Economic Journal of Emerging Markets, 17(1) 2025, 57-69

Check for updates

EJEM
Econ.J.Emerg.Mark.

Economic Journal of Emerging Markets
Available at https://journal.uii.ac.id/jep

The dynamic effect of cash and non-cash payment instruments on money velocity in Indonesia

Dian Zulfa, Sofyan Syahnur*

Department of Economics Development, Faculty of Economics and Business, Universitas Syiah Kuala, Banda Aceh, Indonesia
*Corresponding author: kabari_sofyan@usk.ac.id

Article Info

Article history:
Received 04 April 2024
Accepted 28 April 2025
Published 28 April 2025

JEL Classification Code:
C32, E51, E52

Author's email:
dianazulfa522@gmail.com

DOI:
10.20885/ejem.vol17.iss1.art5

Abstract

Purpose — This study explores the dynamic effect of electronic money as a non-cash payment instrument on the velocity of money in Indonesia from 2012 to 2020.

Method — Using quarterly time-series data from 2012 to 2020, the research employs the Error Correction Model (ECM), stationarity tests, cointegration tests, and classical assumption tests to ensure a correct estimation procedure.

Findings — The findings reveal several essential points: (1) Faster circulation of cash generally increases the velocity of M1; (2) Excessive money supply slows down M1 circulation; (3) An increase in the use of debit cards (ATMs) tends to reduce M1 velocity, while quicker credit card transactions can accelerate it; (4) Rapid circulation of electronic money can expedite M1, but large amounts can hinder it. Overall, both cash and non-cash money equally influence the behaviour of M1 velocity in Indonesia.

Implication — The government should focus more on money velocity to maintain stability, even though various payment instruments are utilised in the economy.

Originality — The current research focuses on the dynamic development of modern finance in Indonesia and on electronic money as a non-cash payment instrument that affects money velocity.

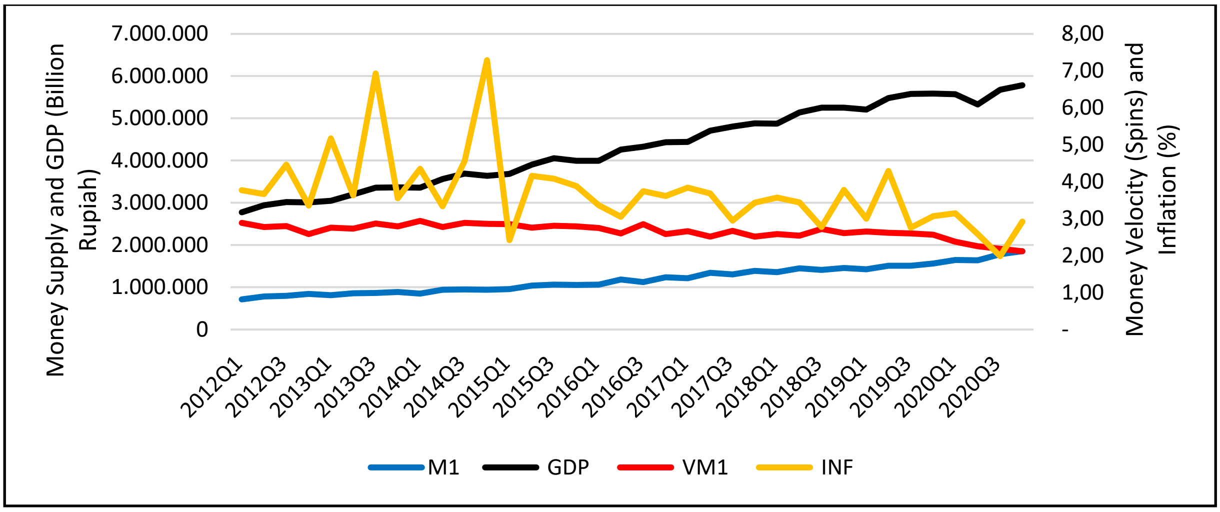
Keywords — Financial development, electronic money, money velocity, ECM, cash payment.

Introduction

Money velocity is a vital monetary indicator that reflects the speed of money movement (Dong & Gong, 2014). It reflects the frequency of currency units used for transactions and the efficiency of money in facilitating transactions (Oyadeyi, 2024). Money velocity is a tool to assess the impact of monetary policy on economic growth (Genemo, 2021). The money supply indicates high, low, and stable money velocity (hereafter *MV*). Wang (2023) highlighted that a larger money supply in the economy will be followed by very active and smooth economic activities, thus stimulating *MV* to be too high. However, a high *MV* tends to result in the possibility of a high inflation rate (Okedigba et al., 2024; Salas, 2020). Conversely, if the money supply is too low, it will result in low money velocity. At the same time, it impacts the economy's sluggishness, and ultimately, the possibility of deflation will be very wide open (Bozkurt, 2014). This cyclical condition underlines that the size of a country's economic activity changes quickly or slowly depending on the amount of money in circulation, as

P ISSN 2086-3128 | E ISSN 2502-180X

indicated by the level of money velocity (Faugere, 2024). It confirms that the stability of the money velocity is a vital indicator in determining the level of economic growth and inflation rate of a country (Avdiu & Unger, 2022; Jung, 2017).



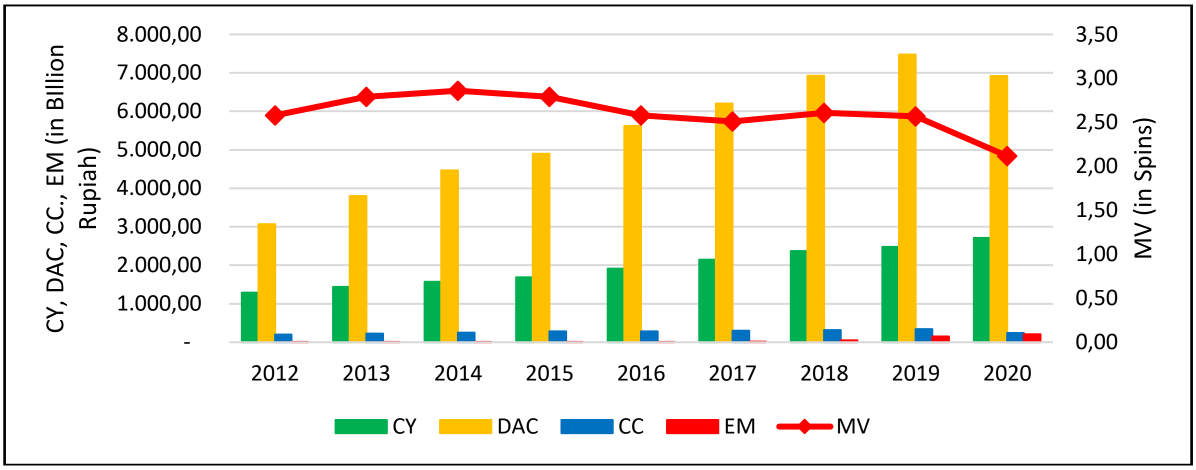
Source: Indonesian Central Bank and Central Bureau of Statistics (CBS) of Indonesia, 2010-2020

