evaluate short-term, long-term, and mediation relationships. The results indicate that QRIS and electronic money significantly strengthen Digital Financial Inclusion in the long term, while APMK has a weaker contribution. However, Digital Financial Inclusion does not significantly mediate the relationship between digital payment instruments and currency in circulation. Electronic money shows a positive and significant long-term effect on currency circulation, indicating that digital payments have not replaced cash but continue to coexist within the payment ecosystem. The study concludes that Indonesia remains in a complementary cashless society phase, where digital payment development advances alongside the continued role of physical currency.

INTRODUCTION

Currency in circulation still has an important role in Indonesia's payment system, although digital transactions show a very rapid increase. In this study, currency in circulation is understood as banknotes and coins that are circulated in the community and are used directly in transaction activities. Theoretically, the development of digital payment instruments should be able to reduce people's need for currency, because part of the function of currency as a means of payment can begin to be replaced by digital channels. In the theory of money demand, (Boediono, 2018) explained that the demand for money is influenced by transaction needs, price levels, real output, and people's habits in making payments, so that when payment habits shift from cash to non-cash, the need for currency has the potential to decrease (Shunmugasundaram, 2026; Solikin, 2018; Soni & Manogna, 2026).

In the Indonesian monetary system, currency is a Rupiah in the form of banknotes and coins issued by Bank Indonesia and used by the public as legal tender. Based on Bank Indonesia Regulation Number 3 of 2026 concerning Paper and Metal Rupiah Notes, paper and metal rupiah banknotes are described as symbols of state sovereignty, the main tool of the economy, a means of exchange or payment, and a price gauge (Bank Indonesia, 2026), so that currency not only has a technical function as a means of transaction, but also a symbolic, economic, and institutional function. Based on Law No. 7 of 2011 concerning Currency and Bank Indonesia Regulation No. 21/10/PBI/2019 concerning Rupiah Management, Bank Indonesia has duties and authority over the entire life cycle of Rupiah, including planning, printing, spending, circulation, revocation and withdrawal, up to destruction (Bank Indonesia, 2019), so that currency in circulation needs to be understood as a payment instrument that requires a complex physical, logistical, security, and distribution management system (Mashaqbeh et al., 2026; Prasad, 2021; Saraswati & Mukhlis, 2018; Sari & Huda, 2025) .

In addition to its important role for the economy, currency has issues in terms of efficiency and environmental sustainability. A study discussed by the European Payments Council based on Oxford Economics research for the European Digital Payment Industry Alliance shows that digital payments have a lower environmental footprint than cash payments in most environmental impact categories, with cash payments in stores generating 5.9 times greater global warming potential than digital payments in Germany, 2.1 times greater in Italy, and 23.6 times greater in Finland, mainly from the operational stages of ATM use and operation (Khoiroh & Agustianto, 2025; Kurniati & Krisdianto, 2026; La Tansany & Falih, 2023; Mankiw, 2019). In line with that, the European Central Bank's Product Environmental Footprint study on euro banknotes found that the main factors contributing to the environmental footprint of banknotes are the energy consumption of ATMs, money transportation, distribution processing, paper production, as well as banknote authentication at the point of sale, with the use of euro banknotes per person per year having an environmental impact equivalent to driving about eight kilometers by car (European Central Bank, 2023). From a sustainability perspective, the digitalization of payment systems also contributes to the development of the green economy (Zhang, 2026) because the use of cashless payment instruments can reduce dependence on currency that requires large-scale physical printing and distribution processes (Aghaei & Rezagholizadeh, 2026; Kashif et al., 2026; Khan & Shahid, 2026).

Data shows that the value of digital transactions in Indonesia increased from Rp154,090 billion in 2013 to Rp2,949,340 billion in 2025, or almost 19 times, while the currency in circulation only increased from Rp399,609 billion to Rp1,214,763 billion, or about three times in the same period. The difference in growth rate shows that the digitization of payments is growing much faster than that of currency, but the increase in digital payments has not been followed by a decline in absolute currency. Comparisons between ASEAN countries also strengthen this phenomenon: in 2020, the proportion of currency to M1 in Indonesia reached 40.96%, much higher than Singapore (20.73%) and Malaysia (24.90%), and in 2025 the proportion will only drop to 35.86%, still higher than Singapore (20.85%) and Malaysia (24.47%). This condition shows that the

payment digitalization process in Indonesia has not completely replaced the role of currency, so Indonesia is more accurately understood to be in the phase of a cashless society rather than a full-fledged cashless society (Ghalib & Maulida, 2023; Haryatiana & Kusherawati, 2025; Kahveci & Gürgür, 2025; Khan & Shahid, 2026) .

