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The Impact of Cashless Transactions on Cash Demand at the Regional Level in Indonesia

ABSTRAK

Penelitian ini mengkaji pengaruh transaksi non-tunai—yang mencakup penggunaan kartu debit, kartu kredit, dan uang elektronik—terhadap permintaan uang tunai di Indonesia dengan menggunakan data panel tingkat kabupaten/kota untuk periode 2019 hingga 2024. Dengan menerapkan model Two-Way Fixed Effects (TWFE), hasil penelitian menunjukkan bahwa transaksi menggunakan kartu debit dan kartu kredit secara signifikan menurunkan permintaan uang tunai di tingkat nasional, yang mengindikasikan peran keduanya sebagai substitusi terhadap uang tunai. Sebaliknya, penggunaan uang elektronik hanya menunjukkan pengaruh yang signifikan secara statistik di wilayah Jawa, yang mencerminkan adanya disparitas regional dalam adopsi pembayaran digital. Di wilayah Jawa, uang elektronik berfungsi sebagai substitusi uang tunai, sedangkan di luar Jawa, kartu debit lebih berperan dalam menurunkan penggunaan uang tunai. Temuan ini menegaskan pentingnya kebijakan yang disesuaikan secara spasial untuk mendorong adopsi sistem pembayaran digital yang lebih luas dan efektif di seluruh wilayah Indonesia.

Kata kunci: permintaan uang tunai, pembayaran digital, kartu debit, uang elektronik, disparitas regional

Klasifikasi JEL: E41, G21, O33, R12

ABSTRACT

This study investigates the impact of non-cash transactions—including debit card, credit card, and electronic money usage—on cash demand in Indonesia using district-level panel data from 2019 to 2024. Employing a Two-Way Fixed Effects (TWFE) model, the findings reveal that debit and credit card transactions significantly reduce cash demand at the national level, indicating their role as substitutes for cash. In contrast, electronic money usage shows a statistically significant effect only in Java, reflecting regional disparities in digital payment adoption. While electronic money functions as a substitute for cash in Java, debit card transactions remain more influential in reducing cash usage in non-Java regions. These results underscore the importance of spatially adaptive policies to support broader and more effective digital payment adoption across Indonesia.

Keywords: cash demand, digital payments, debit card, electronic money, regional disparity

JEL Classification Codes: E41, G21, O33, R12

INTRODUCTION

The advancement of digital technology has driven a significant transformation in global payment systems, including in Indonesia. The increasing penetration of the internet, widespread use of smartphones, and rapid development of financial technology (fintech) have fundamentally altered consumer transaction behaviors, encouraging the adoption of non-cash payment instruments such as debit cards, credit cards, electronic money, and QRIS. These digital transactions offer greater efficiency, speed, and security, progressively replacing the use of physical cash in everyday economic activities (Raya & Vargas, 2022).

The shift toward non-cash payment systems has wide-ranging economic implications, including a decline in cash demand and improvements in transactional efficiency. Although cash continues to be widely used, digital payments provide several advantages—such as faster transactions, reduced risks of theft and counterfeiting, and enhanced financial transparency—which contribute to reducing the informal sector and improving tax compliance (Fabris, 2019; Rogoff, 2017). Non-cash payments also influence consumption, investment, and government spending, with the convenience of digital transactions encouraging higher consumer spending through the psychological "cashless effect" (Schomburgk et al., 2024). Additionally, these systems reduce cash handling costs and improve economic efficiency (Hasan et al., 2012), while strengthening public revenue collection through more effective taxation mechanisms (Schneider & Kepler, 2009).

Despite the growing adoption of digital payment systems, the demand for cash has not been entirely displaced. Cash remains a legal and commonly used means of payment, primarily due to its anonymity, accessibility, and reliability during times of crisis (Baubeau, 2016). Data from Bank Indonesia indicate that the volume of currency in circulation increased from IDR 625.37 trillion in 2018 to IDR 975.93 trillion in 2023, although its share within the M1 monetary aggregate has declined,

suggesting a shift in public payment preferences.

The physical management of cash imposes a significant cost burden. In developed countries, the cost of cash management can reach 0.5% of Gross Domestic Product (GDP), while in developing countries such as India, it may amount to as much as 3% of GDP (Achord et al., 2017). These high operational costs are also associated with the fixed costs of maintaining cash infrastructure, such as Automated Teller Machines (ATMs) and branch office networks, which place a financial burden on banking institutions.

Studies on the role of payment innovation have become increasingly crucial, particularly in the context of monetary policy. Understanding the changing dynamics of cash demand resulting from the digitalization of payment systems is essential. Cash demand is a key variable in liquidity management and monetary aggregate control, and it plays a central role in the transmission of monetary policy (Mishkin, 2016). The growing use of digital payment instruments, such as electronic money, has the potential to affect the central bank's ability to regulate the money supply through conventional instruments. Furthermore, electronic money may alter the structure of monetary aggregates, thereby influencing the effectiveness of monetary policy (Al-Laham et al., 2009; Huang et al., 2024).