Figure 1. The Development of Money Supply (M1), Gross Domestic Product, Inflation, and Money Velocity in Indonesia, 2012 (Q1)-2020 (Q4)

Figure 1 reflects the state of money velocity, Gross Domestic Product (*GDP*), money supply, and inflation rate in Indonesia, which shows a different condition than what should happen. It is exposed by the money velocity, which tends to slow down and decrease. However, *GDP* tends to increase. Theoretically, this condition is quite contradictory: as *GDP* or economic productivity increases, money velocity should also be high, not declining (Arkadani, 2022). In addition, the money supply in Indonesia continues to expand but is unable to increase money velocity, and tends to contract. This contradictory condition makes money velocity an important monetary indicator for predicting the inflation rate. Figure 1 emphasises that the state of Indonesia's money velocity was not very stable during the period 2012Q1 to 2020Q4. In general, this condition explains that, during the 2012-2015 period, Indonesia's money velocity showed a stable condition. During the 2016-2020 period, the money velocity experienced conditions that tended to be stable-low. This is based on the instability of money velocity, measured by the standard deviation over nine years of movement (Benk et al., 2010), which is divided into three categories: high (>2.85), stable (2.66-2.84), and low (<2.65). It indicates that Indonesia's economic movement has recently experienced growth with a slight slowdown. For this reason, the depressed money velocity in Indonesia during this time must be overcome immediately to reach a more stable condition.

Money velocity uncertainty is mainly caused by money supply and *GDP*. The money supply tends to continue increasing and is difficult to reduce. This condition can be caused, among others, by increasingly diverse means of payment that are increasingly difficult for the central bank to control (Durgun & Timur, 2015; Luo et al., 2021). The primary determinant of the money supply is the money multiplier, while non-cash payment instruments can create a sizable one (Abbas et al., 2014; Mughal et al., 2021; Ongan & Gocer, 2023). Thus, non-cash payment instruments can influence money velocity in Indonesia through their effect on the money supply. In addition, non-cash payment instruments can also influence money velocity through *GDP* (Benati, 2020; Mennuni, 2023; Sharma & Syarifuddin, 2019). It is because the level of money velocity can also be affected by various payment instruments that change people's behaviour in transactions (Jiang & Shao, 2020). Through observation of data sourced from Bank Indonesia publications, it is shown that there is also a phenomenon where, during the 2012-2020 period in Indonesia, the use of cash and non-cash instruments continued to increase. However, money velocity dominantly tends to move slower than the average speed.

The analysis of money is quite critical and interesting in economics. Compared to money, the discussion of money velocity (hereafter *MV*) is no less critical (Dong & Gong, 2014). Through Irving Fisher's Quantity Theory of Money, *MV* can be measured by the ratio of *GDP* to money supply, and it is not considered constant. Thus, *GDP* and money supply changes can directly affect *MV* (Sharma & Syarifuddin, 2019). Through *GDP*, *MV* provides a picture of goods and services transaction activities between economic actors. Several studies explore money velocity and prove that money velocity will be affected by external shocks such as interest rates, per capita income, money growth volatility, and inflation (Ardakani, 2022; Benati et al., 2021; Chen & Siklos, 2022; Nunes et al., 2018; Oyadeyi, 2024). However, the shock that occurs in money velocity is not only caused by these macroeconomic variables, but money velocity also responds to various structural changes, one of which is the escalation of payment system efficiency (Mele & Stefanski, 2019).



Source: Indonesian Central Bank and Central Bureau of Statistics (CBS) of Indonesia, 2010-2020
Note: CY=Currency; DAC= debit cards (ATMs); CC=Credit Card; EM=Electronic Money; MV=Money Velocity

Figure 2. Currency, Nominal Transactions of Debit Cards (ATMs), Credit Cards, and Electronic Money in Indonesia (billion rupiahs) and Money Velocity M1 (spins) 2012-2020

A practical payment system facilitates the smooth flow of economic activity by reducing transaction costs and increasing convenience, thereby increasing transaction volumes (Bachas et al., 2021; Brown et al., 2022; Qamruzzaman & Jianguo, 2017). As the intensity of transactions and the amount of money in circulation increase, it is only natural that money will circulate even faster. The prevailing payment system in Indonesia uses cash and non-cash instruments in economic activities. Cash payments use currency. Using less currency in transactions accelerates *MV* (Miskhin, 2010). Based on the data collected, debit cards (ATMs), credit cards, and electronic money are the most popular non-cash payment instruments for non-cash payment systems. Figure 2 illustrates the development of cash and non-cash payments in Indonesia during 2012-2020.

Sharma & Syarifuddin (2019) revealed that Indonesia is currently facing issues in the financial sector, including financial innovation and a cashless society, and these issues are expected to affect the money velocity in Indonesia. Figure 2 shows that currency, debit cards (*ATMs*), credit cards, and electronic money have an increasing trend. Electronic money tends to increase steadily, but since 2017, the nominal increase in electronic money transactions has been rapid. Compared to the other three payment instruments, debit cards (*ATMs*) have an enormous nominal transaction volume. Most of the money velocity during the period moved more slowly and did not have an increasing trend. The decline in transactions with non-cash instruments seen from 2020Q1 to 2020Q2 was due to the COVID-19 pandemic.

Research on innovation in finance and its relationship to money velocity has been conducted by several researchers, including Akinlo (2012), Jung (2017), Nampewo & Opolot (2016), and Tule & Oduh (2016). These studies underlined that developments in finance generate a higher *MV*. However, Hermawan et al. (2024) and Li et al. (2024) demonstrated that the existence of digital money such as Bitcoin and Central Bank Digital Currencies (*CBDCs*) decreases *MV*.