Digital payments in this study are proxied through three main instruments, namely Quick Response Code Indonesian Standard (QRIS), electronic money, and card-based payment instruments (APMK). QRIS was chosen because it is a QR code-based payment innovation that is growing very rapidly and is widely used by the public and business actors, including MSMEs. Electronic money was chosen because it is a powerful instrument driven by the policy of electronification of transactions, especially on toll roads and public transportation. The APMK, which includes debit and credit cards, was chosen because it is a card-based payment instrument that is relatively more stable and has been connecting the public with the formal banking system for a long time. The three instruments represent different stages in the transformation of digital payments in Indonesia.

However, the increase in digital payments does not necessarily directly change people's behavior in holding and using currency, because currency is still widely used in small-value transactions, traditional markets, informal sectors, areas with limited digital infrastructure, and community groups that do not fully trust or are used to using digital financial services. Therefore, the relationship between digital payments and currency needs to be explained through a deeper mechanism, namely the extent to which people are truly connected to digital financial infrastructure. In this study, the mechanism is explained through Digital Financial Inclusion, which is a condition when people have access to and ability to use digital financial services, such as banking accounts, electronic money, mobile banking, internet banking, QR payments, debit cards, and credit cards. This variable is measured through two dimensions, namely formal access represented by the number of Third Party Fund (DPK) accounts per 1,000 adult population, and digital access represented by the amount of electronic money per 1,000 adult population.

Previous research has shown that studies on digital payments and currency in Indonesia still have limitations. (Saraswati & Mukhlis, 2018) tested the influence of debit cards, credit cards, and electronic money on currency demand, but the research was conducted before QRIS expanded widely. (Aditia & Irwansyah, 2023) have included QRIS in the currency demand analysis, but QRIS is still measured as a dummy variable of implementation, not based on the actual transaction nominal. Meanwhile, (Hanivan & Nasrudin, 2019) have compiled a financial inclusion index for Indonesia, but have not integrated it as a mediating variable in the relationship between digital payments and currency in circulation. Thus, previous research still tends to test digital payment instruments partially and has not comprehensively included Digital Financial Inclusion as a connecting mechanism, so the gap in this study lies in testing the direct and indirect relationship between QRIS, electronic money, and APMK to currency in circulation through Digital Financial Inclusion as a mediation variable.

Previous literature mapping shows that studies on payment digitalization have discussed the relationship between digital payments, fintech, financial inclusion, consumption, economic

growth, cashless society, and financial system efficiency, as summarized in Table 1. However, most of these studies have not specifically examined the relationship between digital payment instruments, especially QRIS, electronic money, and APMK, to the currency in circulation in the community. In addition, Digital Financial Inclusion in many previous studies has been positioned more often as an impact of financial digitalization, rather than as a mediating variable that explains the mechanism of change in the use of currency, so the gap in this study lies in testing the direct and indirect relationship between QRIS, electronic money, and APMK to currency in circulation through Digital Financial Inclusion as a mediating variable.

Table 1. Summary of Relevant Previous Research

Researcher (Year)	Method	Key Variables	Key Findings
(Hussain et al., 2026)	Panel Data Regression	Digital economy; Economic growth; Governance	The digital economy has a positive effect on economic growth and system efficiency, strengthened by governance
(Kahveci & Gürgür, 2025)	Regression Analysis	Digital payment; Economic growth; Consumption	Digital payments have a positive effect on consumption and accelerate economic activity
(Kashif et al., 2026)	Data Panel (GMM, 2SLS)	FinTech; Green economy; Ecological footprint	FinTech contributes to reducing the ecological footprint and supporting sustainable development
(Petrikova & Kocisova, 2024)	Panel Data	Digital payment; Financial inclusion; Efficiency	Digital payments improve financial inclusion and encourage the use of cashless
Adi et al. (2023)	Regression Time Series	QRIS (dummy); Debit/credit cards; Currency	QRIS is measured as an implementation dummy, not yet using the actual transaction nominal
(Saraswati & Mukhlis, 2018)	Regression Time Series	Debit cards; Credit cards; E-money; Money requests	Debit cards, credit cards, and e-money affected the demand for currency before QRIS became widespread
Hanivan & Nasrudin (2019)	Composite Indices	Financial inclusion index	Compiling Indonesia's financial inclusion index, which has not been integrated as a mediation variable
(Rahayu et al., 2025)	Multiple Linear Regression	E-commerce; Business capital; QRIS; MSME income	QRIS has a significant positive effect on MSME income