In this context, it is important to analyze the relationship between payment innovation and cash demand in Indonesia. Several studies have identified a negative correlation between payment system innovations, such as the use of ATM cards, credit cards, and electronic money, and the M1 monetary aggregate at the national level (Aristiyowati & Falianty, 2019; Igamo & Falianty, 2018). Nevertheless, most of these studies focus on national aggregate data, while empirical evidence suggests that the impact of financial innovation is heterogeneous across regions and highly dependent on local factors (Cabezas & Jara, 2021; Nagayasu, 2012).

This research gap is particularly relevant because the adoption of payment innovation does not occur

evenly across regions. Such variation is influenced by factors including financial literacy, technological infrastructure, and public preferences regarding payment methods (Demirgüç-Kunt et al., 2008; Zins & Weill, 2016). Therefore, analysis at the regency and municipality level is necessary to obtain a deeper and more contextual understanding of the transformation of the national payment system.

By adopting a regional-level scope of analysis, this study is expected to provide an empirical contribution to understanding the dynamics of cash demand amid the rapid development of payment innovation in Indonesia. Specifically, this study aims to analyze the impact of non-cash payment innovation on cash demand across all regencies and municipalities in Indonesia. The study employs annual data for the 2019–2024 period, with the primary data sourced from Bank Indonesia for payment system information, and macroeconomic data, particularly Gross Regional Domestic Product (GRDP), obtained from Statistics Indonesia Bureau (BPS).

PAYMENT SYSTEM IN INDONESIA

A payment system refers to a set of rules, institutions, and procedures used to transfer funds in order to settle economic obligations. This system has evolved in line with the function of money as a medium of exchange. Generally, payment systems are categorized into two types: cash payments (utilizing physical currency) and non-cash payments (using instruments other than physical money). Non-cash payment instruments have undergone a significant evolution, transitioning from paper-based tools to digital systems. Initially, checks and bank drafts were used to facilitate fund transfers between parties, followed by debit notes that enabled interbank clearing processes. With technological advancement, Card-Based Payment Instruments (CBPIs) emerged, including ATM and debit cards, which directly deduct funds from bank accounts, and credit cards, which allow deferred payments. Further innovations led to the development of electronic money, a monetary value stored in chips or servers, issued based on pre-paid funds,

and not classified as bank deposits. These developments reflect a broader transition toward more efficient, faster, and more convenient payment systems.

FACTORS AFFECTING CASH DEMAND

Cash demand is influenced by a wide range of variables, which can be broadly classified into macroeconomic and other contextual factors. Theoretically, the Keynesian and Monetarist (Friedman) approaches suggest that income has a positive effect on the demand for money, while interest rates and inflation exert negative effects due to the higher opportunity cost of holding cash. Empirical studies demonstrate that increases in income typically lead to greater transactional needs and liquidity preferences, whereas higher interest rates encourage individuals to shift funds to productive financial assets (Arango-Arango & Suárez-Ariza, 2020; Djebbouri et al., 2019; Ivanovski & Churchill, 2019; Joseph et al., 2013; Odeleye & Akam, 2020; Skibińska-Fabrowska et al., 2023). Additionally, rising inflation reduces the real value of cash holdings, thereby diminishing the incentive to retain money in liquid form (Ivanovski & Churchill, 2019; Odeleye & Akam, 2020).

Technological developments in payment systems have also influenced cash demand, particularly the expansion of ATM networks, which has reduced transaction costs and improved cash withdrawal efficiency (Mlambo & Msosa, 2020; Onah et al., 2020; Whitesell, 1989). The adoption of ATM, debit, and credit cards has been shown to have a negative correlation with cash usage (Cabezas & Jara, 2021; Tehranchian et al., 2012). Moreover, the penetration of digital financial services and Point-of-Sale (POS) terminals has further decreased dependence on cash, especially in areas with limited physical banking infrastructure (Mlambo & Msosa, 2020; Onah et al., 2020).

Advancements in technology and payment innovations have driven a global shift in cash usage patterns. Cross-country studies report an annual decline in cash usage of 1.3% to 2.2% during the 2006–2016 period, largely driven by younger generations' preference for

digital payment instruments such as cards and mobile payments (Khiaonarong et al., 2019). Nonetheless, the transition to cashless societies is uneven across countries. Cultural differences and disparities in digital infrastructure have resulted in varying adoption levels, as seen in Europe—from cash-dominant Germany to highly digitalized Denmark (Cabezas & Jara, 2021).