Bitcoin tends to be speculative, and *CBDCs* are often stored rather than actively used for consumption. Their research examines financial innovation through proxies such as mobile money, broad money, digital money, and *M*2 multiplier. Meanwhile, this study will use Indonesia's most used payment instruments: cash, electronic money, debit cards (*ATMs*), and credit cards.

From the previous description, it can be analysed that Indonesia has experienced developments in the payment system, especially in non-cash payments, whose use shows an increasing trend. There is a possibility of increasing the size of economic activity, as measured by *GDP,* through efficient payments (Shahbaz et al., 2017; Sreenu, 2020) in the economy. Money velocity is expected to increase with innovations in the payment system (Rehman et al., 2023). For this reason, this empirical research will investigate non-cash and cash payments and how these two payment methods affect money velocity, particularly in Indonesia. These two payment mechanisms, namely cash and non-cash payments, must be considered. Although non-cash payments have proliferated in Indonesia, cash payments using currency have not been abandoned (Acedański et al., 2024). Therefore, it is necessary to investigate the dynamic influence.

Furthermore, this study will analyse the money velocity in three different models. First, how is nominal *MV* affected by the velocity of cash and non-cash payment instruments in nominal terms? Second, how real *MV* (the velocity of money adjusted to the price level where the real money balance element is included in the model) is affected by cash and non-cash payment instruments, which are also in real terms. Third, how nominal *MV* is affected by the number of cash and non-cash payment instruments (in the form of the ratio of both payment system instruments to *GDP*). This research is supposed to contribute to the literature related to the velocity of money.

Methods

The scope of this study includes the independent variables: monetary base (*M*0), currency, debit cards (*ATMs*), credit cards, electronic money, and trade openness. In contrast, the dependent variable is money velocity. The data used in this research were collected from the Central Bureau of Statistics (*CBS*) of Indonesia and the Indonesian Central Bank in quarterly form for 10 years, from 2012 to 2020.

This empirical research uses a quantitative approach, employing an error correction model (*ECM*). *ECM* assumes that cointegrated economic variables will experience error correction in the next period if there is an imbalance in the current period. This means that they can return to the equilibrium position. This study uses *ECM* because variables are not expected to affect the short term directly, but their impact can occur in the long term. Moreover, the behavior of economic actors in holding money is different, so a *time lag* is also needed to observe differences in individual behavior towards money. In addition, examining the behavior of the data, it appears that *ECM* can be employed as one of the dynamic models in investigating the *MV* in Indonesia. The critical reason is that *ECM* can overcome the usual problems in time series data, such as the observed non-stationary variables and spurious regression results.

Before estimating the *ECM* model, several prerequisite tests must be met. This ensures the *ECM* method is suitable and valid for solving the issues. Therefore, this study starts by demonstrating descriptive statistics to provide a concise overview of the data used before the specific tests are conducted. Furthermore, the validity of the research model is continued by showing classical assumption tests such as normality, autocorrelation, heteroscedasticity, and multicollinearity. The sequences of testing stages that must be carried out are (a) Stationarity test using the Augmented Dickey-Fuller test; (b) Cointegration test with residual-based test method; (c) Specification of Error Correction Term (*ECT*) value; and (d) Short and long run estimation with *ECM*.

The determination of variables used in this study follows the quantity theory of money developed by Fisher (1911), which has become an underlying tool often used in monetary analysis, especially in analysing the money velocity and transactions of goods and services. $MV = PT$ became the equation of Irving Fisher's quantity theory of money. *M* is defined as the money supply. *V* is the money velocity, the money supply in the narrow type, or *M*1. The reason is that *M*1, which consists of currency and demand deposits, has a high level of liquidity compared to *M*2, so its use for transactions will be readily accessible. The behaviour of the money velocity can be verified from the Fisher equation, namely $MV = \frac{PT}{M}$ or $MV = \frac{Y}{M}$. What we need to consider is the condition where the available money is not only paper and coin, but also money in electronic form. For this reason, this study will use cash and non-cash variables along with other variables in the form of trade openness.

This study will develop three different models to explain the velocity of money flows. First, the money velocity will be presented by the following nominal model:

$$\frac{Y}{M_1} = f\left(\frac{Y}{CY}, \frac{Y}{DAC}, \frac{Y}{CC}, \frac{Y}{EM}, TO\right), \text{ or}$$
$$MV_1 = f(cy, dac, cc, em, TO) \quad (1)$$

The equation demonstrates how different types of money, namely cash (*CY*), debit cards in terms of *ATMs* (*DAC*), credit cards (*CC*), electronic money (*EM*), and trade openness (*TO*) explain the velocity of money circulation *M*1. Trade openness is obtained from $\frac{X+M}{GDP}$. *X*, *M*, and *GDP* are the sum of oil and gas, non-oil and gas exports, imports, and gross domestic products. The equation/model is still in nominal form. The second model will consider the element of inflation in the model, resulting in a new equation, namely:

$$\frac{Y}{M_1/_P} = f\left(\frac{Y}{CY/_P}, \frac{Y}{DAC/_P}, \frac{Y}{CC/_P}, \frac{Y}{EM/_P}, \frac{X+M/_P}{GDP}\right), \text{ or}$$
$$VM_{1P} = f(cy_P, dac_P, cc_P, em_P, to_P) \quad (2)$$

Where *P* is the inflation rate, by including the element of inflation, it is expected to provide a picture of the money velocity in real terms, where $M1\ /\ P$ is the real money balance. This study will also create a third model that shows the ratio of cash, non-cash money, and trade to *GDP*. The third model can be written as:

$$MV_1 = f(^{CY}/_{GDP}, ^{DAC}/_{GDP}, ^{CC}/_{GDP}, ^{EM}/_{GDP}, ^{X+M}/_{GDP}) \text{ or}$$
$$MV_1 = f(CY_{GDP}, CY_{GDP}, CY_{GDP}, EM_{GDP}, TO) \quad (3)$$

Based on the function equations for the three models, the economic model can be transformed into an econometric model, which provides an overview of the long-term relationship, namely:

