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DIGITAL PAYMENTS AND REGIONAL FINANCIAL INTERMEDIATION

Arisyi F. Raz

ABSTRACT

The development of information and communication technology (ICT) in the banking sector leads to the proliferation of digital payments. Using Indonesia's sub-national (provincial) banking data, we examine how bank loans and savings respond to digital payments. Our results show that digital payments increase transaction efficiency, boost consumption, and ultimately contribute positively to regional output. Digital payments also provide depositors with various investment options that can be accessed from mobile banking apps, thus increasing these investments while decreasing bank savings. These findings provide insights into the positive effects of digital payments on regional financial intermediation and development.

Keywords :
Digital payments; electronic money; financial intermediation.

JEL Classification : E42, G21, O33

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I. INTRODUCTION

In recent years, the adoption of information and communication technology (ICT) innovation in the banking sector has seen a rapid growth. Theory asserts the importance of technological innovation in the banking sector to ensure competitiveness and help banks improve monitoring and efficiency (Boot & Thakor, 2000; Diamond, 1984). More recent empirical works also support this conjecture. Research suggests that ICT investment helps banks improve their performance, increase their lending, and enhance their stability (Dadoukis et al., 2021; D'Andrea & Limodio, 2024; Silva et al., 2023).

Various recent developments in Indonesian banking sector such as the emergence of FinTechs that disrupts the banking sector as well as the unpredictable external shock of COVID-19 have accelerated the incorporation of ICT in the banking sector. One important aspect of the adoption of ICT in the banking sector is the adoption of electronic money (which includes QRIS, online banking, and internet banking accounts) that enables users to carry out digital payments and transactions. The presence of digital payments allows users to conduct transactions quickly, less costly, and remotely. These benefits are particularly important for Indonesia, a country with geographic diversity and total population of above 270 million people.

Given this backdrop, the researcher aim to examine the effect of digital payments on regional financial intermediation and development in Indonesia's provinces, represented by total outstanding loans and savings at the provincial level. The variation at the sub-national level enables us to exploit Indonesia's provincial heterogeneity and examine geographic impact of digital payments on bank loans and savings. Digital payments, however, may have an endogenous relationship with bank intermediary functions that can lead to simultaneity bias. To address this issue, the researcher instrument the evolution of digital payments using population density. Literature suggests that population density satisfies the exclusion restriction assumption necessary for instrumental variable (IV) estimator because it directly affects the use of digital payments but does not have a

direct impact on bank lending and saving (Allen et al., 2023; Buchak et al., 2018; Choi & Loh, 2023; Erel & Liebersohn, 2022). The researcher therefore complements the ordinary least squares (OLS) model with the IV estimator. Using monthly data of Indonesia's provincial digital payments development between 2020 and 2023, we find that a 1.0% increase in digital payments unit is correlated with 1.9% increase in bank lending. Meanwhile, we find that the introduction of digital payments has a significant and negative impact on savings.

Why do digital payments increase total loans but decrease total savings? The researchers propose two possible channels to explain why digital payments increase total loans but decrease total savings. The first channel is the higher consumption channel. Literature shows that faster and more efficient digital payments, enabled by the availability of electronic money, encourage consumption. (Agarwal et al., 2024; Bounie & Camara, 2020; Choi & Loh, 2023). Higher consumption increases demand for credit and leads to higher bank loans (Dalton et al., 2024). The second channel is the alternative investments channel. The presence of electronic money and digital payments provide savers with more investment options (Thakor, 2020). Because mobile banking and internet banking also offer electronic money and digital payments, these means of transactions are usually connected to investment opportunities offered by banks, such as mutual funds and retail bonds. Owners of electronic money can therefore access these alternative investment options instead of saving their money in time deposits only.

The researcher's empirical tests examine both channels and find that both channels affect financial development. Specifically, digital payments increase provincial output that ultimately expands the demand for bank credit. Similarly, digital payments enable users to seek alternative retail investments instead of simply putting their money in bank deposits, leading to lower overall savings.

The research's relates to two strands of literature. First, the research's is related to a growing literature that studies the effects of ICT in the financial sector. Existing research mostly focuses on FinTechs rather than

banks (Allen et al., 2023; Buchak et al., 2018). Several studies that examine the effects of ICT in the banking sector are those by Scott et al. (2017), which investigate the positive impact of the introduction of the Automated Teller Machine (ATM) in Spanish banks, and D'Andrea & Limodio (2024), which study the effect of the installation of high-speed internet on the interbank market and the real-time gross settlement system (RTGS). In contrast to these studies, the research focuses on the heterogenous effects of the introduction of digital payments on Indonesia's provincial level financial development. The researcher's study is most similar to that of Dalton et al. (2024), which studies the positive impact of electronic payment technology on mobile loans and business stability of small enterprises in Kenya. Instead of focusing on the firm-level, our study exploits Indonesia's subnational variation in examining the impact of digital payments.

Second, the research paper contributes to a small body of research focusing on the development of Indonesian banking sector. Most of the existing research, however, focuses on the impact of prior crises, such as the 1997 Asian financial crisis and the 2008 global financial crisis, on the stability and solvency of the banking sector. Poczter (2016) examines the long-term impact of bank recapitalisation in Indonesia and finds that bank recapitalisation after the 1997 crisis improved lending but also increased long-term bank risk. Shaban & James (2018) show the effect of bank ownership on bank performance and risk in Indonesia. In contrast, the research paper focuses on a new area that is relatively new in the literature, i.e., the impact of digital technology on financial intermediation in Indonesian banking sector.