The adoption of non-cash payments is strongly influenced by financial depth and technological capacity in a given region. Areas with better access to financial institutions, digital banking services, and technological infrastructure tend to exhibit lower dependence on cash. In addition, individual-level factors such as digital literacy and education levels enhance trust in and adoption of electronic payment systems (Kanojia & Lal, 2023; Ozili, 2018).

However, several studies have found that the convenience of non-cash transactions has not entirely shifted public preference away from cash. In developed economies, cash continues to be used as a store of value and a precautionary instrument during times of economic uncertainty (Bech et al., 2018). It is also favored by individuals who prioritize anonymity or operate within the informal sector (Amromin & Chakravorti, 2009).

RESEARCH METHODOLOGY

DATA

This study utilizes secondary data sourced from Bank Indonesia and Statistics Indonesia (Badan Pusat Statistik, BPS) to analyze the impact of non-cash transactions on cash demand in Indonesia. The panel data comprises quarterly observations across 514 districts and municipalities (kabupaten/kota) from 2019 to 2024. A detailed list of variables and data sources is provided in Appendix 1.

SPESIFIKASI EMPIRIS

This study adopts the Keynesian and Monetarist (Friedman) theoretical frameworks on the demand for money, which posit that cash demand is positively influenced by income, and negatively influenced by interest rates and inflation. To examine the effect of

non-cash transactions on cash demand, the empirical specification is adapted from Onah et al. (2020), where cash holdings (M) are modeled as a function of financial innovation (D), a vector of control variables (X), and an unobserved random component (U) that captures other structural factors.

$$M = lnD\alpha(U) + X'\delta(U)$$

The panel fixed effects method is employed, considering the data comprises quarterly observations across 514 districts and cities between 2019 and 2024. Fixed effects estimation is selected to control for time-invariant unobserved heterogeneity across entities, which may bias the results (Stock & Watson, 2020). This approach helps isolate the impact of time-varying independent variables while accounting for district-specific characteristics.

Given the exceptional economic disruption caused by the COVID-19 pandemic during the study period, the estimation also incorporates a Two-Way Fixed Effects (TWFE) model. This approach controls for both individual (district-level) fixed effects and time effects to address potential biases that may arise from macroeconomic shocks, ensuring more robust and consistent estimation results. The econometric model is specified as follows:

$$\begin{aligned} &LNCASHCAP_{i,t} \\ &= \alpha + \beta_1 LNDEBETCAP_{i,t} \\ &+ \beta_2 LNCREDITCARDCAP_{i,t} \\ &+ \beta_3 LNEMONEYCAP_{i,t} + \beta_4 LNGDRPCAP_{i,t} \\ &+ \beta_5 SAVINGRATE_{i,t} + \beta_6 INFLATION_{i,t} \\ &+ \beta_7 LNNDEBETCAP_{i,t} \\ &+ \beta_8 LNNCREDITCARDCAP_{i,t} \\ &+ \beta_9 LNNEMONEYCAP_{i,t} + \beta_{10} ATMMACHINE_{i,t} \\ &+ \beta_{11} LNTRANSFERATMDEBETCAP_{i,t} \\ &+ \beta_{12} LNTRANSFEREMONEYCAP_{i,t} \\ &+ \beta_{13} FINDEPTH_{i,t} + \beta_{14} YOS_{i,t} + \theta_i + \vartheta_t + \varepsilon_{i,t} \end{aligned}$$

In this model, CASHCAP represents the dependent variable, measured as the amount of cash withdrawal per capita. The key independent variables include DEBIT, CREDITCARD, and EMONEY, which respectively denote the per capita value of non-cash transactions conducted using debit cards, credit cards, and electronic money.

Access to DEBIT, CREDITCARD, and EMONEY payment instruments is considered exogenous because its availability is primarily determined by external institutional, technological, and infrastructural factors rather than by

individual-specific characteristics. The infrastructure supporting cashless payment systems such as banking networks, digital payment platforms, merchant acceptance systems, and telecommunications technology—is developed through policy initiatives, financial sector expansion, and technological progress, enabling broad public access without being inherently tied to particular individual attributes or behaviors.

Although cashless access is treated as exogenous, potential endogeneity may arise from reverse causality and omitted regional characteristics. However, the inclusion of district fixed effects and time fixed effects mitigates time-invariant heterogeneity and common shocks. In addition, payment infrastructure expansion in Indonesia is largely policy-driven (e.g., QRIS and national payment system initiatives), which reduces concerns of demand-driven placement bias.

The vector X comprises control variables that may influence cash demand, including gross regional domestic product (GRDP) per capita, saving interest rate, inflation rate, ATM density, financial depth, and average years of schooling. To account for unobserved heterogeneity across regions and time, the model incorporates θ_i as the district fixed effect and ϑ_t as the time fixed effect. The error term ε_{it} captures random disturbances not explained by the included variables.

