

The Responsiveness of the Velocity of Money to the Growth in E-Money Usage in ASEAN Countries: A Comparative Study of Indonesia, Malaysia, and Singapore

Aprilia Maharani*

Department of Development Economics, Universitas Negeri Semarang, Indonesia

* Corresponding author: apriliamaharani53@students.unnes.ac.id

Abstract

This study examines the impact of electronic money usage, real Gross Domestic Product growth, policy interest rates, exchange rates, and the interaction of payment digitalization on the velocity of money in Indonesia, Malaysia, and Singapore. Using quarterly panel data from 2015 to 2025 and a Fixed Effects estimation, the model yields an within R-squared value of 52.11 percent, indicating that variations in the velocity of money can be explained by the variables under study. The estimation results show that e-money has a significant negative effect on the velocity of money, while real GDP growth and interest rates have significant positive effects. The exchange rate and the interaction term between e-money and economic growth do not show significant effects. These findings confirm that the increase in digital transactions has not fully accelerated the circulation of money, as a portion of e-money balances is still held as a precautionary balance. This study provides cross-country empirical evidence on the dynamics of payment digitalization and its implications for the effectiveness of monetary policy in the Association of Southeast Asian Nations.

Keywords: Electronic money, velocity of money, digital payment, digital transformation

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1. Introduction

The development of financial technology (fintech) has transformed payment systems and transaction behaviour, particularly through the growing use of electronic money (e-money). E-money facilitates faster and more convenient transactions while reducing dependence on cash-based payments. In Indonesia, e-money transactions have increased rapidly since 2019, supported by wider internet and smartphone penetration, the expansion of digital wallets, and the integration of electronic payments into transportation, e-commerce, food-delivery services, and other daily activities [1]. Malaysia has experienced a similar transition, supported by high levels of electronic payment adoption and digital financial literacy [2]. Singapore, meanwhile, represents a more mature digital payment environment, characterised by advanced financial infrastructure, extensive merchant acceptance, and regulatory policies that promote payment interoperability and innovation [3]. Although these countries have all experienced substantial growth in e-money usage, they differ considerably in their levels of economic development, financial-system maturity, and payment digitalisation.

The increasing use of e-money may also influence the VOM, which measures how frequently a unit of money is used to purchase goods and services during a given period. In principle, digital payments reduce transaction costs, shorten settlement times, and improve payment accessibility. These improvements may increase transaction frequency and accelerate the circulation of money. However, greater payment efficiency does not necessarily produce a proportional increase in VOM. E-money may instead encourage users to retain funds in digital accounts for future transactions. Moreover, changes in VOM are influenced not only by payment technology but also by economic growth, interest rates, liquidity preferences, consumption behaviour, and broader macroeconomic conditions.

The experiences of Indonesia, Malaysia, and Singapore illustrate this complexity. In Indonesia, VOM has generally declined and fluctuated despite the rapid expansion of e-money transactions. Malaysia has exhibited a comparatively stable VOM pattern, apart from a marked decline in 2020, when economic activity and household expenditure were disrupted by the COVID-19 pandemic. In Singapore, VOM has remained relatively stable even though electronic payments are already widely adopted. This pattern suggests that, in a mature digital economy, payment digitalisation may primarily alter the method and efficiency of transactions without

necessarily increasing the circulation rate of the broader money supply. The contrasting patterns across the three countries therefore indicate that the monetary effects of e-money may depend on each economy's structural and institutional characteristics.

Previous empirical findings also remain inconclusive. Several studies suggest that e-money can reduce VOM because users tend to retain digital balances for future transactions [4–6]. Other studies report that payment digitalisation increases VOM by reducing transaction frictions and facilitating more frequent economic exchanges [7–9]. These mixed findings suggest that the relationship between e-money and VOM is not uniform across countries. Its direction and magnitude may vary according to the intensity of e-money usage, the level of economic development, the maturity of the financial system, and prevailing monetary conditions..