The researcher highlights several important policy implications. First, financial regulators should continue the development of electronic money and digital payments, thanks to its importance for regional economies, as well as its ability to increase the efficiency of financial intermediation and encourage investments and consumption. Second, the utilisation of electronic money and digital payments is even more crucial in provinces with sparser population and lower income. In these regions, cash transactions can be time consuming, less safe, and costly. By increasing the use of electronic money and digital payments in these regions,

financial regulators can optimise economic potentials in these regions that further reinforces the role of financial intermediation. Third, electronic money and digital payments in provinces with sparser population can improve financial inclusion. This policy has been adopted in various developing countries (Agarwal et al., 2024; D'Andrea & Limodio, 2024). Indonesian financial regulators therefore should consider this approach as one of their policy objectives in improving financial inclusion. Fourth, digital payments contribute to financial deepening by giving its users access to various investment options.

This paper is organised as follows. Section II presents literature review and the development of digital payments system in Indonesia. In Section III, we explain our data and empirical specification. Section IV exhibits our empirical findings and further discussions. Sections V and VI conclude and provide policy recommendations.

II. LITERATURE REVIEW

A. The Introduction of Digital Payments in Indonesia

In its broadest definition, digital payments are payments carried out without the exchange of cash. This can be done through digital or online modes such as credit card, debit card, prepaid card, and other electronic and digital means. The presence of digital payments and electronic money in Indonesia started in 2009, when Bank Indonesia, the central bank issued Bank Indonesia Regulation No. 11/12/PBI/2009 about electronic money. After the issuance of this regulation several large banks in Indonesia started issuing their electronic money in the form prepaid cards. Initially, the use of these prepaid cards is limited to small amount transactions such as parking and tool fee payments. However, the use of these cards slowly expanded to other transactions such as transportation ticket and small amount grocery transactions.

After the launching of the electronic money regulation, Bank Indonesia has been continuously supporting the development of digital payments and electronic transactions in the country. In 2014, it launched

the Non-Cash National Movement (GNNT, 2014), aimed at establishing a secure, transparent, and efficient payment system that relies less on cash. The propagation of digital payments also reduces the costs associated with cash distribution, printing, and maintenance. During this period, most banks in Indonesia have already launched their e-banking or mobile-banking that helped further the utilisation of digital payments. Therefore, debit card, credit card, and other electronic transactions started to flourish in Indonesia, even though cash payments were still a more dominant transaction means.

The movement was soon followed by a presidential decree in 2016 and government regulation in 2019 that encourage further the use of electronic money to increase the number of digital payments. These regulations increase the volume of electronic transactions and digital payments within regional governments as well as electronic social assistance payments.

Another milestone occurred in 2019 when Bank Indonesia launched the Quick Response Code Indonesian Standard (QRIS) that ensures real time and secure electronic transactions. After the release of the QRIS, Bank Indonesia also started requiring all merchants to use the QRIS for payments and transactions.

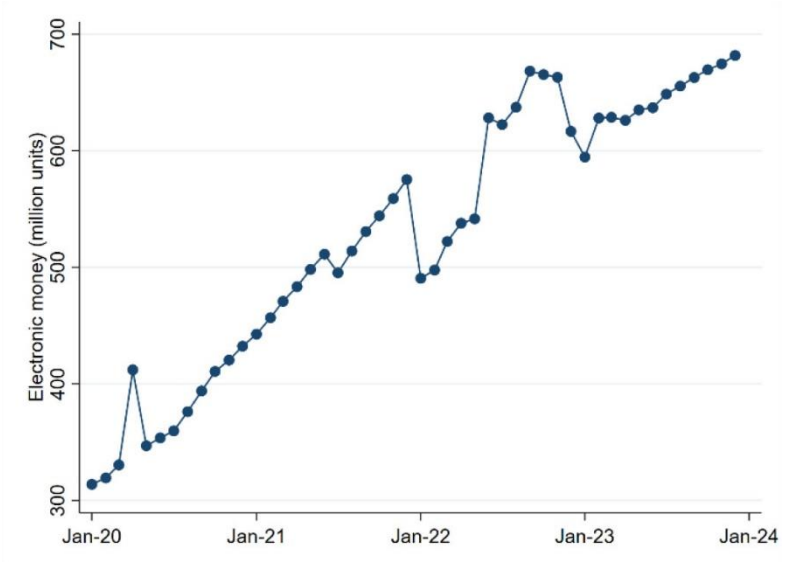

Figure 1. The evolution of electronic money in Indonesia

When COVID-19 struck, the Indonesian banking system was well prepared to ensure the smoothness of the payment system during the pandemic restrictions (via remote or non-cash transactions), thanks to various digital payments regulations and products that have been launched and implemented in the market. Therefore, the pandemic saw a significant increase of electronic money utilisation. Figure 1 shows that the number of electronic money in Indonesia increased from 300 million units in January 2020 to almost 600 million unit by the end of 2022. Bank Indonesia also launched "Indonesian Payment System Blueprint 2025-2030" to further enhance the effectiveness of electronic money and digital payments in Indonesia.