Model 1. $MV_{1t} = \beta_0 + \beta_1 cy_t + \beta_2 dac_t + \beta_3 cc_t + \beta_4 em_t + \beta_5 TO_t + \varepsilon_t$ (4)
Model 2. $MV_{1t} = \beta_0 + \beta_1 cy_{Pt} + \beta_2 dac_{Pt} + \beta_3 cc_{Pt} + \beta_4 em_{Pt} + \beta_5 to_{Pt} + \varepsilon_t$ (5)
Model 3. $MV_{1t} = \beta_0 + \beta_1 CY_{GDPt} + \beta_2 DAC_{GDPt} + \beta_3 CC_{GDPt} + \beta_4 EM_{GDPt} + \beta_5 TO_t + \varepsilon_t$ (6)

where β_0 is the intercept, while β_1, β_2, β_3, β_4, and β_5 are regression coefficients (as parameters). Furthermore, to examine the short-term relationship of the variables observed in this study, the equation above can be reformulated in an *ECM* form as follows (Engle & Granger, 1987):

Model 1. $\Delta MV_t = \gamma_0 + \gamma_1 \Delta cy_t + \gamma_2 \Delta dac_t + \gamma_3 \Delta cc_t + \gamma_4 \Delta em_t + \gamma_5 \Delta TO_t + \gamma_6 cy_{t-1} + \gamma_7 dac_{t-1} + \gamma_8 cc_{t-1} + \gamma_9 em_{t-1} + \gamma_{10} TO_{t-1} + \gamma_{11}(cy_{t-1} + dac_{t-1} + cc_{t-1} + em_{t-1} + to_{t-1} - MV_{t-1}) + \varepsilon_t$ (7)
Model 2. $\Delta MV_{Pt} = \gamma_0 + \gamma_1 \Delta cy_{Pt} + \gamma_2 \Delta dac_{Pt} + \gamma_3 \Delta cc_{Pt} + \gamma_4 \Delta em_{Pt} + \gamma_5 \Delta TO_{Pt} + \gamma_6 cy_{Pt-1} + dac_{Pt-1} + \gamma_8 cc_{Pt-1} + \gamma_9 em_{Pt-1} + \gamma_{10} TO_{Pt-1} + \gamma_{11}(cy_{Pt-1} + dac_{Pt-1} + cc_{Pt-1} + em_{Pt-1} + to_{Pt-1} - MV_{Pt-1}) + \varepsilon_t$ (8)
Model 3. $\Delta MV_t = \gamma_0 + \gamma_1 \Delta CY_{GDPt} + \gamma_2 \Delta DAC_{GDPt} + \gamma_3 \Delta CC_{GDPt} + \gamma_4 \Delta EM_{GDPt} + \gamma_5 \Delta TO_t + \gamma_6 CY_{GDPt-1} + DAC_{GDPt-1} + \gamma_8 CC_{GDPt-1} \gamma_9 EM_{GDPt-1} + \gamma_{10} TO_{t-1} + \gamma_{11}(CY_{GDPt-1} + DAC_{GDPt-1} + CC_{GDPt-1} + EM_{GDPt-1} + TO_{t-1} - MV_{Pt-1}) + \varepsilon_t$ (9)

Where, ΔMV is the change in velocity of money in period *t*. The variable ΔX_t or independent variable is the change in the independent variable in period *t*. Meanwhile, X_{t-1} is the lags of the independent variable. $\gamma 0$ is the intercept, while γ_1, γ_2, γ_3, γ_4, γ_5, γ_6, γ_7, γ_8, and γ_9 are the regression coefficients of Error Correction Term (ECT).

Results and Discussion

Descriptive Statistics

Table 1 displays the descriptive statistics of each variable used in this study. The average values of MV_1 and MV_{1P} are not different during the study period, 2012Q1-2020Q4, with 2,661 and 2,862 spins, respectively. When the nominal and real money velocity of all payment instruments is compared, on average, electronic money circulates very quickly, and debit cards (*ATMs*) and *M*1 have a very weak speed. However, debit cards (*ATMs*) have the highest ratio to Indonesia's GDP. Meanwhile, electronic money has the lowest ratio to *GDP*. This suggests that debit cards (*ATMs*) are more widely used in transactions in Indonesia, hence their ratio to *GDP* is also significant, at 43.29 percent. The low speed of rotation of real *DAC* and nominal *DAC*, which amounted to 2.32 and 2.48, respectively, can be caused by the large amount of money in the form of debit cards (*ATMs*) available, causing debit cards (*ATMs*) to circulate more slowly.

Table 1. Descriptive Statistics of All Variables Observed (Period 2012Q1-2020Q4)

Variable	Unit	Mean	Max	Min	Std. Dev	Frequency (in Time)		Total Frequency (%)
MV_1	spins	2.661	2.940	2.117	0.195	7	'12Q1, '13Q3, '14Q1Q3Q4, '15Q1, '16Q3	19.4
MV_{1P}	spins	339.05	418.41	223.77	44.18	2	'13Q3Q4	5.6
cy	spins	6.469	7.182	5.169	0.464	7	'12Q1, '13Q3, '14Q4, '15Q1Q2Q3, 16Q1	22.2
cy_P	spins	822.55	1008.28	546.32	101.12	3	'13Q1Q2Q3	8.33
CY_{GDP}	percent	15.538	19.343	13.923	1.182	4	'17Q4, 20Q2Q3Q4	11.1
dac	Spins	2.329	2.959	2.059	0.225	6	'12Q1Q2Q3Q4, '13Q1Q3	16.7
dac_P	spins	296.07	387.84	220.36	42.677	8	'12Q1Q2Q3Q4, '13Q1Q2Q3Q4	22.2
DAC_{GDP}	percent	43.290	48.557	33.788	3.826	4	'18Q4, '19Q1Q2, '20Q4	11.1
cc	spins	46.515	76.585	38.845	8.338	33	All the time, except for '20Q2Q3Q4	91.6
cc_P	spins	5857.5	8046.04	4609.06	779.58	4	'18Q3, 20Q2Q3Q4	11.1
CC_{GDP}	percent	2.198	2.574	1.305	0.282	3	'14Q4, '15Q2Q4	8.33
em	spins	1888.556	6346.680	65.194	1616.931	4	'12Q1Q2Q3, 13Q1	11.1
em_P	spins	242665.4	831732.5	6889.80	212404.0	7	'12Q1Q2Q3Q4, '13Q1Q2Q4	22.2
EM_{GDP}	percent	0.314	1.533	0.015	0.465	7	'19Q2Q3Q4, '20Q1Q2Q3Q4	22.2
TO	percent	35.380	46.922	27.519	5.248	6	'12Q1Q2Q4, '13Q3Q4, '14Q2	16.7
to_P	percent	0.279	0.378	0.2104	0.0419	9	'12Q1Q2Q4, '13Q4, '14Q1Q2Q3Q4	25