Existing studies have generally focused on individual countries and employed relatively simple empirical models incorporating variables such as e-money transactions, economic growth, interest rates, and exchange rates [5], [8]. Consequently, limited attention has been given to structural heterogeneity among economies at different stages of digital development. Cross-country comparative evidence for ASEAN is particularly limited, even though countries in the region differ substantially in their payment infrastructure, digital adoption, and macroeconomic characteristics. Furthermore, previous studies have rarely examined whether the effect of economic growth on VOM changes as e-money usage intensifies. This omission is important because payment digitalisation may alter how increases in production and expenditure are transmitted into monetary circulation.

This study addresses these limitations by examining the effects of e-money usage on VOM in Indonesia, Malaysia, and Singapore using quarterly data from 2015 to 2025. It makes three principal contributions. First, it employs a cross-country panel-data approach to compare economies with different levels of development and payment digitalisation. Second, it incorporates an interaction between e-money usage and economic growth to determine whether payment digitalisation moderates the relationship between economic activity and VOM. Third, the use of quarterly data enables the analysis to capture short-term monetary dynamics and changes in e-money adoption more accurately than studies relying on annual observations. Accordingly, this study provides comparative empirical evidence on how financial digitalisation affects monetary circulation across structurally different ASEAN economies.

2. Literature Review

The digitization of payment systems has become a key element in the modernization of financial services, particularly due to its ability to improve transaction efficiency, accelerate processing, and provide a more integrated data flow. The adoption of digital payment instruments is influenced by perceptions of convenience, perceived benefits, digital literacy, and users' level of trust in the security of the technology [13]. Digital competence and financial literacy have also been shown to play a significant role in determining an individual's readiness to adopt m-payment and m-banking services, particularly on app-based platforms [14]. On the other hand, payment digitization generates transactional data that holds strategic value for business intelligence development, including in analyzing consumer behavior and designing data-driven services. Recent studies in the context of QRIS in Indonesia indicate that the integration of digital payment technology enhances payment system efficiency and expands the use of non-cash instruments [15].

Empirical findings on the impact of e-money on the VOM show mixed results. An increase in e-money transactions has been shown to accelerate the circulation of money through expanded financial inclusion and payment efficiency [16], [17]. However, the effect of e-money held as a floating balance on VOM may vary across countries with uneven levels of digitalization. Thus, payment digitalization does not always automatically increase the velocity of money.

In a macroeconomic context, real GDP growth has been shown to increase the velocity of money through the expansion of transaction activity, as detailed in recent findings on the determinants of money velocity in Indonesia [7]. Furthermore, payment digitalization and increased use of non-cash instruments such as e-money also drive the acceleration of money circulation, consistent with empirical evidence that e-money, inflation, and interest rates have a significant impact on VOM [5], [18]. Cashless payment instruments also exhibit dynamic effects on M/P, both through increased daily transaction intensity and shifts in public preferences regarding money holding [8], [17]. These findings underscore that the integration of digital payments and monetary policy plays a crucial role in shaping M/P dynamics, although the direction and magnitude of their influence may vary across countries.

Based on theory and empirical findings, the relationships among the variables can be summarized as follows: the use of e-money has a direct effect on VOM, real economic growth (GrowthGDP) accelerates money circulation, and the EM × GrowthGDP interaction acts as a moderator that indicates whether the digitization of payments strengthens or weakens the effect of economic growth on VOM. Interest rates (IR) and exchange rates (ER) are included as control variables that also influence the dynamics of money circulation. This theoretical

framework serves as the basis for the empirical testing in this study using a cross-country panel regression model for ASEAN countries (Indonesia, Malaysia, and Singapore). With this approach, the study not only assesses the direct effect of e-money on M/Y but also accounts for the role of economic conditions and other control variables, thereby providing a more comprehensive understanding of money circulation dynamics in the digital era across ASEAN economies.

Although many studies have examined the relationship between e-money, macroeconomic indicators, and VOM, most remain focused on a single country. Previous literature has also not fully integrated digital business and business intelligence perspectives regarding the utilization of digital data, payment system efficiency, and technological readiness. This study aims to address this gap by analyzing the impact of payment digitalization on VOM across three ASEAN countries, while also examining the interaction between e-money and economic growth. This approach offers new insights into understanding the dynamics of digitalization and its implications for the effectiveness of monetary policy in the ASEAN region.