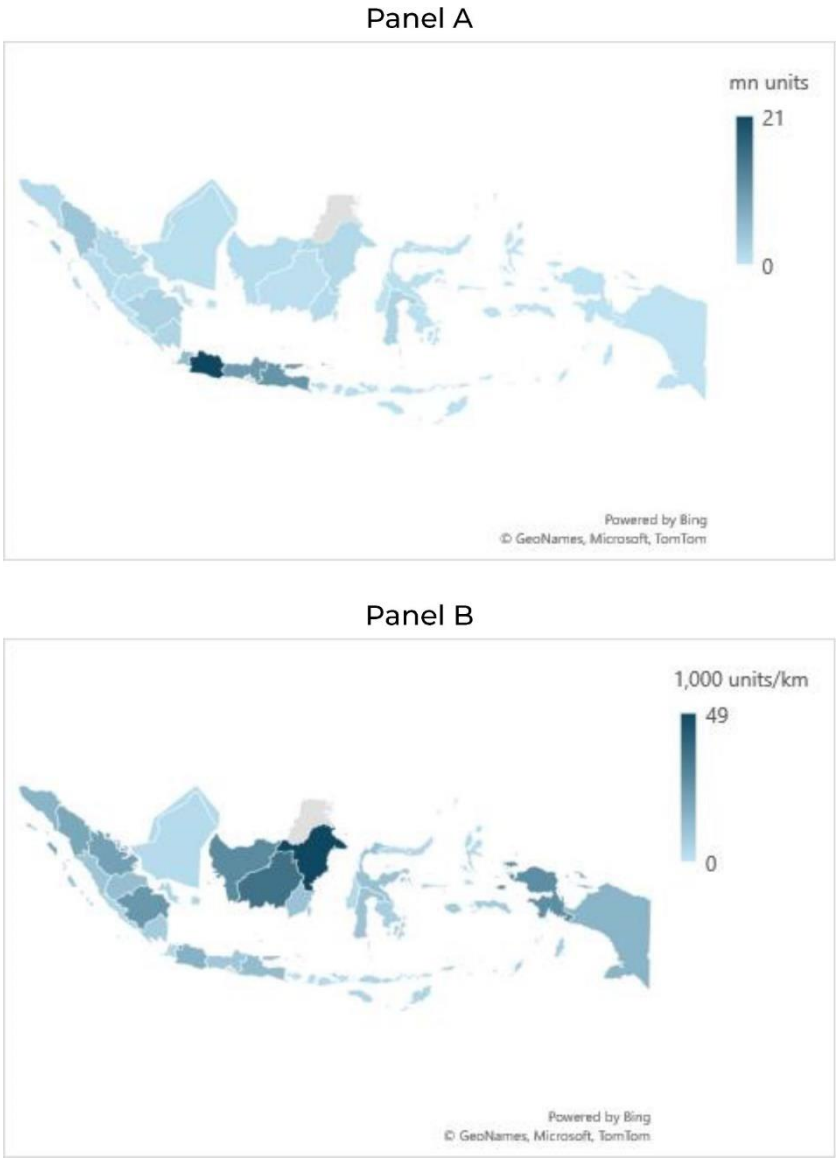

Figure 2. Geographic distribution of electronic money utilisation in Indonesia

Despite the positive trend since its initiation, there is a degree of demographic variation of electronic money development in Indonesia, as shown by Figure 2. Panel A shows that the development of electronic money is concentrated on provinces on Java Island. At first glance, this observation seems intuitive since provinces in Java tend to have the highest nominal gross regional domestic product (GRDP) in the country. Meanwhile, provinces with lower GRDP such as those in Sumatra and Papua Islands tend to have slower development of electronic money growth.

Nevertheless, further investigation shows a more nuanced information. After weighting the number of electronic money using population density, we find that Java, including Jakarta, does not have the highest utilisation of electronic money and digital payments. Instead, geographically larger provinces with sparser population such as those in Kalimantan, Papua, and Sumatra Islands tend to have higher units of electronic money and digital payments per squared kilometre. This evidence suggests that provinces with sparser populations are more likely to have higher number of digital payments. One possible explanation is because people in sparser area are less likely to meet, thus more likely to conduct transactions remotely via the utilisation of electronic money and digital payments. We discuss this economic rationale in more detail in the following subsection.

B. Conceptual Framework

Innovation is an important aspect for financial institutions, particularly banks. Theory suggests that innovation enhances efficiency and bank intermediary functions (Boot & Thakor, 2000). More recent empirical literature is also generally consistent with this theoretical prediction. For example, banks that have adopted more technological innovations tend to charge lower interest rates, thanks to their improved efficiency (Dadoukis et al., 2021; Silva et al., 2023). Innovation also enables banks to reach untapped markets by improving loan access for marginal borrowers, thus increasing credit supply and contributing to financial inclusion (Allen et al., 2023; Erel & Liebersohn, 2022). Literature also shows

that innovative banks tend to be more resilient to external shocks (Saka et al., 2022).

One specific innovation of the banking system that plays a crucial role in improving its performance is the development of digital payments. Prior research suggests that improved payment system lowers operating costs and positively contributes to bank efficiency (D'Andrea & Limodio, 2024). The implementation of digital payments also enables banks to improve their asset-liability management because banks can facilitate payments and create credit in a more effective way (Merrouche & Nier, 2012). Together, these factors suggest that the proliferation of digital payments increase a bank's capacity to undergo its financial intermediary functions. In other words, we hypothesise that:

> ***H1:*** *Digital payments increase bank efficiency and transparency, ultimately improving financial intermediary functions.*

Next, researcher explore the potential mechanisms in which digital payments can affect bank financial intermediation. Prior research shows that people are less attached to electronic money relative to cash, making it easier for them to make payments or purchase items using electronic money (Agarwal et al., 2019; Anagol et al., 2018). People also start thinking that digital payments are easier to carry out relative to cash transactions, prompting them to consume more (Ho et al., 2022). As a consequence, the use of digital payments increases point-of-sale transactions, automatic bill payments, and electronic funds transfers (Agarwal et al., 2024; Bounie & Camara, 2020; Choi & Loh, 2023). The presence of digital payments also alleviates geographic barriers, which benefits people in sparser population or with limited access to financial services.

Meanwhile, higher consumption stimulates economic activities and output, driving entrepreneurs to seek additional funding from the financial sector to finance their business expansion (Anagol et al., 2018; Dalton et al., 2024; Merrouche & Nier, 2012). Simultaneously, higher levels of digital transactions increase bank liquidity, encouraging banks to expand their credit supply (Blickle, 2022; Garber et al., 2024). We therefore propose:

H1a: *Efficient transactions carried out by digital payments increase consumption and economic activities that ultimately prompt banks to increase their credit supply.*

Researcher refer to this hypothesis as the higher consumption channel.