Source: Real data and calculations based on the Indonesian Central Bank and Central Bureau of Statistics (CBS) of Indonesia, 2012-2020

Note: MV_1=Velocity of money (*M*1); MV_{1P}= velocity of money M1 real; *cy*=velocity of currency; cy_P=velocity of currency real; CY_{GDP}=ratio currency to *GDP*; dac=velocity of debit cards (*ATMs*) transactions; dac_P=velocity of debit cards (ATMs) transactions real; DAC_{GDP}=ratio of debit cards (*ATMs*) transaction to *GDP*; cc=velocity of credit card transaction; cc_P=velocity of credit card transaction real; CC_{GDP}=ratio credit card transaction to *GDP*; *em*=velocity of electronic money transactions; em_P=velocity of electronic money transactions real; EM_{GDP}=ratio electronic money transaction to *GDP*; *TO*=trade openness; to_P=trade openness real.

Based on the nominal model, from 2012Q1 to 2020Q4, descriptive statistics show that 19 per cent of the nominal *M*1 money velocity data circulate very fast. Then, 22 per cent of banknotes experienced rapid turnover. Sixteen per cent of debit cards (*ATMs*) circulate at a high speed. As for credit cards, 91 per cent circulate at a higher speed. Only 11 per cent of the data has a high velocity for electronic money. In general, it can be concluded that almost all variables had good values at the beginning of the study period, as seen from the frequency table over time.

Classical Assumption Test

Classical assumption tests are essential for identifying whether a model's OLS coefficient estimates are BLUE. The classical assumption tests assess the absence of autocorrelation, multicollinearity, and heteroscedasticity. In addition to the classical assumptions, this paper conducts a normality test to checkwhether the data is normally distributed. The results of the normality test using the Jarque-Bera test show that the data used in this study for the three models applied are proven to be normally distributed, which is reflected in the probability value of the Jarque-Bera test, which is above 0.05. Then, the results of the autocorrelation test using the Breusch-Godfrey *LM*-test indicated no autocorrelation in the models used. It can be seen from the $Obs*R^2$ value that the probability of Chi-Square is greater than the 5% alpha level. White's test is used to detect the presence of heteroscedasticity in the model, with the result that all models have no heteroscedasticity. It is shown from the probability Chi-squared, which is above the 5% alpha level or above 0.05. By using Variance Inflation Factors (*VIF*), the correlation between independent variables in the model can be detected. The test results show no multicollinearity in models 1, 2, and 3, indicated by the centered *VIF* value of all the independent variables being less than 10.

Table 2. Classical Assumption Test Result

Models	Variable	Multicollinearity Test	Normality Test		Autocorrelation Test		Heteroskedasticity Test	
			Jarque-Bera	Prob.	Obs-Squared	Prob.	Obs-Squared	Prob.
Model 1	cy	2.381	0.710	0.701	1.964	0.374	18.470	0.956
	dac	7.326						
	cc	3.315						
	em	7.647						
	TO	2.939						
Model 2	cy_P	7.342	0.092	0.954	3.171	0.204	26.863	0.545
	dac_P	5.897						
	cc_P	6.529						
	em_P	2.157						
	to_P	2.631						
Model 3	CY_{GDP}	2.398	1.456	0.482	0.396	0.820	19.533	0.487
	DAC_{GDP}	2.750						
	CC_{GDP}	3.713						
	EM_{GDP}	3.081						
	TO	2.940						

Notes: Model 1: *MV* and payment instruments in nominal; Model 2: *MV* and payment instruments in real; and Model 3: Ratio of all payment instruments to *GDP*

Stationarity Test

This study employs the Augmented Dickey-Fuller test to examine stationary or non-stationary data. Stationarity of data will prevent spurious regression. Based on Table 3, it can be concluded that all variables are stationary at the first difference level. This implies that all variables have the same direction towards equilibrium conditions in the long term. The unit root test at the level using the Augmented Dickey-Fuller test shows that of the 17 variables used, only three are stationary in-level, namely CC_P, TO_P, and EM_{GDP}. The probability of the three variables being below $a = 5$ %. A unit root test at the level found that not all variables were stationary, and there were still unit root problems; all variables must be transformed into the first difference form so that all variables can be stationary at the same level. It is known from the calculation results that all variables are stationary at the same level, which is at first difference or *I*(1).

Table 3. Augmented Dickey-Fuller Stationarity Test Results Level and 1st Difference

Model	Variable	Level	First Difference	Conclusion
Model 1	MV_1	-2.140 (0.503)	-12.447*** (0.000)	I(1)
	CY	-1.924 (0.618)	-15.146*** (0.000)	I(1)
	DAC	-3.165 (0.107)	-4.375*** (-0.007)	I(1)
	CC	-2.226 (0.460)	-5.363*** (0.000)	I(1)
	EM	-2.553 (0.302)	-6.757*** (0.000)	I(1)
	TO	-2.972 (0.154)	-8.565*** (0.000)	I(1)
Model 2	MV_{1P}	-0.673 (0.838)	-6.578*** (0.000)	I(1)
	cy_P	-0.679 (0.837)	-6.631*** (0.000)	I(1)
	dac_P	-0.728 (0.825)	-6.763*** (0.000)	I(1)
	cc_P	-7.062*** (0.000)	-6.366*** (0.000)	I(1)
	em_P	-0.998 (0.741)	-6.434*** (0.000)	I(1)
	to_P	-6.048*** (0.001)	-6.222*** (0.000)	I(1)
Model 3	MV_1	-2.140 (0.503)	-12.447*** (0.000)	I(1)
	CY_{GDP}	-1.536 (0.794)	-14.950*** (0.000)	I(1)
	DAC_{GDP}	-3.203 (0.100)	-4.670*** (0.003)	I(1)
	CC_{GDP}	-2.440 (0.354)	-7.360*** (0.000)	I(1)
	EM_{GDP}	-3.769** (0.034)	-3.829** (0.027)	I(1)
	TO	-2.972 (0.154)	-8.565*** (0.000)	I(1)

Notes: Entries in ***, **, * are significant at 1%, 5%, and 10% confidence levels, respectively.