3. Methods

3.1. Data Variable Measurement

This study uses a balanced quarterly panel comprising Indonesia, Malaysia, and Singapore from the first quarter of 2015 to the second quarter of 2025. The resulting dataset contains 126 country-quarter observations. Data were compiled from official publications of Bank Indonesia, Bank Negara Malaysia, the Monetary Authority of Singapore, the respective national statistical agencies, the World Bank, and CEIC. These countries were selected because they represent different levels of economic development and payment-system digitalisation while providing sufficiently consistent quarterly monetary and payment data.

Nominal GDP, real GDP, and broad money (M2) were collected at quarterly frequency. Monthly policy interest rates and exchange rates were converted into quarterly averages, whereas monthly e-money transaction values were aggregated into quarterly totals and converted into US dollars to improve cross-country comparability. Table 1 summarises the definitions, units, and sources of all variables used in the empirical analysis.

Table 1. Operational Definitions of Variables

Variable	Operational Definition	Unit	Source
VOM (Y)	The velocity of money in a country's economy.	Time	BI, BNM, MAS, CEIC, World Bank
EM (X ₁)	The total value of electronic money transactions each quarter.	USD	BI, BNM, MAS
GrowthGDP (X ₂)	Quarter-over-quarter changes in real GDP.	Percentage (%)	BI, BNM, MAS, World Bank
IR (X ₃)	Central bank policy interest rates (BI Rate, Malaysia's OPR, Singapore's SORA/benchmark rate).	Percentage (%)	BI, BNM, MAS
ER (X ₄)	The exchange rate of the domestic currency against the USD.	Local currency per USD	BI, BNM, MAS
EM × GrowthGDP (X ₆)	The relationship between the digitization of payments and economic conditions.	–	Derived from key variables

The dependent variable is the VOM, measured as the ratio of nominal GDP to M2. This measure indicates how frequently the broad money stock supports nominal economic transactions:

$$VOM = \frac{\text{Nominal GDP}}{\text{Money Supply (M2)}} \quad (1)$$

The principal explanatory variable is the value of e-money transactions, which captures the intensity of digital payment activity more directly than the number of issued cards or registered accounts. Real GDP growth is measured as the quarter-on-quarter percentage change in real economic activity:

$$\text{Real GDP Growth} = \frac{GDP_t - GDP_{t-1}}{GDP_{t-1}} \times 100\% \quad (2)$$

The policy interest rate is included because it represents the opportunity cost of holding money, while the exchange rate controls for external monetary conditions that may influence domestic liquidity and asset preferences. An interaction between e-money transaction value and real GDP growth is constructed to examine whether the relationship between economic growth and VOM varies with the intensity of digital payments.

3.2. Empirical Model

Panel-data regression is used because it combines variation over time with variation across countries and allows the analysis to account for time-invariant country characteristics that are not directly observed. E-money transaction value is transformed into its natural logarithm to reduce skewness and stabilise its variance. Consistent with the variables reported in the estimation results, the direct e-money term is entered in logarithmic form, while the interaction term is constructed from the underlying transaction value and real GDP growth. The empirical model is specified as follows.

$$VOM_{it} = \beta_0 + \beta_1 \ln(EM_{it}) + \beta_2 \text{GrowthGDP}_{it} + \beta_3 IR_{it} + \beta_4 ER_{it} + \beta_5 (EM_{it} \times \text{GrowthGDP}_{it}) + \mu_i + \varepsilon_{it} \quad (3)$$

where VOM_{it} is the ratio of nominal GDP to the M2 money supply in country i during quarter t , EM_{it} is the total value of e-money transactions, GrowthGDP_{it} is real GDP growth, IR_{it} is the policy interest rate, ER_{it} is the domestic exchange rate against the US dollar, $EM_{it} \times \text{GrowthGDP}_{it}$ is the interaction term, μ_i captures unobserved country-specific effects, β_0 is the constant, β_1 – β_5 are the regression coefficients, and ε_{it} is the idiosyncratic error term.