The proliferation of electronic money as a means of carrying out digital payments also increases the options for people with excess funds to invest their money (Thakor, 2020). Digital contents have a profound effect on their users, including altered behaviour and increased adoption (Viard & Economides, 2015). Banks with sophisticated digital payment systems may utilise this factor because their digital payment applications are usually connected to mobile digital investment applications such as mobile trading, offer features that can influence their users to invest more (Grant et al., 2024). Consequently, savers may not only put their money in time deposits, but also look for other alternative investments such as stocks or retail bonds. This is useful for people with limited access to financial services. Without digital platforms, these people need to visit bank branches and make investments by filling various documents. Digital platforms enable the transactions to be conducted quickly using various mobile applications or internet banking. This leads to the following hypothesis:

H1b: *Digital payments and electronic money enable savers to divert their savings to alternative investments because they have access to various investment products via digital platforms.*

Researcher refer to this hypothesis as the alternative investments channel.

Ultimately, which, if any, of these channels–the higher consumption channel, alternative investments channel, or both–affects bank financial intermediary functions is an empirical matter.

III. DATA AND METHODOLOGY

A. Data and Descriptive Statistics

Researcher retrieve monthly, quarterly, and annual data from various sources at the provincial level. Monthly digital payments data are retrieved from Bank Indonesia's Payment System and Financial Market Infrastructure Statistics (PSFMI). The researcher's data focus on the registered amount of electronic money used for digital payments, including chip based, server based, and other registered electronic money. Monthly regional outstanding loans and savings data are retrieved from Financial Services Authority's (OJK) Indonesian Banking Statistics (IBS). Monthly regional inflation and construction index data are retrieved from Statistics Indonesia's Economic Statistics database. Quarterly provincial investment realisation data are collected from Indonesia Investment Coordinating Board (IICB). We also collect quarterly nominal GRDP data and annual population density data from Statistics Indonesia. To ensure linear relationship between the dependent and independent variables, we convert all monetary data into their logarithmic form.

Researcher merge these data and construct a balanced monthly panel containing information on 34 provinces between Jan-2020 and Dec-2023.[1] The merged dataset provides a sample of 1,632 observations. Table 1 exhibits variable definitions and sources.

Table 2 shows descriptive statistics of all variables in each year. Researcher can infer several things from the table. First, bank and other economic variables show a continuous upward trend between 2020 and 2023. Second, the standard deviations of the variables are relatively stable, alleviating the concerns related to heteroskedasticity issue. Nevertheless, researcher use robust standard errors to ensure that the inferences are correct and are not confounded by heteroscedasticity.

[1] Four provinces (South Papua, Central Papua, Highland Papua, and Southwest Papua) have to be dropped due to data unavailability.

Table 1. Variable description

Variable	Definition	Source
Dependent variables		
Loans	Log of total loans	Bank Indonesia
Savings	Log of total savings	Bank Indonesia
GRDP	Log of gross regional domestic product	Statistics Indonesia
Bond market	Log of outstanding retail bonds	Bank Indonesia
Capital market	Log of market capitalisation	OJK
Independent variable (coefficient of interest)		
Digital payments	Log of electronic money used for digital payments, including QRIS as well as online and internet bank accounts.	Bank Indonesia
Control variables		
ATM	Log of ATM transactions	Bank Indonesia
Investment	Log of realized investments within a province	IICB
Inflation	Provincial price indeks	Statistics Indonesia
Construction index	Provincial construction index	Statistics Indonesia
Density	Population density/1000 squared km	Statistics Indonesia
Population	Log of total population	Statistics Indonesia

Table 2. Descriptive statistics

	2020		2021		2022		2023	
Variable	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Loans	11.13	1.19	11.16	1.17	11.25	1.17	11.33	1.17
Savings	10.83	1.31	10.90	1.32	10.98	1.33	11.03	1.33
GRDP	10.98	1.10	11.06	1.10	11.20	1.10	11.27	1.10
Bond market	10.81	0.21	11.37	0.04	11.58	0.02	11.66	0.05
Capital market	15.60	0.06	15.81	0.06	16.03	0.04	16.12	0.07
Digital payments	-1.13	2.80	-0.43	2.77	0.02	2.71	0.01	2.14
ATM	-2.58	2.36	-2.72	2.08	-3.28	1.95	-3.43	1.84
Investment	6.99	1.72	7.28	1.47	7.47	1.37	7.82	1.20
Inflation	0.02	0.01	0.02	0.01	0.04	0.02	0.04	0.01
Construction index	102.5 9	3.90	106.3 7	3.02	106.7 5	2.98	108.4 1	3.19
Density	739.2 4	2672. 11	744.2 6	2684.0 4	751.1 5	2713.8 0	752.6 5	2711.7 2
Population	8.40	1.00	8.41	1.00	8.42	1.00	8.43	1.00

B. Empirical Specification

The researcher's study examines the causal effects of the introduction of digital payments on regional financial development within Indonesia's provinces. To achieve this objective, researcher estimate the following OLS model:

$$y_{r,t} = \beta \cdot digial_{r,t} + \delta \cdot X_{r,t} + \varphi_i + \varphi_t + \epsilon_{r,t}, \quad (1)$$

where $y_{r,t}$ is the outcome of interest (either total loans or total savings) for province *r* in month *t*; $X_{r,t}$ is a vector of province-level covariates; φ_i and φ_t are province and month fixed effects; and $\epsilon_{r,t}$ is the error term. Standard errors are calculated using a robust approach.

Equation (1), however, may suffer from several endogeneity issues. First, digital payments may not be endogenous since it is also affected by the levels of total loans and savings, i.e., simultaneity bias. Additionally, the selection in observables may also lead to omitted variable bias.