The development of the hypothesis in this study is based on the theory of money demand (Boediono, 2018) and the concept of digitization of the payment system and digital financial inclusion directed by Bank Indonesia (2019, 2023) to support fast, easy, cheap, secure, and reliable transactions. Theoretically, the increase in the use of digital payments can affect people's needs for currency because part of the function of money as a medium of exchange can begin to be carried out through digital channels, so that QRIS, electronic money, and APMK are estimated to have an effect on circulating currency, either directly or through increasing Digital Financial

Inclusion as a transmission mechanism. Based on this description, the research hypothesis is formulated as follows: QRIS (H1), electronic money (H2), and APMK (H3) affect circulating currency; Digital Financial Inclusion affects circulating currency (H4); QRIS (H5), electronic money (H6), and APMK (H7) affect Digital Financial Inclusion; and Digital Financial Inclusion mediated the influence of QRIS (H8), electronic money (H9), and APMK (H10) on the currency in circulation. The framework of thought that describes the relationship between these variables is presented in Figure 1.

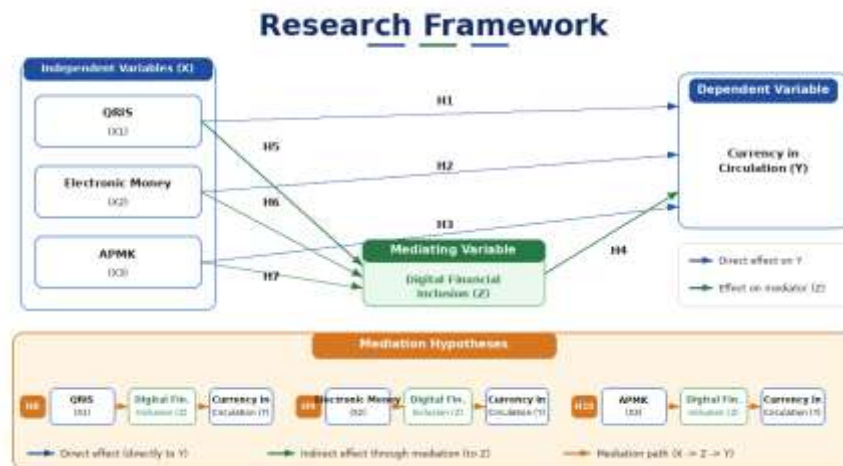


Figure 1. Research Framework

Based on the description of the background and frame of mind, this study aims to analyze the ~~nominal~~ influence of QRIS transactions, electronic money, and APMK on currency in circulation, either directly or through Digital Financial Inclusion as a mediation variable. This research is expected to make a theoretical contribution by integrating the concepts of digital payments, digital financial inclusion, and currency in circulation in one analytical framework, as well as practical contributions in the form of empirical images of the impact of payment system digitalization on the use of currency in Indonesia for payment system industry players, banking, and business actors.

METHOD

This study uses a quantitative approach with a causal associative design to test the influence of independent variables on dependent variables, either directly or indirectly through mediation variables. The independent variables consist of QRIS (X1), electronic money (X2), and APMK (X3); the dependent variable is the currency in circulation (Y); and Digital Financial Inclusion (Z) as the mediation variable. The research population is the entire time series data related to QRIS transactions, electronic money, APMK, the number of deposit accounts per 1,000 population, the amount of electronic money per 1,000 population, and the currency in circulation published by Bank Indonesia. The research sample is in the form of monthly data for the period January 2020 to December 2025 (6 years × 12 months = 72 observations), which was chosen because it reflects the phase of accelerating payment digitalization since the implementation of QRIS nationally on

January 1, 2020 and the policy of electronification of toll and public transportation transactions since 2017. Data was collected through documentation techniques from official publications of Bank Indonesia.

The operationalization of the research variables is presented in Table 2. QRIS, electronic money, and APMK are measured based on the nominal transaction in units of billions of rupiah and transformed into a natural logarithm, while the currency in circulation is measured from the amount of currency in circulation in the community outside the banking system and is also transformed into a natural logarithm. Digital Financial Inclusion is formed as a composite index of the average z-score of the natural logarithm of the number of deposit accounts per 1,000 adult population and the natural logarithm of the amount of electronic money per 1,000 adult population.