Cointegration Test

Table 4. Cointegration Test Results

Model	adj. t-Stat	Prob.*
Model 1	-4.220	0.001
Model 2	-8.005	0.000
Model 3	-6.183	0.000

The cointegration test can be recognized by testing the stationarity of the residuals generated from the long-term equation model, also known as the method of residual-based test using the Phillips-Perron test. Cointegration occurs when the residual is stationary at the level. Table 4 shows that the residual test results of the research models used are stationary and significant at the level because the probability value is below *a* = 5%. For this reason, it can be interpreted that there is a cointegration or long-term relationship in the *ECM* model, and the method can be continued.

Error Correction Model (ECM)

Following the primary purpose of this study, *ECM* is employed to estimate the short-term and long-term effects of the independent variables on the dependent variable of this study. The test results for the short term can be represented in Table 5. Furthermore, Table 5 shows the results of the statistically significant *ECT* regression coefficient with a probability value of 0.000, 0.000, and 0.001, respectively, for model 1, model 2, and model 3. Moreover, the coefficient of *ECT* has a negative value. This indicates that the result of the *ECM* model used in this empirical research is valid. The coefficient of *ECT* will determine the speed at which equilibrium can be re-achieved.

Table 5. Short-term Estimation Results

Model 1	Coefficient (Prob.)	Model 2	Coefficient (Prob.)	Model 3	Coefficient (Prob.)
C	-0.452 (0.536)	C	-0.052 (0.451)	C	-0.470 (0.526)
Δcy	0.188*** (0.009)	$\Delta \boldsymbol{cy_P}$	0.465*** (0.000)	$\Delta \boldsymbol{CY_{GDP}}$	-0.067** (0.017)
Δdac	-0.003 (0.995)	$\boldsymbol{\Delta dac_P}$	-0.495* (0.056)	$\Delta \boldsymbol{DAC_{GDP}}$	-0.0028 (0.865)
Δcc	-0.007 (0.238)	$\boldsymbol{\Delta cc_P}$	0.013** (0.026)	$\boldsymbol{\Delta CC_{GDP}}$	0.140 (0.450)
Δem	9.931** (0.015)	$\boldsymbol{\Delta em_P}$	0.000*** (0.000)	$\Delta \boldsymbol{EM_{GDP}}$	0.023 (0.915)
ΔTO	-0.004 (0.560)	$\boldsymbol{\Delta to_P}$	-0.004 (0.833)	ΔTO	-0.004 (0.560)
cy(-1)	0.026 (0.769)	$\boldsymbol{cy_P}$(-1)	0.036 (0.609)	$\boldsymbol{CY_{GDP}}$(-1)	0.008 (0.831)
dac(-1)	0.092 (0.624)	$\boldsymbol{dac_P}$(-1)	-0.049 (0.8314)	$\boldsymbol{DAC_{GDP}}$(-1)	0.005 (0.472)
cc(-1)	-0.001 (0.861)	$\boldsymbol{cc_P}$(-1)	-0.002 (0.8427)	$\boldsymbol{CC_{GDP}}$(-1)	-0.032 (0.814)
em(-1)	-1.771 (0.510)	$\boldsymbol{em_P}$(-1)	4.071 (0.918)	$\boldsymbol{EM_{GDP}}$(-1)	-0.032 (0.605)
TO(-1)	0.004 (0.382)	$\boldsymbol{to_P}$(-1)	0.040 (0.133)	TO(-1)	0.006 (0.232)
ECT (-1)	-0.997*** (0.000)	ECT(-1)	-1.050*** (0.000)	ECT(-1)	-0.864*** (0.001)

Notes: ***, **, * indicate significant at 1%, 5%, and 10% confidence level.

The cointegration test results show the existence of cointegration, which indicates a long-term relationship in the model, so the long-term estimates for model 1, model 2, and model 3 is shown in Table 6. In the long and short run, the *MV* of both nominal and real currency (*CY*) positively and significantly influences the *MV* of *M*1. The currency is part of the money in the narrow sense (*M*1). For this reason, the faster the currency circulates, the faster *M*1 rotates. This result is supported by Khavgpom's (1967) and Aggarwal et al. (2024) findings. They underlined that the currency could spur an increase in *MV* through increased consumption and productive investment.

Meanwhile, the estimation results of the ratio of the currency to *GDP* have a negative and significant relationship with the *MV* in both the long-term and short-term. When the ratio of the currency to *GDP* increases, it means that more currency is in circulation compared to the economic activity that occurs. If the amount of money in the economy rises without a corresponding increase in economic activity, the currency tends to settle and is not actively used for transactions. This condition indicates that the greater the ratio of the currency to *GDP*, the slower the rotation of *M*1 will be. This result is consistent with Irving Fisher's quantity theory of money, which states that the money supply and the velocity of money are negatively related. An increase in the amount of currency can reduce *MV*.

Table 6. Long-term Estimation Results

Model 1	Coefficient (Prob.)	Model 2	Coefficient (Prob.)	Model 3	Coefficient (Prob.)
C	1.862*** (0.000)	C	-0.148 (0.528)	C	3.417*** (0.000)
cy	0.229*** (0.000)	cy_P	0.541*** (0.000)	CY_{GDP}	-0.086*** (0.000)
dac	-0.325** (0.046)	dac_P	-0.676*** (0.005)	DAC_{GDP}	0.002 (0.714)
cc	0.005* (0.087)	cc_P	0.013** (0.037)	CC_{GDP}	0.145 (0.120)
em	5.711** (0.016)	em_P	0.0001*** (0.001)	EM_{GDP}	-0.100* (0.056)
TO	0.006 (0.194)	to_P	0.004 (0.595)	TO	0.006 (0.215)

Notes: ***, **, * indicate significant at 1%, 5%, and 10% confidence levels.

Using debit cards (*ATMs*) on the velocity of *M*1 shows a negative and significant effect for both nominal and real models. This implies that an increase in the use of debit cards (ATMs) can trigger the velocity of *M*1 to decrease. Debit cards (*ATMs*) are categorised into the broad money supply (*M*2). Debit cards (*ATMs*) allow individuals to reduce their use of cash and demand deposits. Bachas et al. (2021) explained that low-income people use credit cards to accumulate savings and reduce current consumption. Financial hoarding without using it for productive economic purposes also results in a slowdown of the *MV* (Fu et al., 2021). Credit cards in the real model show that they positively affect money velocity. This can be interpreted as the more often credit cards are used, the greater the *MV*. The results of this study support the statement of Genemo (2021) and Liu & Serletis (2021) that payments using credit cards generate much higher *MV*.