Table 3. Pei et al. (2019) **balancedness test**

	(1)	(2)	(3)
Dependent variable:	Investment	Inflation	Construction index
Digital payments	0.0925	0.0001	-0.1241
	(1.01)	(0.13)	(-0.85)
Month FE	YES	YES	YES
Province FE	YES	YES	YES
Observations	1,632	1,632	1,632
R-squared	0.8093	0.7660	0.8839

Note: This table reports results on balancedness test at the country level as outlined by Pei et al. (2019). All explanatory variables are normalised to have mean zero and a standard deviation of one. *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

The researcher therefore carry out several steps to deal with these concerns. First, researcher include province and month fixed-effects to control time-invariant province-specific characteristics that affect bank variables and monthly shocks common to the provinces in our sample, respectively. Second, researcher complement the baseline results with an instrumental variable estimation. Specifically, researcher use population density to instrument digital payments. Literature suggests that population density affects the usage of bank digital platform (Allen et al., 2023; Buchak et al., 2018; Choi & Loh, 2023; Erel & Liebersohn, 2022). However, the opposite relationship is less likely to happen because population density does not evolve as rapidly as that of digital banking services. Additionally, population density does not directly affect bank savings and loans because these variables are more affected by the levels of income and wealth of a region rather than its density. Based on this conjecture, researcher believe that population density satisfies the exclusion restrictions required for instrumental variable (IV) estimation. Third, since the inclusion of control variables may lead to “bad-controls” phenomenon, researcher carry out a balancedness test outlined by Pei et al. (2019). The test aims to detect potential confounding variables by placing our control variables on the left-hand side of the equation instead of the original outcome variables. The researcher then regress each of these control variables on digital payments. Table 3 displays that none of

the balancing regressions show a systematic relationship between digital payments and any of the control variables, thus absence of confounding effects in the model. Later, researcher also conduct a coefficient stability test suggested by Oster (2019) to ensure the robustness of our estimated coefficients.

IV. RESULTS AND DISCUSSIONS

A. Main Findings

Table 4 shows the estimates of Equation (1) using total outstanding loans as the outcome variable. Column 1 displays the OLS results without any control variables. The estimated coefficient is positive and statistically significant at the 1% level. Economically, this implies that 1% increase in digital payments leads to 1.86% higher outstanding bank loans, thus supporting researcher hypothesis. In column 2, researcher estimate Equation (1) by including all control variables. The coefficient of interest remains qualitatively and quantitatively consistent with researcher previous result. Among the control variables, researcher find that both investment and inflation do not significantly affect the outcome variable. In contrast, construction index has a positive and significant effect on bank loans.

Columns 3 and 4 of Table 4 present the estimates of researcher instrumental variable regression with and without control variables, respectively. Similar to researcher previous results, the estimated coefficients are positive and statistically significant in both columns. Nevertheless, the effects the IV results are considerably bigger relative to researcher OLS results. In both regressions, the KB-Paap F-statistics are high and significantly above the 10% critical values of 16.38, implying that population density is a valid instrument for digital payments. Overall, these findings imply that researcher OLS results are slightly downward biased and confirm that the IV results are better than the OLS results.

Provinces in Java are economically and technologically more advanced than other provinces in Indonesia. Figure 2 shows that even

though the absolute value of digital payment utilisation is highest in Java, when weighted according to population density, the utilisation of digital payments in some provinces outside Java becomes more substantial. Due to the distinctive characteristics of the provinces in Java, the inclusion of these provinces may drive researcher main findings. To ensure that researcher results are not driven by the provinces from Java, researcher exclude them and re-estimate Equation (1), reducing the number of observations to 1,344 observations from 1,632 observations. Columns 5-8 of Table 4 present the results. Throughout these cells, the estimated coefficient remains positive and significant, thus corroborating the findings in columns 1-4 of Table 4. This evidence implies that researcher main findings are not driven by the inclusion of observations from Java in the sample.

Next, researcher examine the effects of digital payments development on total savings. Similar to the results in Table 4, researcher start begins the analysis by presenting the OLS results. In column 1 of Table 5, researcher find that digital payments have no significant effect on total savings within a province. When researcher include control variables, the results in column 2 remain consistent. Columns 3 and 4 of Table 5 present the IV regression results. In contrast to researcher OLS results, column 3 shows a negative and statistically significant effect of digital payments on total savings. The estimated coefficient suggests that 1% increase in digital payments usage reduces total savings by 13.27%. The result remains consistent when researcher add control variables in column 4. The KB-Paap F-statistics are also above the 10% critical value threshold of 16.38, thus confirming the validity of our instrument. Similar to our loan regression results, researcher can infer that the OLS results are biased due to the endogeneity of digital payments. In other words, the IV results are preferred to the OLS results.

Researcher also try to exclude Java from the sample and re-estimate the model to ensure that the results are not driven by the unique characteristics of Java. Again, the results in columns 5-8 of Table 5 remain consistent after dropping Java from researcher sample.

Table 4. Digital payments and bank loans

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All samples				Excluding Java			
Dependent variable:	Loans	Loans	Loans	Loans	Loans	Loans	Loans	Loans
Digital payments	0.0186***	0.0192***	0.0566***	0.0373***	0.0196***	0.0202***	0.1419**	0.1448**
	(4.69)	(4.89)	(3.96)	(3.77)	(5.77)	(6.10)	(2.29)	(1.98)
Investment		0.0056		0.0045*		0.0063		-0.0015
		(0.72)		(1.92)		(0.75)		(-0.28)
Inflation		-0.7138		-0.7165***		-0.8024		-0.4862
		(-0.66)		(-2.60)		(-0.64)		(-1.06)
Construction index		0.0088***		0.0092***		0.0086***		0.0121***
		(4.11)		(10.20)		(3.43)		(4.69)
Month FE	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
KB-Paap F-stat			92.460	77.528			13.796	10.386
Observations	1,632	1,632	1,632	1,632	1,344	1,344	1,344	1,344
R-squared	0.9976	0.9977	0.4899	0.4992	0.9934	0.9937	-1.0995	-1.0849