RESULT AND DISCUSSION

In this study, all variables are measured on a per capita basis to ensure proportional comparisons across districts and over time. This approach adjusts the values relative to the population size in each region, enabling more accurate and meaningful inter-regional and temporal comparisons.

The primary variable of interest—per capita cash withdrawals via various instruments (ATMs, credit cards, and electronic money)—has an average value of IDR 9.06 million, with a relatively high standard deviation of IDR 22.8 million. The wide range, from IDR 883 to IDR 702 million, indicates substantial disparities in cash withdrawal behavior across

regions. While some districts exhibit very limited withdrawal activity, others show considerably high levels of cash usage.

In contrast, non-cash transactions record the highest average value for debit card usage at IDR 859 thousand per capita, followed by electronic money at IDR 566 thousand and credit card usage at IDR 394 thousand. Although these amounts are relatively small compared to cash transactions, all three instruments display significant variation, suggesting uneven adoption of digital payment technologies across regions.

The minimum value for each of these instruments is zero, indicating the existence of areas where non-cash transactions have not yet been adopted. Conversely, the high maximum values—IDR 155 million for debit cards, IDR 118 million for electronic money, and IDR 60 million for credit cards—reflect a concentrated use of these instruments in certain regions with more advanced levels of digitalization.

Table 1: Descriptive Statistics

Variabel	Obs	Mean	Std. dev.	Min	Max
Cash withdrawals via ATM, credit card, and electronic money (per capita)	3084	9,056,196	22,800,000	883	702,000,000
Transaction value using debit card (per capita)	3084	859,788	4,525,806	-	155,000,000
Transaction value using credit card (per capita)	3084	393,992	2,602,848	-	60,000,000
Transaction value using electronic money (per capita)	3084	565,634	3,324,964	-	118,000,000
GRDP at constant prices (per capita)	3084	38,200,000	44,300,000	3,131,489	570,000,000
Saving interest rate (%)	3084	0.77	0.38	-	3.71
Inflation (GDP deflator, %)	3084	3.39	6.74	-34.99	204.40
Number of ATMs per KM²	3084	109	515	-	11,590
Number of debit cards per 100,000 population	3084	73,504	101,571	-	2,383,805
Number of credit cards per 100,000 population	3084	2,680	8,080	-	137,555
Number of electronic money users per 100,000 population	3084	65,761	903,058	-	27,300,000
Transfer value via ATM/Debit (per capita)	3084	9,401,852	47,800,000	-	1,550,000,000
Transfer value via electronic money (per capita)	3084	222,679	4,175,679	-	194,000,000
Outstanding credit (in million IDR)	3084	12,300,000	48,500,000	3,629	992,000,000
Average years of schooling	3084	8.49	1.64	0.97	13.10

Source: Bank Indonesia dan BPS

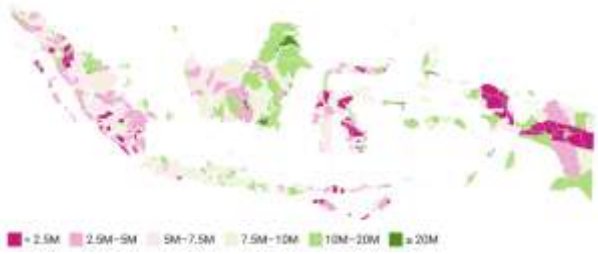
There is substantial variation in per capita cash withdrawals across regions, as illustrated in Figure 1a, where red shading indicates low withdrawal levels and dark green signifies high levels of cash activity. Regions with low cash withdrawals are generally located in remote areas such as Papua and East Nusa Tenggara, whereas high withdrawal levels are concentrated in major urban centers such as Jakarta and parts of Maluku. This pattern reflects disparities in infrastructure accessibility and varying levels of reliance on cash.

The distribution of debit card transactions shows a similar pattern to cash withdrawals, with high transaction values observed in western and central Java, South Sulawesi, and parts of North and East Kalimantan (Figure 1b). In contrast, eastern regions such as Maluku and Papua exhibit low levels of debit card adoption despite high cash withdrawals, indicating a continued preference for cash transactions.

Credit card usage remains limited, with most regions recording transactions of less than IDR 200 thousand per capita (Figure 1c). The highest credit card usage is concentrated in major cities such as Jakarta and other provincial capitals. This limited usage is primarily due to the low ownership rate of credit cards, particularly in areas with restricted access to financial services.

The highest usage of electronic money is observed in metropolitan areas (Figure 1d), with the highest transaction value recorded in South Jakarta at IDR 118 million per capita. In contrast, eastern regions of Indonesia still report near-zero values, largely due to infrastructural constraints and low levels of digital literacy.