Table 2. Definition and Operationalization of Variables

Variable Type	Variable Name	Variable Code	Operational Definition	Indicator	Scale
Dependency	Currency Circulation	LN_UANG_KARTAL_MILIARRP	The amount of currency in circulation in the community outside the banking system	The value of the currency in circulation	Ratio
Independent	QRIS	LN_QRIS_MILIARRP	Value of payment transactions using QRIS	QRIS transaction amount	Ratio
Independent	Electronic Money	LN_UE_MILIARRP	The value of transactions using electronic money	Nominal electronic money transaction	Ratio
Independent	APMK	LN_APMK_MILIARRP	Value of debit and credit card transactions	APMK transaction nominal	Ratio
Mediation	Digital Financial Inclusion	DFI_INDEX	A digital financial inclusion index that reflects access to formal financial services and digital payment instruments	Average z-score LN_DPK1000 and LN_UE1000	Index/Interval

Data Analysis Methods

The analysis method used is Autoregressive Distributed Lag (ARDL) because it is able to test short-term and long-term relationships in time series data with a relatively limited number of observations (72 observations) and can accommodate variables in the order of integration $I(0)$ and $I(1)$ as long as there are no variables $I(2)$. Other alternative methods, namely Vector Error Correction Model (VECM), Vector Autoregression (VAR), and Ordinary Least Squares (OLS), are considered less suitable because they require a larger number of observations, do not explicitly distinguish the positions of independent, mediator, and dependent variables, or risk producing pseudo-regression in non-stationary data.

The stages of analysis include: (1) descriptive statistics to see the characteristics of the data; (2) stationariness test using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests at the level and first difference levels; (3) determination of optimal lag using Automatic ARDL Lag Selection based on Akaike Information Criterion (AIC) in EVIEWS software; (4) cointegration test through Bounds Test to test long-term relationships; (5) long-term relationship estimation through Long Run Form; (6) Error Correction Model (ECM) estimation to analyze short-term dynamics and adjustment speed towards long-term equilibrium through Term Error Correction (ECT) coefficients; and (7) model diagnostic tests which included residual normality tests (Jarque-Bera), autocorrelation tests (Breusch-Godfrey Serial Correlation LM Test), heteroscedasticity tests (ARCH Test), and parameter stability tests (CUSUM and CUSUMSQ). All tests used a significance level of 5 percent ($\alpha = 0.05$).

The direct influence hypothesis test (H1–H7) refers to the direction of the coefficient and probability value of the results of the ARDL estimation, both in the short and long term relationships. The hypothesis is accepted if the direction of the coefficient is in accordance with the direction of the hypothesis and the probability value is less than 0.05. The mediation hypothesis test (H8–H10) was carried out using the Sobel test by utilizing the path coefficient and standard error from the results of the ARDL estimation, namely the path of influence of QRIS, electronic money, and APMK on Digital Financial Inclusion, as well as the path of influence of Digital Financial Inclusion on the money circulation. The influence of mediation is declared significant if the probability value of Sobel is less than 0.05.

RESULTS AND DISCUSSION

Descriptive Statistics

Descriptive statistical analysis was conducted on all research variables during the period January 2020 to December 2025 (72 observations), as presented in Table 3. APMK has the largest average transaction value (IDR 66,418.27 billion) compared to electronic money (IDR 41,277.08 billion) and QRIS (IDR 33,928.04 billion), which shows that APMK is still the instrument with the largest transaction value on average. However, judging from the standard deviation, QRIS showed the highest growth dynamics (IDR 44,147.52 billion), followed by electronic money (IDR 22,427.40 billion) and APMK (IDR 17,592.02 billion), which indicates that QRIS experienced the fastest adoption acceleration during the study period. The DFI_INDEX variable has an average of

close to zero with a Jarque-Bera probability of 0.05, while the currency in circulation has an average of Rp856,027.40 billion with a probability of Jarque-Bera 0.34, which shows that the residual is relatively close to the normal distribution. Overall, these results show that the Indonesian payment system in the 2020–2025 period is not fully in the cashless society stage, but is still in the cashless society phase because the currency in circulation continues to show great value and trends.