Note: This table reports estimates of Equation 1 using log savings as the outcome variable. Columns 1-4 exhibit the estimates using all sample. Columns 5-8 display estimates by excluding Java. Control variables are log investment, annual inflation rate, and construction index. Variable definitions are reported in Table 1. Standard errors are robust and the corresponding t-statistics are reported in parentheses. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Digital payments and bank savings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All samples				Excluding Java			
Dependent variable:	Savings	Savings	Savings	Savings	Savings	Savings	Savings	Savings
Digital payments	0.0069	0.0062	-0.1327***	-0.1536***	0.0097	0.0105	-0.1003**	-0.1027*
	(0.84)	(0.71)	(-7.58)	(-7.09)	(1.30)	(1.38)	(-2.01)	(-1.72)
Investment		0.0076*		0.0172***		0.0079*		0.0150***
		(1.91)		(5.15)		(1.82)		(3.36)
Inflation		1.8646***		1.8888***		2.4756***		2.1882***
		(3.26)		(6.30)		(4.45)		(6.78)
Construction index		0.0014		-0.0016		0.0034		0.0002
		(0.40)		(-0.92)		(0.99)		(0.09)
Month FE	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
KB-Paap F-stat			92.460	77.528			13.796	10.386
Observations	1,632	1,632	1,632	1,632	1,344	1,344	1,344	1,344
R-squared	0.9985	0.9987	0.4766	0.4629	0.9964	0.9968	-1.2725	-1.1993

Note: This table reports estimates of Equation 1 using log savings as the outcome variable. Columns 1-4 exhibit the estimates using all sample. Columns 5-8 display estimates by excluding Java. Control variables are log investment, annual inflation rate, and construction index. Variable definitions are reported in Table 1. Standard errors are robust and the corresponding t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

To summarise, the researcher's empirical examination shows that the utilisation of digital payments increases bank loans but reduces bank savings. Further analysis suggests that the OLS results may be biased due to the potential simultaneous relationship between digital payments and financial intermediation variables. The results remain robust after dropping Java from the sample, implying that the findings are not driven by the distinct characteristics of Java as a financial centre.

B. Transmission Mechanism

Now, the researcher turn the analysis into examining the transmission mechanisms. The researcher's conceptual framework suggests that digital transactions can improve financial intermediation through higher efficiency. To test this, researcher examine the correlation between digital transactions and net interest margin (NIM). Literature suggests that more efficient banks tend to have lower NIM (Trinugroho et al., 2014). The researcher therefore expected a negative correlation between NIM and digital transactions. The results shown in Equation (2) below show the coefficient of digital transactions is negative with *t*-value of 3.87 (significant at the 1% level), thus confirming the strong association between digital transactions and bank efficiency.

$$NIM = -\widehat{1.79} \cdot digital - \widehat{0.02} \cdot \log assets - \widehat{0.22} \cdot rate^{deposits} + \widehat{0.26} \cdot rate^{loans} + \widehat{0.01} \cdot NPL + \widehat{0.05} \cdot securities \quad (2)$$

Next, researcher focus on the individual channel that can affect bank loans and savings. First, researcher examine how digital payments can increase bank loans via higher consumption. Specifically, the proliferation of digital payments increases transactions efficiency that ultimately leads to higher consumption and economic growth. Indonesia's economic growth is primarily driven by consumption growth, and digital financial services play an important role in boosting consumption in the country (Chen et al., 2023). To test this channel, researcher examine the effect of digital payments on GRDP. Because GRDP data are only available quarterly, researcher modify the frequency of the sample from monthly to quarterly, resulting in a balanced sample containing 544 observations.

Column 1 of Table 6 presents the results. The researcher's regress GRDP on digital payments and find a positive and significant impact of digital payments on GRDP. Economically, researcher find that 1% increase in digital payments increases GRDP by 1.71%. This evidence therefore supports the presence of higher consumption channel.

Table 6. The effect of digital payments on regional output, bond market, and capital market

	(1)	(2)	(3)
Dependent variable:	GRDP	Bond market	Stock market
Digital payments	0.0171**	0.1873***	0.1061***
	(2.48)	(4.08)	(4.78)
Investment	0.0035	0.0467***	0.0210**
	(0.59)	(3.36)	(2.25)
Inflation	0.5299	1.2570	3.3431***
	(1.15)	(1.64)	(7.93)
Construction index	0.0041*	0.0698***	0.0374***
	(1.84)	(11.04)	(11.73)
Quarter FE	YES	YES	YES
Province FE	YES	YES	YES
Observations	544	544	544
R-squared	0.9984	0.7524	0.7656

Note: This table reports estimates of Equation 1 using log GRDP, log ORI, and log market cap as the outcome variables. Control variables are log investment, annual inflation rate, and construction index. Variable definitions are reported in Table 1. Standard errors are robust and the corresponding t-statistics are reported in parentheses. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Finally, how digital transactions can reduce savings, i.e. researcher investigate the alternative investments channel. As mentioned in the conceptual framework, electronic money can be activated by downloading mobile banking apps or utilising internet banking. These apps usually connect the user's saving account to their investment accounting, improving the convenience of making investments online. In Indonesia, many banks have enabled the purchase of various investments products via mobile banking apps or internet banking such as retail bonds such as

ORI and SUKUK retail bond series, mutual fund products, or even stocks if a bank has a securities company subsidiary or sister company. The researcher therefore retrieve outstanding retail bond data from Bank Indonesia and stock market capitalisation data from OJK as proxies for alternative investments. Then, we use these variables as the outcome variables in our model.