In the short term and long term, electronic money significantly and positively affects the *MV* of the currencies. The more transactions made by using electronic money, the greater the speed at which electronic money circulates, ultimately accelerating the *MV* of *M*1. This finding is supported by Anwar et al. (2024). Electronic money has facilitated easy and fast transactions in the economy. It is now often used for micro-transactions such as payment of parking fees, toll roads, public transportation, and others (Brown et al., 2022). Thus, although the value of electronic money transactions is relatively small, the high frequency of transactions accelerates the overall *MV* of the currencies.

Conclusion

This study explores the effect of cash and non-cash payment systems on money velocity in Indonesia from 2012Q1 to 2020Q4 by applying the Error Correction Model (*ECM*). There are several main conclusions from this research, namely: (1a) in the short run, an increase in the money velocity of nominal and real currency and electronic money causes *MV*1 to increase, meaning that there is a positive and significant relationship, while the speed of circulation of real debit cards (*ATMs*) has a negative and significant effect, increasing the velocity of transactions with debit cards (*ATMs*) in real terms can reduce *MV*1; (1b) in the long run, the velocity of nominal and real currency, credit cards and electronic money has a significant positive effect on *MV*1, while the velocity of nominal and real debit cards (*ATMs*) transactions has a negative and significant impact on *MV*1; (2a) in the short term, the ratio of currency has an adverse effect on *MV*1; (2b) in the long run, the ratio of banknotes and electronic money has a negative and significant impact on *MV*1; (3) trade openness both in the short and long term for the three research models has no considerable effect.

Based on the results of this study, the government can consider the suggestion that banks should introduce innovations and better services in the banking sector to support the public's use of non-cash payments and install more *EDC* machines, especially in areas with limited availability. In general, non-cash payments are essential in determining *MV* in Indonesia. Therefore, the government should pay more attention to *MV* stabilization, especially *NCPI*.

Acknowledgement

Not Applicable

References

Abbas, K., Qasim, M. A., & Khan, A. H. (2014). An Analysis of Monetary Policy in Controlling the Monetary Assets in Pakistan: A Money Multiplier Approach (1971-72 to 1989-90). *The Pakistan Development Review*, *32*(4), 1043-1054. https://doi.org/10.30541/v32i4IIpp.1043-1054

Acedański, J., Maciejewski, G., & Pietrucha, J. (2024). Cash holding by consumers: The role of the perceived characteristics of money. *International Journal of Consumer Studies*, *48*(4). e13075 https://doi.org/10.1111/ijcs.13075

Aggarwal, S., Jeong, D., Kumar, N., Park, D. S., Robinson, J., & Spearot, A. (2024). Shortening the path to productive investment: Evidence from input fairs and cash transfers in Malawi. *Journal of Development Economics*, *170*, 103288. https://doi.org/10.1016/j.jdeveco.2024.103288

Akinlo, A. E. (2012). Financial Development and the Velocity of Money in Nigeria: Akinlo, A. E. (2012). Financial Development and the Velocity of Money in Nigeria: An Empirical Analysis. Review of Finance and Banking, 4(2), 97–113. An Empirical Analysis. *Review of Finance and Banking*, *4*(2), 97–113.

Anwar, C. J., Ayunda, V. T., Suhendra, I., Ginanjar, R. A. F., & Kholishoh, L. N. (2024). Estimating the effects of electronic money on the income velocity of money in Indonesia. *International Journal of Innovative Research and Scientific Studies*, *7*(2), 390–397. https://doi.org/10.53894/ijirss.v7i2.2632

Ardakani, O. M. (2023). The dynamics of money velocity. *Applied Economics Letters*, *30*(13), 1814-1822.

Avdiu, K., & Unger, S. (2022). Predicting inflation—A holistic approach. *Journal of Risk and Financial Management*, *15*(4), 151. https://doi.org/10.3390/jrfm15040151

Bachas, P., Gertler, P., Higgins, S., & Seira, E. (2021). How Debit Cards Enable the Poor to Save More. *Journal of Finance*, *76*(4), 1913–1957. https://doi.org/10.1111/jofi.13021

Benati, L. (2020). Money velocity and the natural rate of interest. *Journal of Monetary Economics*, *116*, 117–134. https://doi.org/10.1016/j.jmoneco.2019.09.012

Benati, L., Lucas, R. E., Nicolini, J. P., & Weber, W. (2021). International evidence on long-run money demand. *Journal of Monetary Economics*, *117*, 43–63. https://doi.org/10.1016/j.jmoneco.2020.07.003

Benk, S., Gillman, M., & Kejak, M. (2010). A banking explanation of the US velocity of money: 1919-2004. *Journal of Economic Dynamics and Control*, *34*(4), 765–779. https://doi.org/10.1016/j.jedc.2009.11.005

Bozkurt, C. (2014). Money, Inflation, and Growth Relationship: The Turkish Case. *International Journal of Economics and Financial Issues*, *4*(2), 309–322.

Brown, M., Hentschel, N., Mettler, H., & Stix, H. (2022). The convenience of electronic payments and consumer cash demand. *Journal of Monetary Economics*, *130*, 86–102. https://doi.org/10.1016/j.jmoneco.2022.06.001

Chen, H., & Siklos, P. L. (2022). Central bank digital currency: A review and some macro-financial implications. *Journal of Financial Stability*, *60*, 100985. https://doi.org/10.1016/j.jfs.2022.100985

Dong, B., & Gong, J. (2014). Velocity of Money and Economic Development in Medieval China: The case of Northern Song. *Review of Development Economics*, *18*(2), 203–217. https://doi.org/10.1111/rode.12079

Durgun, Ö., & Timur, M. C. (2015). The Effects of Electronic Payments on Monetary Policies and Central Banks. *Procedia - Social and Behavioral Sciences*, *195*, 680–685. https://doi.org/10.1016/j.sbspro.2015.06.271

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, *55*(2), 251–276.