Table 3. Descriptive Statistics

Statistics	DFI_INDEX (index)	EU (Billion Rp)	QRIS (Billion IDR)	APMK (Billion Rp)	Currency (Billion Rp)
Mean	-6,55	41.277,08	33.928,04	66.418,27	856.027,40
Median	0,14	36.795,08	12.285,77	75.174,21	836.654,50
Maximum	1,56	104.694,10	169.670,80	91.657,98	1.214.729,00
Minimum	-1,43	14.954,57	364,58	29.280,08	607.961,00
Std. Dev.	0,99	22.427,40	44.147,52	17.592,02	141.771,10
Skewness	-0,14	1,13	1,41	-0,64	0,30
Kurtosis	1,64	3,53	3,89	1,88	2,41
Jarque-Bera	5,75	16,09	26,34	8,66	2,14
Probability	0,05	0,01	0,01	0,01	0,34
Observations	72	72	72	72	72

Stationarity Test

The stationarity test using ADF and PP test showed that all variables were not stationary at the level level (probability > 0.05), but became stationary after the first differentiation (probability 0.00), as presented in Table 4. Thus, all variables were integrated on order one or I(1) and there were no variables integrated at order two or I(2), so the data were eligible to be analyzed using the ARDL method.

Table 4. Stationary Test Results (ADF and PP Test)

Variable	ADF Level (Prob.)	ADF 1st Diff. (Prob.)	PP Level (Prob.)	PP 1st Diff. (Prob.)	Integration Order
LN_QRIS_MILIARRP	0,80	0,00	0,35	0,00	I(1)
LN_UE_MILIARRP	0,98	0,00	0,99	0,00	I(1)
LN_APMK_MILIARRP	0,75	0,00	0,72	0,00	I(1)
LN_UANG_KARTAL_MILIARRP	0,91	0,00	0,96	0,00	I(1)
DFI_INDEX	0,93	0,00	0,97	0,00	I(1)

Optimal Lag Determination and Cointegration Test

The optimal lag determination was carried out through Automatic ARDL Lag Selection based on AIC criteria with a maximum limit of 6 lags, so that EViews evaluated 2,058 lag combinations for each model. Model 1, with DFI_INDEX as the dependent variable, produced the

best specification of ARDL(3,1,6,6) with an AIC of -3.66 and 66 effective observations. Model 2, with currency in circulation as a dependent variable, produced an ARDL(1,1,0,0,2) specification with an AIC of -4,31 and 70 effective observations. Model 1 produces an R-squared of 0.99 with an F-statistic of 2,585.12 (Prob. 0.00), while Model 2 produces an R-squared of 0.97 with an F-statistic of 305.20 (Prob. 0.00), which shows that the independent variables in both models simultaneously have a significant effect on each of the dependent variables.

The results of the Bounds Test in Table 5 show that the F-Bounds Statistical Model 1 (10.81) and Model 2 (10.65) are both above the critical value of the upper limit I(1) at the significance level of 1%, 5%, or 10%, so that H_0 which states that there is no long-term relationship is rejected in both models. Thus, there is a long-term cointegration or equilibrium relationship between QRIS, electronic money, APMK, Digital Financial Inclusion, and currency in circulation, so that the analysis can be continued on the Long Run Form and Error Correction Model estimates.

Table 5. Results of Optimal Lag Determination and Bounds Test

Description	Model 1 (DFI_INDEX)	Model 2 (Money Circulating)
Selected ARDL models	ARDL (3,1,6,6)	ARDL (1,1,0,0,2)
AIC Value	-3,66	-4,31
Number of effective observations	66	70
F-Bounds Statistic	10,81	10,65
Critical Value I(0)/I(1) 5%	2,97 / 3,89	2,72 / 3,71
Critical Value I(0)/I(1) 1%	4,05 / 5,15	3,60 / 4,86
Verdict	Minus H_0	Minus H_0
Conclusion	There is cointegration	There is cointegration

Long-Term Relationship Estimation

The short-term empirical equations of Model 1 and Model 2 of the ARDL estimation results are written as follows:

$$\text{DFI_INDEX}_t = -4.61 + 0.35\text{DFI_INDEX}_{t-1} + 0.39\text{DFI_INDEX}_{t-2} - 0.20\text{DFI_INDEX}_{t-3} + 0.03\text{LN_QRIS}_t + 0.17\text{LN_QRIS}_{t-1} - 0.14\text{LN_UE}_t + \dots + 0.21\text{LN_APMK}_t + \dots + \varepsilon_t$$

$$\text{LN_UANG_KARTAL}_t = 7.95 + 0.29\text{LN_UANG_KARTAL}_{t-1} + 0.11\text{LN_QRIS}_t - 0.11\text{LN_QRIS}_{t-1} + 0.15\text{LN_UE}_t - 0.01\text{LN_APMK}_t - 0.02\text{DFI_INDEX}_t - 0.15\text{DFI_INDEX}_{t-1} + 0.19\text{DFI_INDEX}_{t-2} + \varepsilon_t$$