The results are shown in columns 2 and 3 of Table 6. Column 2, which uses the logarithmic form of the outstanding retail bond as the dependent variable, shows that the coefficient of interest is positive and statistically significant at the 1% level. In column 3, the researcher conduct a similar estimation using stock market capitalisation as the outcome variable. Similarly, the coefficient of interest is positive and significant. Together, these findings suggest that alternative investments in the capital market, namely bond and stock markets, are positively affected by the introduction of digital payments. This also potentially explains the negative effect of digital payments on bank savings because there is a shifting of excess of funds from the banking sector to other investment options, thus confirming the presence of alternative investments channel.

C. The Effect of Per Capita Income

So far, researcher results show the significant effect of digital payments on bank loans and savings. However, the effect may differ in high-income and low-income provinces. Prior research suggests that the impact of digital payments is more profound in low-income regions because people in these regions usually work in the informal sector and have limited access to the financial services (such as bank branches and automated teller machines) (Agarwal et al., 2024). In contrast, high-income provinces usually have better access to financial services, thus the contribution of digital payments may relatively be smaller.

Table 7. The impact of digital payments in high-income and low-income provinces

	(1)	(2)	(3)	(4)
	High-income		Low-income	
Dependent variable:	Loans	Savings	Loans	Savings
Digital payments	-0.3191	0.5239	0.0429***	-0.0864***
	(-0.55)	(0.54)	(3.48)	(-5.37)
Control variables	YES	YES	YES	YES
Month FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Observations	816	816	816	816
R-squared	0.6676	0.7316	0.6403	0.5096

Note: This table reports estimates of Equation 1 using log loans and log savings as the outcome variables by splitting the sample based on provincial income per capita. Columns 1-2 exhibit the estimates using low-income sub-sample. Columns 3-4 display estimates using high income sub-sample. The unreported control variables are log investment, annual inflation rate, and construction index. Variable definitions are reported in Table 1. Standard errors are clustered at the province level and the corresponding t-statistics are reported in parentheses. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1%, 5%, and 10% levels, respectively.

To test this conjecture, researcher split the sample into high-income and low-income provinces based on the median of monthly GRDP per capita data. The researcher then estimate the baseline model using the split samples. Table 7 presents the results. Overall, the researcher find no significant impact of digital payments and savings in high-income provinces. In contrast, the effect of digital payments is statistically significant in low-income provinces. These findings support the researcher's conjecture that the effects of digital payments are driven by higher levels of transactions in low-income provinces.

D. Robustness Checks

The researcher conduct several robustness checks to ensure the consistency of the main findings. As mentioned in Section III, the researcher conduct the stability of the estimated coefficients using the test proposed by Oster (2019). According to Oster (2019), omitted variable bias

cannot be examined using sensitivity analysis alone because the size of the bias often depends on the variability of the estimated coefficients that are scaled by the change in *R*-squared. The test therefore tests the variability (or the stability) of the estimated coefficients by constructing parameter bounds based on *R*-squared movements. Following Oster (2019) the researcher tolerate *R*-squared to vary 1.2-1.5 times as the basis of the parameter bounds. The results in Table 8 below show that the estimated coefficients for loans and savings remain stable in both 1.2 and 1.5 parameters, confirming the stability of the estimated coefficients.

Table 8. Coefficient stability test

	No controls		All controls		R^2_{max}		Bounding values	
Specification	$\dot{\beta}$	$\dot{R^2}$	$\dot{\beta}$	$\dot{R^2}$	$\Pi = 1.2$	$\Pi = 1.2$	$\beta^*_{\Pi=1.2}$	$\beta^*_{\Pi=1.5}$
Loans	0.3369	0.578	0.0193	0.998	1.000	1.000	0.0177	0.0177
Savings	0.3585	0.519	0.006	0.999	1.000	1.000	0.005	0.005

Notes: This table estimates coefficient stability using the procedure outlined by Oster (2019). The test assumes that selection on unobservables is proportional to selection on observables and the degree of proportionality between selection on unobservables and selection on observables is one. We use $R^2 = \min(1, \Pi \cdot \widetilde{R^2})$ with $\Pi = 1.2$ as the benchmark. Our more conservative value of $\Pi = 1.5$.

Next, finding a good instrument is one of the biggest challenges of an IV setting. To ensure that the results are not driven by the selection of instrument, the researcher re-estimate the main model using a different instrument. Instead of using population density, researcher use the logarithmic form of total population. Similar to population density, total population satisfies the exclusion restriction assumption of IV estimation.

Table 9 presents the results. Overall, the findings are quantitaitvely and qualitatively consistent with the baseline findings. Additionally, all of the KB-Paap F-statistics are above the 10% critical value threshold and

confirm the validity of the instrument. This evidence confirms that the results are robust and not driven by the selection of instrument.

Table 9. Alternative instrument

	(1)	(2)	(3)	(4)
Dependent variable:	Loans	Loans	Savings	Savings
Digital payments	0.0466***	0.0280*	-0.1365***	-0.1503***
	(2.73)	(1.73)	(-5.12)	(-5.89)
Investment		0.0051**		0.0170***
		(2.06)		(4.85)
Inflation		-0.7151***		1.8883***
		(-2.61)		(6.39)
Construction index		0.0090***		-0.0015
		(9.31)		(-0.80)
Month FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
KB-Paap F-stat	45.125	54.556	45.125	54.556
Observations	1,632	1,632	1,632	1,632
R-squared	0.4493	0.4188	0.4785	0.4612

Note: This table reports estimates of Equation 1 using log loans and log savings as the outcome variable. Control variables are log investment, annual inflation rate, and construction index. Variable definitions are reported in Table 1. Standard errors are clustered at the province level and the corresponding t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Prior research suggests that the adoption of digital payments may be negatively correlated with the closures of ATM (Choi & Loh, 2023). To ensure the results are not confounded by this factor, researcher append the baseline equation by including the logarithmic form of total ATM transactions. The results in Table 10 show that the baseline findings endure.