Faugere, C. (2024). Velocity of Money and Productivity Growth: Explaining the 2% Inflation Target in the US (1959–2007). *International Journal of Financial Studies*, *12*(1), 15. https://doi.org/10.3390/ijfs12010015 Fisher, I. (2006). *The purchasing power of money: its' determination and relation to credit interest and crises*. Cosimo, Inc.

Fisher, I. (1911). *The purchasing power of money: its' determination and relation to credit interest and crises*. Cosimo, Inc.

Fu, Y., Su, Z., & Guo, Q. (2021). The impact of financial hoarding on economic growth in China. *Sustainability (Switzerland)*, *13*(15). https://doi.org/10.3390/su13158434

Genemo, K. B. (2021). Velocity of Money in Ethiopia. *Macro Management & Public Policies*, *3*(3), 35–41. https://doi.org/10.30564/mmpp.v3i3.3547

Hermawan, D., Lie, D., Sasongko, A., & Yusan, R. I. (2024). Money velocity, digital currency, and inflation dynamics in Indonesia*. *Bulletin of Indonesian Economic Studies*, 1–49. https://doi.org/10.1080/00074918.2024.2398347

Jiang, J. H., & Shao, E. (2020). The cash paradox. *Review of Economic Dynamics*, *36*, 177–197. https://doi.org/10.1016/j.red.2019.09.003

Jung, A. (2017). Forecasting broad money velocity. *North American Journal of Economics and Finance*, *42*, 421–432. https://doi.org/10.1016/j.najef.2017.08.005

Khavgpom, J. D. (1967). Covariations in the currency ratio and the velocity of money in underdeveloped countries. *The Journal of Development Studies*, *3*(3), 293-306. https://doi.org/10.1080/00220386708421228

Li, X., Wu, R., & Wang, C. (2024). Impacts of bitcoin on monetary system: Is China's bitcoin ban necessary? *Research in International Business and Finance*, *69*, 102237. https://doi.org/10.1016/j.ribaf.2024.102237

Liu, J., & Serletis, A. (2022). Credit cards, the demand for money, and monetary aggregation. *Macroeconomic Dynamics*, *26*(8), 2161–2203. https://doi.org/10.1017/S1365100521000262

Luo, S., Zhou, G., & Zhou, J. (2021). The Impact of Electronic Money on Monetary Policy: Based on DSGE Model Simulations. *Mathematics*, *9*(20), 2614. https://doi.org/10.3390/math9202614

Mele, A., & Stefanski, R. (2019). Velocity in the long run: Money and structural transformation. *Review of Economic Dynamics*, *31*, 393–410. https://doi.org/10.1016/j.red.2018.09.004

Mennuni, A. (2023). Money and Credit Coexistence, Excess Capacity, and the Size of Monetary Aggregates. *Journal of Money, Credit and Banking*. *57*(2-3), 477-513.

https://doi.org/10.1111/jmcb.13106

Mishkin, F. S. (2007). *The economics of money, banking, and financial markets* Pearson -Wesley.

Mughal, K. S., Schneider, F. G., Aslam, F., & Tahir, A. (2021). Money Multiplier Bias Due to Informal Sector: An Extension of the Existing Money Multiplier. *South Asian Journal of Macroeconomics and Public Finance*, *10*(2), 139–157. https://doi.org/10.1177/2277978720979888

Nampewo, D., & Opolot, J. (2016). *Financial Innovations and Money Velocity in Uganda*. *28*(4), 371–382.

Nunes, A. B., St. Aubyn, M., Valério, N., & de Sousa, R. M. (2018). Determinants of the income velocity of money in Portugal: 1891–1998. *Portuguese Economic Journal*, *17*(2), 99–115. https://doi.org/10.1007/s10258-017-0141-1

Okedigba, D. O., Akintola, A. A., Umaru, A., Mcdonald, Q. E., Inusa, E. M., Fashoro, B. O., Etudaiye, I. M., Joshua, R., & Osagu, F. N. (2024). Exploring Sub-Saharan Africa's money supply-inflation nexus: A GARCH-MIDAS approach. *Scientific African*, *23*. e02111. https://doi.org/10.1016/j.sciaf.2024.e02111

Ongan, S., & Gocer, I. (2023). Money Supply Determination Process for Japan. *Journal of Central Banking Theory and Practice*, *12*(1), 249–261. https://doi.org/10.2478/jcbtp-2023-0011

Oyadeyi, O. O. (2024). The Velocity of Money and Lessons for Monetary Policy in Nigeria: An Application of the Quantile ARDL Approach. *Journal of the Knowledge Economy*. 1-37. https://doi.org/10.1007/s13132-024-02201-7

Qamruzzaman, Md., & Jianguo, W. (2017). Financial innovation and economic growth in Bangladesh. *Financial Innovation*, *19*(3). 1-24. https://doi.org/10.1186/s40854-017-0070-0

Rehman, M. A., Irfan, M., Naeem, M. A., Lucey, B. M., & Karim, S. (2023). Macro-financial implications of central bank digital currencies. *Research in International Business and Finance*, *64*. 101892. https://doi.org/10.1016/j.ribaf.2023.101892

Salas, S. (2020). Precautionary Money Demand in a Cash-in-Advance Model. *Journal of Money, Credit and Banking*.

Shahbaz, M., Hoang, T. H. Van, Mahalik, M. K., & Roubaud, D. (2017). Energy consumption, financial development, and economic growth in India: New evidence from a nonlinear and asymmetric analysis. *Energy Economics*, *63*. 199–212. https://doi.org/10.1016/j.eneco.2017.01.023

Sharma, S. S., & Syarifuddin, F. (2019). Determinants of Indonesia's Income Velocity of Money. *Buletin Ekonomi Moneter Dan Perbankan*, *21*(3), 323–342.

Sreenu, N. (2020). Cashless Payment Policy and Its Effects on Economic Growth of India: An Exploratory Study. *ACM Transactions on Management Information Systems*, *11*(3). https://doi.org/10.1145/3391402

Tule, M. K., & Oduh, M. O. (2016). Financial innovations and the future of monetary policy in Nigeria. *Economics of Innovation and New Technology*, *26*(5), 453-476. https://doi.org/10.1080/10438599.2016.1229854

Wang, Y. (2023). Long-run Effects of Monetary Policy of China on Its Economic Growth. *The Chinese Economy*, *56*(6), 431–440. https://doi.org/10.1080/10971475.2023.2200662