The results of the Long Run Form Model 1 estimate in Table 6 show that QRIS (coefficient 0.20; Prob. 0.00) and electronic money (coefficient 0.14; Prob. 0.01) have a positive and significant effect on Digital Financial Inclusion in the long term, while APMK (coefficient 0.12; Prob. 0.05) has a positive effect but is only significant at the level of 10%. QRIS is the most dominant variable in encouraging Digital Financial Inclusion, followed by electronic money and APMK, which indicates that QRIS plays an important role as a digital payment instrument that is easily accessible, inexpensive to implement, and suitable for small and medium-sized retail businesses.

Table 6. Long Run Form Model 1 Results (Dependent Variable: DFI_INDEX)

Variable	Coefficients	t-Statistic	Prob.	Remarks
LN_QRIS_MILIARRP	0,20	5,19	0,00	Significant
LN_UE_MILIARRP	0,14	2,58	0,01	Significant
LN_APMK_MILIARRP	0,12	1,96	0,05	Significant at 10%
Constant	-4,61	-4,14	0,00	Significant

The results of the Long Run Form Model 2 estimate in Table 7 show that electronic money has a positive and significant effect on the currency in circulation in the long term (coefficient of 0.15; Prob. 0.00), which means that the increase in electronic money transactions is still followed by an increase in the currency in circulation, not a decrease. In contrast, QRIS (coefficient of 0.01; Prob. 0.68), APMK (coefficient -0.01; Prob. 0.78), and DFI_INDEX (coefficient of 0.01; Prob. 0.55) do not have a significant effect on the currency in circulation in the long term. These findings show that in the long term, digital payments and Digital Financial Inclusion have not conclusively reduced people's need for currency.

Table 7. Long Run Form Model 2 Results (Dependent Variable: Currency Circulation)

Variable	Coefficients	t-Statistic	Prob.	Remarks
LN_QRIS_MILIARRP	0,01	0,40	0,68	Insignificant
LN_UE_MILIARRP	0,15	5,18	0,00	Significant
LN_APMK_MILIARRP	-0,01	-0,27	0,78	Insignificant
DFI_INDEX	0,01	0,59	0,55	Insignificant
Constant	7,95	6,34	0,00	Significant

Error Correction Model (ECM)

The ECM estimate in Table 8 shows that the ECT/CointEq(-1) Coefficient of Model 1 is -0.45 (Prob. 0.00), which is negative and significant, which means that about 45.47% of deviations from the long-term balance are corrected every month, or it takes about 2.20 months to return to balance. In the short term, QRIS in the current period has not had a significant effect on DFI_INDEX (Prob. 0.42), while electronic money and APMK show a significant influence on some lag periods, which indicates that the formation of digital financial inclusion is gradual.

Table 8. Error Correction Model (ECM) and ECT Model 1 Results

Variable	Coefficients	t-Statistic	Prob.	Verdict
D(DFI_INDEX(-1))	-0,18	-2,09	0,04	Significant
D(DFI_INDEX(-2))	0,20	2,05	0,04	Significant
D(LN_QRIS_MILIARRP)	0,03	0,80	0,42	Insignificant
D(LN_UE_MILIARRP)	-0,14	-1,90	0,06	Insignificant
D(LN_UE_MILIARRP(-1) to (-4))	-0.46 to -0.21	-5.29 to -2.50	0,00–0,01	Significant

Variable	Coefficients	t-Statistic	Prob.	Verdict
D(LN_APMK_MILIARRP)	0,21	3,55	0,01	Significant
D(LN_APMK_MILIARRP(-2) to (-5))	-0.16 to -0.09	-2.44 to -2.08	0,01–0,04	Significant
CointEq(-1)	-0,45	-7,66	0,00	Significant
Speed of Adjustment	45.47% per month	-	-	≈ 2.20 months

The ECM Model 2 estimate in Table 9 shows an ECT/CointEq(-1) coefficient of -0.70 (Prov. 0.00), which means that about 70.44% of deviations are corrected every month, or it takes about 1.42 months to return to long-term equilibrium. In the short term, QRIS has a positive and significant effect on the currency supply (coefficient of 0.11; Prob. 0.00), which indicates that the increase in QRIS transactions in the current month is still followed by the increase in the currency supply. DFI_INDEX in the current period has not been significant (Prov. 0.65), but DFI_INDEX in the previous period had a negative and significant effect (coefficient -0.19; Prob. 0.00), which indicates that the influence of digital financial inclusion on currency requires a time lag.