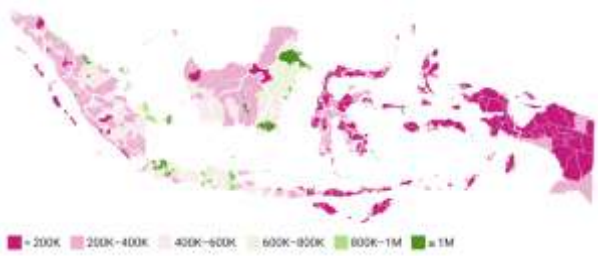
Figure 1: Distribution of Per Capita Cash Withdrawals and Non-Cash Purchase and Payment Transactions in Indonesia, 2024



(a) Cash Withdrawals per Capita

(b) Value of Purchase Transactions Using ATM Debit Cards per Capita

(C) Value of Purchase Transactions Using Credit Cards per Capita



(d) Value of Purchase Transactions Using Electronic Money per Capita

Source: Bank Indonesia

ESTIMATION RESULTS

Based on the estimation using the Two-Way Fixed Effects (TWFE) model, the value of debit card transactions per capita exhibits a negative and statistically significant effect on cash demand, with a coefficient of -0.082 at the 1% significance level. This indicates that increased use of debit cards as non-cash payment instruments serves as a substitute for cash in household consumption activities. Debit cards facilitate more practical, efficient, and direct payments from savings accounts, thereby reducing the public's need to hold physical cash. A 1% increase in debit card transaction value per capita is estimated to reduce cash demand by 0.082%. These findings are consistent with empirical evidence from Nigeria, where innovations such as ATM and point-of-sale (POS) transactions have shown a negative effect on cash holdings (Onah et al., 2020).

Similarly, credit card transactions per capita also show a negative and statistically significant impact on cash demand, with a coefficient of -0.021 at the 1% significance level. Credit cards provide payment flexibility without the immediate use of cash and even allow deferred payments until the next billing cycle. This feature reduces the urgency for individuals to hold large amounts of cash, as transactions can be made within available credit limits. Therefore, a 1% increase in credit card transaction value is estimated to lower cash demand by 0.021%.

On the other hand, electronic money transactions per capita do not exhibit a significant effect on cash demand, as indicated by a statistically insignificant coefficient of 0.018. This suggests that although electronic money is a form of non-cash payment, its overall utilization has not yet reached a level sufficient to replace the role of cash in economic activities. One possible explanation is the uneven adoption of electronic money, which remains concentrated in urban areas and has not yet reached many regions with limited digital infrastructure. According to data from Bank Indonesia, more than 90% of electronic money ownership in Indonesia is held by provinces on the island of Java, with the highest concentration in DKI Jakarta.

Control variables also offer important insights. Gross Regional Domestic Product (GRDP) per capita shows a negative but statistically insignificant effect, suggesting that rising income levels have not directly translated into reduced cash demand. In contrast, the saving interest rate exhibits a significant negative effect (-0.057), aligning with Keynesian theory which posits that higher interest rates incentivize individuals to deposit funds in banks rather than holding cash. Inflation, measured by the GDP deflator, yields a negative coefficient but remains statistically insignificant, possibly due to relatively stable inflation during the observation period.

Table 2: TWFE Estimation Results for National, Java, and Non-Java Regions

Dependent Variable: Ln(Cash Withdrawal)	National	Java	Non Java
Ln(Debit Card Purchase and Payment Transactions per Capita)	-0.082***	0.123***	-0.100***
	(0.013)	(0.020)	(0.016)
Ln(Credit Card Purchase and Payment Transactions per Capita)	-0.021***	-0.007	-0.027***
	(0.007)	(0.013)	(0.008)
Ln(Electronic Money Purchase and Payment Transactions per Capita)	0.018	-0.062**	0.020
	(0.012)	(0.025)	(0.014)
Ln(GRDP at Constant Prices per Capita)	-0.061	0.281**	-0.071
	(0.064)	(0.132)	(0.074)
Saving Interest Rate	-0.057*	0.096	-0.058*
	(0.031)	(0.063)	(0.035)
Inflation (Deflator)	-0.001	-0.000	-0.001
	(0.001)	(0.002)	(0.001)
Number of Debit Cards per Capita	0.107***	0.365***	0.101***
	(0.014)	(0.027)	(0.016)
Number of Credit Cards per Capita	-0.031***	-0.094***	-0.027***
	(0.008)	(0.023)	(0.009)
Number of Electronic Money per Capita	0.036**	0.011	0.020
	(0.016)	(0.022)	(0.022)
Number of ATMs per Square Kilometer	-0.000*	-0.000***	0.000
	(0.000)	(0.000)	(0.000)
Ln(ATM/Debit Card Transfer Value per Capita)	0.703***	0.496***	0.717***
	(0.011)	(0.016)	(0.013)
Ln(Electronic Money Transfer Value per Capita)	-0.009	0.051**	-0.008
	(0.012)	(0.022)	(0.015)
Financial Depth	-0.316**	0.012	-0.816***
	(0.131)	(0.066)	(0.296)
Average Years of Schooling	-0.032	-0.148***	0.013
	(0.047)	(0.041)	(0.060)
Constant	5.941***	-0.053	5.801***
	(1.173)	(2.315)	(1.373)
Observations	3084	714	2370
R-squared	0.749	0.887	0.744
Adjusted R-squared	0.697	0.860	0.690