Table 10. The effect of ATM

	(1)	(2)	(3)	(4)
Dependent variable:	Loans	Loans	Savings	Savings
Digital payment	0.0599***	0.0381***	-0.1588***	-0.2021***
	(3.67)	(2.93)	(-6.94)	(-6.51)
ATM	0.0096***	0.0065***	0.0019	-0.0010
	(4.51)	(3.16)	(0.65)	(-0.28)
Investment		0.0031		0.0160***
		(1.33)		(4.32)
Inflation		-0.7176***		2.1463***
		(-2.60)		(6.85)
Construction index		0.0086***		0.0024
		(9.55)		(1.58)
Month FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
KB-Paap F-stat	45.125	54.556	45.125	54.556
Observations	1,632	1,632	1,632	1,632
R-squared	0.5466	0.5305	0.5653	0.5511

Note: This table reports estimates of Equation 1 using log savings and log deposits as the outcome variable. Control variables are log investment, annual inflation rate, and construction index. Variable definitions are reported in Table 1. Standard errors are clustered at the province level and the corresponding t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Finally, researcher conduct sensitivity analysis by using different fixed efect similar to the exercise carried out by Raz (2023). Instead of using month and province fixed effects, researcher use year and province as well as quarter and province fixed effects. Columns 1-4 of Table 11 present the results of year and province fixed effects, while columns 5-8 show the estimates of quarter and province fixed effects. Overall, the results show that the estimates are consistent with the main findings.

Table 11. Different fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Loans	Loans	Savings	Savings	Loans	Loans	Savings	Savings
Digital payments	0.0566***	0.0336**	-0.1327***	-0.1732***	0.0566***	0.0357***	-0.1327***	-0.1515***
	(3.23)	(2.23)	(-5.66)	(-5.88)	(3.96)	(3.45)	(-8.39)	(-7.57)
Investment		0.0041*		0.0215***		0.0046*		0.0172***
		(1.67)		(4.94)		(1.91)		(4.99)
Inflation		-0.0440		1.1208***		-0.5734**		1.7022***
		(-0.26)		(4.53)		(-2.32)		(5.90)
Construction index		0.0076***		0.0079***		0.0091***		-0.0015
		(9.56)		(4.98)		(10.11)		(-0.89)
Year FE	YES	YES	YES	YES	NO	NO	NO	NO
Quarter FE	NO	NO	No.	NO	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
KB-Paap F-stat	111.635	85.135	111.635	85.135	117.837	87.894	117.837	87.894
Observations	1,632	1,632	1,632	1,632	1,632	1,632	1,632	1,632
R-squared	0.4954	0.4648	0.4832	0.4265	0.4898	0.4867	0.4766	0.4606

Note: This table reports estimates of Equation 1 using log savings and log deposits as the outcome variable. Control variables are log investment, annual inflation rate, and construction index. Variable definitions are reported in Table 1. Standard errors are clustered at the province level and the corresponding t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

V. CONCLUSIONS

Digital payments have been one of the most important innovations in the banking sector. In Indonesia, the proliferation of digital payments can tackle various issues surrounding the effectiveness of financial intermediary functions such as the limited presence of brick-and-mortar bank branches as well as costly cash distribution in some remote areas.

In this paper, the researcher study the effect of digital payments on bank intermediary functions, i.e. total loans and savings at sub-national level. However, identifying the causal effect of digital payments on bank savings and deposits is challenging due to the simultaneous relationships among these variables that can lead to endogeneity bias. The researcher therefore use population density to instrument digital payments.

The empirical findings suggest that higher number of digital payments lead to higher loans and lower savings. Higher number of digital payments result in better transparency as well as faster and more efficient transactions, thus increasing the demand for consumption and stimulating business. This ultimately leads to higher bank loans. In contrast, the utilisation of digital payments and electronic money provide depositors with access to alternative investment options other savings. As a result, it leads to a shift from savings to other investments such as retail bonds and stocks, creating more diversified financial services. The researcher's results are robust to various confounding factors and sensitivity checks.

The findings of researcher paper have several policy implications. First, financial regulators should continue to develop electronic money and digital payment systems, given their importance to regional economies, their ability to increase the efficiency of financial intermediation, and their capacity to encourage investments and consumption. Second, the utilisation of electronic money and digital payments is even more crucial in provinces with sparser population, where cash transactions can be time consuming, less safe, and costly. The use of electronic money, therefore, can help financial regulators optimise regional economic potentials that further reinforce the role of financial institutions and financial system. Third, digital payments can potentially contribute to financial inclusion,

particularly in developing countries with huge population. Finally, digital payments contribute to financial deepening by giving its users access to various investment options. A more granular analysis focusing on different types of digital payments and electronic money is an interesting avenue for future research.

VI. POLICY RECOMMENDATIONS

The researcher propose several policy recommendations based on the findings. First, the promotion of digital payments can be incorporated as part of the National Strategy for Financial Inclusion (SNKI). According to SNKI, the third pillar of financial inclusion is the facilitation of financial intermediaries, products, and distribution. Indeed, according to Coordinating Minister for the Economy's Ministerial Decree No. 4, 2021 about financial inclusion, digital payments and transactions have been included as the main indicators of financial inclusion. The findings of this paper, therefore, can be used to reinforce the importance of these targets. Second, OJK can encourage rural banks (BPR) to adopt digital payments infrastructure more intensively. So far, only a limited number of rural banks have human resources and financial capacity to adopt digital payments. The findings of this study can be utilised to motivate these rural banks to speed up their adoption of digital payments infrastructure considering its significant positive impact on the banks' financial intermediary functions as well as regional economy.

Third, OJK as the financial authority can establish a policy that incentivise non-bank financial institutions (NBFIs) affiliated with banks to link their mobile applications with the banks' digital banking applications. This enables depositors to allocate their excess of funds to other investment options such as insurance products, mutual funds, stocks, etc., that can contribute to financial deepening and develop non-bank financial sector.

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