Table 9. Error Correction Model (ECM) and ECT Model 2 Results

Variable	Coefficients	t-Statistic	Prob.	Verdict
D(LN_QRIS_MILIARRP)	0,11	5,36	0,00	Significant
D(DFI_INDEX)	-0,02	-0,45	0,65	Insignificant
D(DFI_INDEX(-1))	-0,19	-3,49	0,00	Significant
CointEq(-1)	-0,70	-8,31	0,00	Significant
Speed of Adjustment	70.44% per month	-	-	≈ 1.42 months

Diagnostic Test and Model Stability

The results of the diagnostic test in Table 10 showed that the residual Model 1 and Model 2 were normally distributed (Prob. Jarque-Bera 0.25 and 0.13, respectively) and did not experience autocorrelation (Prob. Chi-Square 0.98 and 0.26, respectively). The ARCH test showed that Model 1 was indicated to have mild heteroscedasticity (Prob. 0.04), while Model 2 did not show heteroscedasticity problems (Prob. 0.80). Heteroscedasticity mainly had an impact on the accuracy of standard errors, not on the direction of the coefficient, so the Model 1 estimation results were still used by listing these limitations. Stability tests using CUSUM and CUSUMSQ graphs (Figure 2 and Figure 3) showed that the statistical lines in both models were within the critical limit of 5%, so that the parameters of both models were declared stable during the study period.

Table 10. Summary of Model Diagnostic Test Results

Diagnostic Tests	Model 1 (Value; Prob.)	Model 2 (Value; Prob.)	Conclusion
Normality (Jarque-Bera)	2,74; 0,25	4,04; 0,13	Normally distributed residual

Diagnostic Tests	Model 1 (Value; Prob.)	Model 2 (Value; Prob.)	Conclusion
Autocorrelation (Breusch-Godfrey)	0,88; 0,98	7,65; 0,26	No autocorrelation
Heteroskedasticity (ARCH)	13,19; 0,04	3,17; 0,78	Model 1 indicated mild heteroscedasticity; Model 2 homoskedastic
Stability (CUSUM/CUSUMSQ)	Stable	Stable	Model parameters stable at 5% critical limit

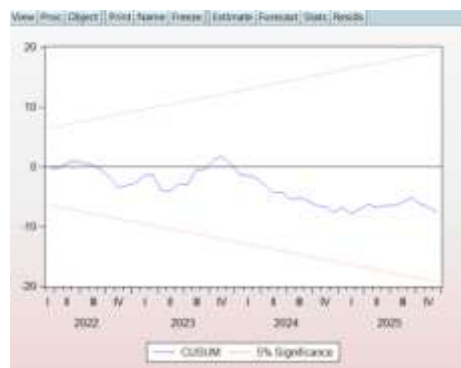


Figure 2. CUSUM Model 1 Stability Test Results

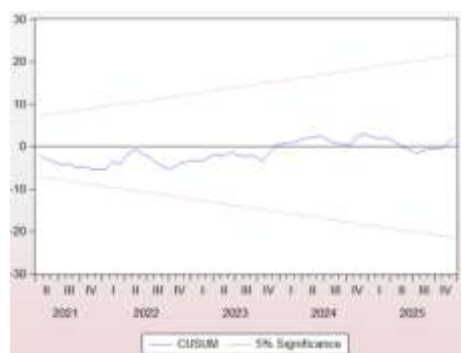


Figure 3. CUSUM Model 2 Stability Test Results

Sobel Test Results (Mediation Test)

The results of the Sobel test in Table 11 show that the three mediation pathways, namely QRIS, electronic money, and APMK on currency in circulation through Digital Financial Inclusion, produce a probability value greater than 0.05 (0.55; 0.56; and 0.56, respectively). Thus, Digital Financial Inclusion has not been proven to mediate the influence of the three digital payment instruments on the currency in circulation. This result is consistent with the findings of the Long Run Form Model 2 which shows that DFI_INDEX does not have a significant effect on the currency in circulation in the long term, so that the influence of digital payments on currency in the study period is more accurately understood as a direct relationship that runs side by side, rather than a relationship that is significantly mediated by digital financial inclusion.