*p<0,1 **p<0,05 ***p<0,01

The estimation results for the Java region show that debit card purchase transactions per capita have a positive and statistically significant effect on cash demand. A coefficient of 0.123, significant at the 1% level, indicates that

a 1% increase in debit card transactions per capita would lead to a 0.123% increase in cash demand. This finding differs from the national and non-Java estimates, where debit cards act as a substitute for cash. In Java, this result suggests that debit card usage does not replace but complements cash transactions—possibly due to high levels of consumption and economic activity, which encourage the simultaneous use of multiple payment methods.

Meanwhile, credit card transactions yield a negative coefficient of -0.007 but are not statistically significant, indicating that although credit cards can theoretically reduce the need for cash, their influence in the context of Java remains limited in statistical terms. This may be attributed to the concentration of credit card ownership within specific population groups and the still uneven penetration across all layers of society.

On the other hand, electronic money transactions show a negative and statistically significant effect on cash demand, with a coefficient of -0.062 at the 5% significance level. This finding reflects that in Java, electronic money has begun to serve as a real substitute for cash. This can be associated with high levels of digital technology adoption, financial literacy, and payment infrastructure such as QRIS, which have expanded the use of electronic money in daily transactions. The increasing penetration of e-wallets and digital payment applications also accelerates the transition from cash to non-cash. This result is also consistent with previous national-level studies (Aristiyowati & Falianty, 2019) , which found a negative and significant relationship between electronic money and M1.

Several control variables also yield relevant findings. GRDP per capita has a positive and significant effect on cash demand, suggesting that higher income leads to more economic activity and transactions, including the need for cash. Average Years of Schooling shows a negative relationship, indicating that regions with better-educated populations tend to have higher levels of financial and digital literacy, thus adopting non-cash payment instruments more quickly. The variable for the

number of ATMs per km² also has a negative effect, suggesting that a higher density of ATM infrastructure may promote withdrawal efficiency, reducing the need to hold large amounts of cash, in line with Baumol's theory of money demand (Tavor et al., 2018).

The estimation results for the non-Java region show that debit card purchase transactions have a negative and statistically significant effect on cash demand. A coefficient of -0.100 at the 1% significance level indicates that a 1% increase in debit card transactions would reduce cash demand by 0.10%. This finding aligns with the pattern observed at the national level, indicating that debit cards function as a substitute for cash in the transactional behaviour of the public. This reinforces the argument that in non-Java regions, debit card use has been effective in shifting payment behaviour from cash-based to non-cash transactions, thereby reducing the demand for physical currency.

On the other hand, electronic money transactions do not yet show a significant effect on cash demand in non-Java regions. This is reflected in a coefficient of 0.020, which is not statistically significant. This finding indicates that although electronic money has been introduced nationwide, its level of penetration and usage intensity outside Java remains relatively low. Limitations in digital infrastructure, low digital financial literacy, and unequal access to payment technology are key factors that hinder the role of electronic money as a substitute for cash in these regions. Accordingly, although card-based payment instrument (debit and credit cards) have been effective in reducing cash demand outside Java, electronic money has not shown the same effectiveness—unlike the pattern observed in the Java region.

Several control variables also yield relevant results. The saving interest rate shows a negative and significant effect on cash demand, with a coefficient of -0.058, implying that higher interest rates provide greater incentives for people to save in banks rather than hold cash. The variable for financial depth, as measured by the ratio of credit to GRDP, also has a significant negative effect (-0.816), indicating that the deeper a

region's financial sector, the lower the demand for cash, as people tend to transact through formal financial mechanisms. Meanwhile, GRDP per capita and Average Years of Schooling do not show significant effects. This suggests that income and education levels in non-Java regions have not been sufficient to drive changes in financial behavior related to cash usage, which contrasts with the patterns observed in Java.

The comparison across regions shows that the transformation of the payment system is more advanced in Java, where electronic money serves as the main substitute for cash. Conversely, in non-Java areas, card based instruments remain the dominant tools.

ROBUSTNESS CHECK

A robustness check was conducted to assess the consistency of the estimation results by comparing models across the subsamples of Java and non-Java regions. The findings indicate that the direction and statistical significance of the relationship between non-cash transactions and cash demand remain stable. In Java, debit card transactions continue to have a positive and significant effect on cash demand, while electronic money maintains a negative and significant effect, reaffirming its role as a substitute for cash. In non-Java regions, the negative effect of debit card usage on cash demand becomes stronger, while the previously insignificant effect of electronic money becomes significantly positive, reflecting differing patterns of adoption. Most control variables also exhibit stable results, confirming that the main findings of this study are robust to changes in model specifications and regional contexts.