3.3. Estimation and Model Selection

Pooled ordinary least squares, Fixed Effects (FE), and Random Effects (RE) estimators were initially considered. FE permits unobserved country-specific effects to be correlated with the explanatory variables, whereas RE assumes that these effects are uncorrelated with the regressors. Model selection was conducted at the 5% significance level using three complementary tests. The Chow test compares pooled ordinary least squares with FE, the Breusch–Pagan Lagrange Multiplier test compares pooled ordinary least squares with RE, and the Hausman test determines whether FE or RE provides a consistent estimator. The test outcomes, reported in Tables 3–5, were jointly used to select the final estimator.

3.4. Model Diagnostic

Diagnostic testing was conducted after estimation to evaluate the reliability of the model. The Shapiro-Wilk test was used to examine whether the residual distribution departed substantially from normality. Multicollinearity was assessed using variance inflation factors (VIF), with larger values indicating that an explanatory variable can be closely approximated by the remaining regressors and may therefore produce unstable coefficient estimates. The results of the residual-normality and multicollinearity diagnostics are presented in Tables 7 and 8, respectively.

4. Result and Discussion

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics for the 126 country-quarter observations. VOM ranges from 0.15 to 0.69, indicating substantial variation in money circulation across countries and periods. The relatively large dispersion in e-money transactions and exchange rates reflects the structural differences among Indonesia, Malaysia, and Singapore. These differences support the use of a panel-data model that controls for unobserved country-specific characteristics.

Tabel 2. Descriptive Statistics

Variable	Obs	Mean	Maximum	Minimum	Std. Dev.
VOM	126	0.3467	0.69	0.15	0.2062
lnEM	126	16.3540	23.3957	12.0143	3.8904
GrowthGDP	126	23.2949	57.38	0	14.0984
IR	126	3.1646	7.58	0.1257	1.9088
ER	126	4821.164	16426	1.31	6863.022
Interaction	126	-7.16×10^{14}	1.03×10^{15}	-8.75×10^{15}	1.86×10^{15}

Source: Stata Data Analysis Results (2025).

4.2 Model Selection

The Chow, Lagrange Multiplier (LM), and Hausman tests were used to select the appropriate panel estimator. As reported in Table 3, the Chow test rejects pooled ordinary least squares in favour of the Fixed Effects Model (FEM) ($p < 0.001$). Table 4 shows that the LM test does not support the Random Effects Model over pooled ordinary least squares ($p = 1.000$), while Table 5 shows that the Hausman test favours FEM over the Random Effects Model ($p < 0.001$). Taken together, these results support FEM because country-specific effects are significant and correlated with the explanatory variables.

Table 3. Results of the Chow Test

Test statistic	Value
F(2, 118)	74.04
Prob. > F	0.0000

Source: Stata data analysis results (2025).

Table 4. Results of the Breusch-Pagan Lagrange Multiplier Test

Test statistic	Value
Chibar2	0.00
Prob. > chibar2	1.0000

Source: Stata data analysis results (2025).

Table 5. Results of the Hausman Test

Test statistic	Value
Chi-square	18.69
Prob. > chi2	0.0003

Source: Stata data analysis results (2025).

4.2 Fixed Effects Estimation

Table 6 shows that e-money usage is negatively and significantly associated with VOM, whereas real GDP growth and the policy interest rate have significant positive associations. In contrast, the exchange rate and the interaction between e-money usage and economic growth are not statistically significant. The model explains 52.1% of the within-country variation in VOM, indicating moderate explanatory power, and the explanatory variables are jointly significant ($p < 0.001$). These results confirm that the selected fixed-effects specification provides a statistically meaningful explanation of changes in VOM over time within the three countries. By controlling for unobserved, time-invariant country characteristics, the model isolates the relationships between changes in the explanatory variables and changes in VOM within each economy. Nevertheless, the remaining variation suggests that other time-varying monetary and institutional factors may also influence money-circulation dynamics.

Table 6. Results of Panel Regression Estimation (Fixed Effects Model)

Independent Variable	Coefficient (β)	Std. Error	T-statistic	Sig. (p)	Notes
InEM	-0.01636	0.00353	-4.63	0.000	Significant
GrowthGDP	0.00115	0.00025	4.68	0.000	Significant
IR	0.00522	0.00176	2.96	0.004	Significant
ER	-6.48E-06	4.85E-06	-1.34	0.184	Not significant
Interaction	-2.41 $\times 10^{-18}$	1.60 $\times 10^{-18}$	-1.51	0.135	Not significant
Constant	0.60053	0.04416	13.6	0.000	Significant

Source: Stata Data Analysis Results (2025).