Table 11. Sobel Test Results

Mediation Pathway	Z Sobel	p-value	Verdict
QRIS → DFI_INDEX → Currency Circulating	0,59	0,55	Insignificant
Electronic Money → DFI_INDEX → Currency in Circulation	0,58	0,56	Insignificant
APMK → DFI_INDEX → Currency in Circulation	0,57	0,56	Insignificant

Based on the results of the direct influence test, H1 is acceptable in the short-term relationship because QRIS has been shown to have an effect on the currency in circulation in the current period, but it is not yet acceptable in the long term because QRIS has not been proven to be a strong factor influencing the currency in circulation. These findings show that QRIS and currency still run side by side, so QRIS's development strategy needs to be focused on expanding its use more evenly and establishing digital payment habits, not just increasing transaction value.

H2 can be accepted in a long-term relationship because electronic money has been proven to have an effect on the currency in circulation, but a positive direction of influence indicates that electronic money has not replaced currency money, but is still moving together in the Indonesian payment system. Managerially, the development of electronic money needs to be focused on sectors with massive use such as public transportation, toll roads, parking, and public services. As for H3, it is not yet acceptable because the APMK has not been proven to have a strong influence on the currency circulation, so the APMK remains relevant as a supporting instrument, but not the main driver in reducing dependence on currency money.

H4 has not been acceptable in long-term relationships because Digital Financial Inclusion has not been proven to be a strong factor influencing the currency circulation, but it is acceptable in short-term relationships through DFI_INDEX one period before, which suggests that digital financial inclusion takes time before it has an effect on the use of currency. H5 and H6 are acceptable in the long term because QRIS and electronic money have been shown to have an effect on Digital Financial Inclusion, with QRIS being the most dominant driver. H7 is acceptable at a significance level of 10% but is not yet strong at a level of 5%, which suggests that APMK contributes to digital financial inclusion, but its role is more limited than QRIS and electronic money because its users generally already have formal banking access.

The results of the Sobel test show that H8, H9, and H10 were rejected because Digital Financial Inclusion has not been proven to mediate the influence of QRIS, electronic money, and APMK on the currency in circulation. This means that although the three digital payment instruments are able to encourage increased digital financial inclusion, the increase is not strong enough to explain the change in currency circulation through mediation. Overall, the variable that has the most influence on the currency in circulation is electronic money with a positive direction, which means that the increase in electronic money transactions is still followed by an increase in currency, so the two have not replaced each other. These findings confirm that the development of digital payments in Indonesia reflects a phase of a cash-less society that is complementary, not a full substitute for currency.

CONCLUSION

This study concludes that digital payments in Indonesia have not completely replaced currency, so the national payment system is still in the phase of a complementary cash-less society. QRIS has an effect on the circulating currency in the short term, but not significantly in the long term; electronic money has a positive and significant effect in the long term, but the positive direction shows that electronic money has not replaced currency, but is still moving together; while APMK has not been proven to have a significant effect on circulating currency. Digital Financial Inclusion has not significantly affected the circulating currency in the long term, but it has begun to have a significant negative effect in the previous period in the short term. QRIS and electronic money have been proven to significantly strengthen Digital Financial Inclusion in the long term, while APMK is only significant at the level of 10%. The results of the Sobel test show that Digital Financial Inclusion has not been proven to mediate the influence of QRIS, electronic money, and APMK on the currency in circulation, so the relationship between digital payments and currency is more accurately understood as a direct relationship that runs side by side. Based on these findings, Bank Indonesia and payment system authorities are advised to continue to strengthen payment digitalization without ignoring the availability of currency; payment service providers are advised to develop QRIS for small and medium retail businesses, electronic money for massive transaction sectors such as public transportation, and position APMK as a supporting instrument for people who have been connected to formal banking. Local governments are advised to strengthen digital financial literacy and equitable infrastructure distribution, especially in MSMEs and regions that have not been digitized, while further research is suggested to expand the Digital Financial Inclusion indicator and use an interprovincial panel data approach to capture differences in regional characteristics more comprehensively.

ACKNOWLEDGEMENTS

The author would like to express his gratitude to Dr. Ir. Hakiman, MM as the supervisor for the guidance and direction provided during the research process, as well as to the leaders and academic community of the Faculty of Economics and Business, Mercu Buana University, for the support of facilities and academics during the preparation of this research. This research does not receive special funding from government, private, or other organizations, and the authors state that there is no conflict of interest in the implementation, writing, or publication of this article.

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