Table 3: Robustness Check Test Results

Dependent Variable: Ln(Cash Withdrawal)	Java	Non-Java	Urban Areas in Java	Districts in Non-Java
Ln(Debit Card Purchase and Payment Transactions per Capita)	0.123***	-0.100***	0.103***	-0.140***
	(0.020)	(0.016)	(0.030)	(0.020)
Ln(Credit Card Purchase and Payment Transactions per Capita)	-0.007	-0.027***	-0.059**	-0.029***
	(0.013)	(0.008)	(0.027)	(0.009)
Ln(Electronic Money Purchase and Payment Transactions per Capita)	-0.062**	0.020		0.025*
	(0.025)	(0.014)		(0.015)
Ln(GRDP at Constant Prices per Capita)	0.281**	-0.071	0.328	-0.167*
	(0.132)	(0.074)	(0.275)	(0.085)
Saving Interest Rate	0.096	-0.058*	0.095	-0.051
	(0.063)	(0.035)	(0.120)	(0.037)
Inflation (Deflator)	-0.000	-0.001	0.004	-0.002
	(0.002)	(0.001)	(0.008)	(0.001)
Number of Debit Cards per Capita	0.365***	0.101***	0.306***	0.201***
	(0.027)	(0.016)	(0.044)	(0.027)
Number of Credit Cards per Capita	-0.094***	-0.027***	-0.081*	-0.026**
	(0.023)	(0.009)	(0.046)	(0.010)
Number of Electronic Money per Capita	0.011	0.020	0.077*	0.019
	(0.022)	(0.022)	(0.042)	(0.027)
Number of ATMs per Square Kilometer	-0.000***	0.000	-0.000***	0.010***
	(0.000)	(0.000)	(0.000)	(0.003)
Ln(ATM/Debit Card Transfer Value per Capita)	0.496***	0.717***	0.603***	0.702***
	(0.016)	(0.013)	(0.029)	(0.016)
Ln(Electronic Money Transfer Value per Capita)	0.051**	-0.008	0.098**	-0.011
	(0.022)	(0.015)	(0.043)	(0.017)
Financial Depth	0.012	-0.816***	-0.037	-0.971**
	(0.066)	(0.296)	(0.102)	(0.393)
Average Years of Schooling	-0.148***	0.013	-0.274***	0.032
	(0.041)	(0.060)	(0.083)	(0.066)
Constant	-0.053	5.801***	-1.375	6.856***
	(2.315)	(1.373)	(4.923)	(1.571)
Observations	714	2370	204	1986
R-squared	0.887	0.744	0.912	0.745
Adjusted R-squared	0.860	0.690	0.883	0.690

*p<0,1 **p<0,05 ***p<0,01

CONCLUSION

At the national level, the estimation results indicate that consumption transactions conducted using card-based payment instruments—both debit and credit cards—have a negative effect on cash

demand, suggesting a substitution function relative to cash. However, electronic money transactions have not yet shown a significant impact on aggregate cash demand. In the Java region, the use of electronic money has been found to significantly reduce cash demand, reflecting a shift in consumer preferences toward digital payment instruments. Conversely, debit card transactions exert a positive effect on cash demand, indicating that this instrument has not fully functioned as a substitute and instead tends to complement cash usage. Meanwhile, credit card usage does not exhibit a statistically significant effect.

In non-Java regions, the observed pattern is generally consistent with the national trend, wherein card-based payment instruments act as substitutes for cash, while electronic money still lacks a meaningful effect. These findings suggest that outside Java, the adoption of non-cash payment systems continues to be dominated by card-based instruments, whereas electronic money has not yet replaced the role of cash. In contrast, Java has experienced a shift toward electronic money as the primary mode of payment, particularly supported by the implementation of the QRIS system since 2020. This indicates that, especially in Java, electronic money is beginning to replace the dominance of card-based payment instrument in consumer payment preferences and has the potential to become the principal instrument in reducing cash demand.

Future research is encouraged to utilize micro-level and longitudinal data to more deeply explore individual behavioral dynamics in the transition from cash to non-cash usage, including the role of demographic factors and trust in digital payment systems. Furthermore, the adoption of spatial econometric approaches is necessary to examine geographic disparities in digital payment adoption and to identify structural and institutional factors contributing to interregional inequalities. More focused studies are also needed to evaluate the long-term impacts of strategic initiatives such as QRIS, BI-FAST, and Regional Government Transaction Electronification (ETPD) on household

financial behavior, levels of financial inclusion, and the overall stability of the national payment system. Finally, it is essential to investigate the implications of changes in the structure of money supply on the responsiveness of macroeconomic variables to monetary policy, considering that digital transformation may fundamentally alter the mechanisms of policy transmission.