Model statistics: within R-squared = 0.5211; F-statistic = 25.68; Prob. > F = 0.000; F-test of country effects = 74.04 ($p = 0.000$)

4.3 Diagnostic Tests

The Shapiro–Wilk test reported in Table 7 yields a W statistic of 0.9913 and a probability value of 0.6189. Since the probability exceeds the 5% significance level, the null hypothesis of normally distributed residuals cannot be rejected, indicating no substantial departure from normality. This result supports the reliability of the statistical inference derived from the model. Table 8 shows that the VIF values range from 1.28 to 3.18, with a mean of 2.06. The highest VIF is observed for the exchange rate, followed by the policy interest rate, but both remain below the commonly applied threshold of 5. The corresponding tolerance values are also above 0.10. Moreover, the inclusion of the interaction term does not create excessive linear dependence with the other explanatory variables. Collectively, these findings indicate no serious multicollinearity, suggesting that the estimated coefficients are sufficiently stable and can be interpreted reliably.

Table 7. Results of the Shapiro-Wilk Test

Variable	Obs	W	V	z	Prob > z
uhat	126	0.9913	0.874	-0.302	0.61886

Source: Stata Data Analysis Results (2025).

Tabel 8. Variance Inflation Factor Results)

Variable	VIF	1/VIF
ER	3.18	0.31445
IR	2.91	0.34373
InEM	1.54	0.65001
GrowthGDP	1.4	0.7163
Interaction	1.28	0.77995
Mean VIF	2.06	

Source: Stata Data Analysis Results (2025)

5. Discussion

The negative association between e-money usage and VOM suggests that expanding digital payments does not automatically accelerate the circulation of the broader money supply. This finding is consistent with evidence that non-cash instruments can alter money-holding behaviour and money-demand dynamics [7], [8], [18]. One possible explanation is that some digital-wallet balances are retained for future transactions rather than immediately spent. However, because dormant balances and liquidity preferences are not directly observed, this mechanism remains an interpretation rather than a tested causal channel.

Real GDP growth and policy interest rates are positively associated with VOM. Stronger economic activity increases transaction intensity among households and businesses, while higher interest rates raise the opportunity cost of holding non-interest-bearing money and may encourage funds to move toward financial assets [5], [7], [21], [22]. By contrast, the exchange rate is not statistically significant, providing insufficient evidence that quarterly exchange-rate movements systematically influence domestic money circulation [8]. The insignificant interaction term also indicates that e-money usage does not significantly moderate the relationship between economic growth and VOM during the observation period.

Overall, payment digitalisation and macroeconomic conditions play distinct roles in monetary circulation. Expanding digital payment infrastructure alone may therefore be insufficient to accelerate VOM. Policy should also promote active usage, interoperability, consumer confidence, and the integration of digital balances into everyday transactions.

4. Conclusion

This study examines the relationship between e-money usage and the velocity of money (VOM) in Indonesia, Malaysia, and Singapore using quarterly panel data from 2015 to 2025. The fixed effects estimates show that e-money usage is negatively associated with VOM, whereas real GDP growth and policy interest rates have significant positive associations. Exchange-rate movements and the interaction between e-money usage and economic growth are not statistically significant. Therefore, the findings do not support the proposition that e-money usage moderates the relationship between economic growth and VOM.

These findings indicate that the expansion of digital payments does not automatically accelerate the circulation of the broader money supply. Policies should consequently extend beyond increasing e-money adoption by encouraging active usage, improving payment interoperability, strengthening consumer confidence, and integrating digital balances into everyday transactions. The study contributes comparative evidence showing that payment digitalisation and macroeconomic conditions play distinct roles in monetary circulation across ASEAN economies with different structural characteristics.

This study is limited to three countries and aggregate quarterly data. Future research could include additional ASEAN countries, indicators of active digital-wallet usage and stored balances, and dynamic panel methods to distinguish short- and long-run effects. Addressing potential endogeneity between e-money usage and VOM would also strengthen causal interpretation.

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