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Appendix 1 – Data Used

No	Data	Data Description	Unit	Freq	Source
1	Cash Demand	The monetary value of cash withdrawal transactions conducted through ATM/debit cards, credit cards, and electronic money within a specific period.	Rp	Monthly Aggregate	BI
2	Debit Card Transactions	The monetary value of expenditure and payment transactions conducted using debit cards within a specific period.	Rp	Monthly Aggregate	BI
3	Credit Card Transactions	The monetary value of expenditure and payment transactions conducted using credit cards within a specific period.	Rp	Monthly Aggregate	BI
4	Electronic Money Transactions	The monetary value of expenditure and payment transactions conducted using electronic money within a specific period.	Rp	Monthly Aggregate	BI
5	GRDP at Current Prices	Gross Regional Domestic Product at current market prices.	Rp	Quarterly	BPS
6	GRDP at Constant Prices	Gross Regional Domestic Product at constant prices.	Rp	Quarterly	BPS
7	Saving Interest Rate	Percentage of effective interest or return on savings.	%	Monthly Average	BI
8	Number of ATM Machines	The number of ATM machines available for conducting cash withdrawal transactions as well as cash and non-cash deposit transactions.	-	End of year	BI
9	Number of Emoney Readers	Number of electronic money readers (devices used to read data stored on electronic money instruments), as of the end of December each year.	-	End of year	BI
10	Number of Debit Cards	Total number of debit cards in circulation among the public at the end of December each year, including active and temporarily blocked cards.	-	End of year	BI
11	Number of Credit Cards	Total number of credit cards in circulation among the public at the end of December each year.	-	End of year	BI

No	Data	Data Description	Unit	Freq	Source
12	Number of Electronic Money Instruments	Total number of electronic money instruments in circulation at the end of December each year, including chip-based, server-based, registered, and unregistered forms.	-	End of year	BI
13	ATM/Debit Transfer Value	Nominal value of interbank and intra-bank transfers conducted via ATM or debit card.	Rp	Monthly Aggregate	BI
14	Electronic Money Transfer Value	Nominal value of transfers using electronic money, either to another e-money account or a bank account.	Rp	Monthly Aggregate	BI
15	Total Credit Outstanding	Loans provided by commercial and rural banks as of the end of December each year.	Rp	End of year	BI
16	Population	Total population based on census and population projections.	-	yearly	BPS
17	Average Years of Schooling	Average number of years of education completed by individuals aged 15 and above across all levels of education attended.	Year	yearly	BPS
18	Geographical Area	Geographic size of a district or municipality.	KM^2	-	BPS

Appendix 2 – Multicollinearity and Heteroskedasticity Tests

Multicollinearity Tests

Variable	VIF	1/VIF
lndebetcap	4.82	0.20729
lncreditcardcap	5.95	0.16799
lnemoneycap	5.68	0.17602
lnpdrbcap	1.67	0.60030
savingrate	1.29	0.77646
inflation	1.03	0.97546
lnndebetcap	3.56	0.28052
lnncreditcardcap	5.24	0.19079
lnnemoneycap	7.37	0.13577
atmmachine	1.51	0.66201
lnemoneytransfercap	8.46	0.11823
lntransferatmdebetcap	3.14	0.31875
findepth	1.56	0.63911
yos	2	0.49904
Mean VIF	**3.81**	

Heteroskedasticity Tests

Assumption: Normal error terms
Variable: Fitted values of lncashcap

H0: Constant variance

chi2(1) = 1524.23
Prob > chi2 = 0.00

Appendix 3 – Breusch-Pagan Lagrange Multiplier (LM) Test and Hausman Test

The Breusch-Pagan Lagrange Multiplier (LM) test is a statistical procedure used in panel data analysis to determine whether a random effects model is preferable to a pooled Ordinary Least Squares (OLS) model. The primary objective of the Breusch-Pagan LM test is to assess whether there is significant unobserved heterogeneity among the individual units (e.g., firms, countries, individuals) in the panel data.

	Variance	SD = sqrt(Var)
lncashcap	1.3718	1.1713
e (error term)	0.0845	0.2906
U (random effect)	0.0905	0.3008
Test: Var(u) = 0		
	chibar2(01) =	1,882.39
	Prob > chibar2 =	0.000

The Hausman test is used to decide between the fixed effects and random effects models. It evaluates whether there is a significant correlation between the unobserved individual-specific effects and the explanatory variables in the model.

Test of H_0: Difference in coefficients not systematic

chi2(15)	=	(b-B)'[(V_b-V_B)^(-1)](b-B)
	=	169.37
Prob > chi2	=	0.0000

(V_b-V_B is not positive definite)