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PAYMENT SYSTEM INNOVATIONS AND FINANCIAL INTERMEDIATION: THE CASE OF INDONESIA

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Abstract

This paper explores the relationship between innovations in payment systems and financial intermediation. By focusing on excess reserves and the currency demand, we provide evidence on the extant transmission mechanism. In this direction, we applied the generalized method of moments (GMM) and vector error correction model (VECM) techniques to a dataset collated for Indonesia. We found that the currency demand affects financial intermediation whilst observing a limited role of excess reserves in affecting financial intermediation. We discovered that credit card payments have a statistically significant effect on the currency demand, whereas debit card payments only influence financial intermediation in the long run. In addition, the real-time gross settlement (RTGS) exerts upward pressure on excess reserves. The findings are of great importance, as they provide support for policies that favor payment migration to an electronic platform, particularly that of card-based payment systems.

Keywords: payment systems, financial intermediation, excess reserves, currency demand, monetary policy

JEL Classification: E42, E58, N25, G21

Contents

1. INTRODUCTION

Research has defined a payment system as facilitating a settlement between economic agents to complete their transactions. Payment systems serve as the plumbing of the economy (Kahn and Roberds 2009). The significant investment in infrastructure necessary to start the operation (large fixed costs) and the relatively small marginal cost of services provided using the existing infrastructure subject their production to economies of scale (Hasan, Schmiedel, and Song 2013). A massive improvement in technology with the introduction of credit cards, debit cards, automatic teller machines (ATMs), and more recently the Internet has reshaped the way in which people pay.

The authorities see the development of the payment system itself as an opportunity to overcome income inequality by providing the payment infrastructure in remote places, particularly in emerging-market countries (Martowardojo 2015). However, as mentioned previously, the cost of these services is high; more importantly, there is a perception that these payment services may not be sufficiently profitable for the business.

Furthermore, these rapid innovations direct the attention of the monetary authorities to addressing the payment system in the monetary policy decision-making process. The increasing speed, reliability, and financial risks of the payment system may affect the money demand and money supply (Johnson 1998). These developments provide a challenge to the effectiveness of the monetary instruments and the transmission mechanism, which may center on financial intermediation.

Innovations in large-value payment systems enhance the excess reserves of the banking system as well as providing the lending side with liquidity. Furthermore, improvements in the retail payment systems can reduce the use of cash in transactions, which enables banks to utilize the deposit side to the lending side. Given the validity of these premises, we could formulate a set of research questions regarding the impact of payment system innovation in the following manner. First, how does an improvement in payment systems affect currency holdings? Second, what is the impact of customer limitations in the large-value payment system on the relationship between the innovation of the payment system and the loan supply?

Despite its relative importance and recent developments in the field of payment markets, the empirical literature on payments is rather sparse (Kahn and Roberds 2009). In answering these questions, we empirically investigated the underlying relationships by collating data for Indonesia. Being the biggest economy in Southeast Asia, Indonesia needs to take steps toward improving the involvement of the financial sector in the economy. Compared with other countries, Indonesia is relatively new to payment system innovations. Automatic teller machine (ATM) cards were first introduced in 1995, and real-time gross settlement (RTGS) was launched in 2000. As recorded by the World Bank in the World Development Index, only 35.9% of the total population above 15 years old in the country had a bank account in 2014, an increase from only 19.6% in 2011.[1] In addition, the loan to GDP ratio, which suffered its lowest value after the 1997–1998 Asian crisis of 17.34% in Q1-2000, increased to 34.75% in Q2-2017.[2]

[1] Data available online at http://databank.worldbank.org/data/reports.aspx?source=2&country=IDN.

[2] Data from Indonesian Financial Statistics, Bank Indonesia.

A novel element of this paper is that, for the first time, we considered the policies embodied in the payment system, such as the limitation of the value that customers can settle through the large-value payment system. It would have been interesting to incorporate Internet banking data or other forms of telecommunication-based money, such as "Applepay," "Googlepay," or "GoPay" (Indonesia) to complement the analysis, but, due to the lack of availability of such data, we used only card-based transactions, such as ATM/debit and credit cards. In this context, it is possible to argue that telecommunication-based money can be representative of a bank's deposit accounts, since these services usually require a bank account or a debit card.

This paper makes three contributions. Firstly, it provides empirical evidence on how improvements in payment systems affect financial intermediation through excess reserves and currency holdings; secondly, it gauges the impact of limitations in the transaction value in payment systems as a means of reducing uncertainty regarding the payment flows as well as banks' excess reserves; and, thirdly, we demonstrate that reduced currency holdings may increase the loan supply whilst the increasing use of payment technology, such as debit cards and credit cards, contributes to decreasing currency holdings.

The remainder of the paper is organized as follows. Section 2 highlights the literature that has discussed the role of payment systems in financial intermediation, whilst section 3 presents a simple model to examine the role of the payment system in financial intermediation. Section 4 touches on the empirical estimation as well as discussing the evidence generated, and, finally, section 5 provides some concluding remarks.

2. THE ROLE OF PAYMENT SYSTEMS IN FINANCIAL INTERMEDIATION

A payment is a transfer of monetary value that intends to free any liabilities that occur in exchanging goods and services (Kahn and Roberds 2009). In a market economy, economic agents are independent and able to choose any form of payment to settle a transaction. A payment system comprises the instruments, organizations, operating procedures, and information and communication systems used to initiate and transmit payment information from payer to payee and to settle payments (Bank for International Settlements 2001). This payment system ensures the circulation of money; therefore, central banks, as authorities in the issuing of money, are always interested in the smooth running of payment systems.

It is possible to categorize payment systems into two types in terms of their end customers: wholesale payment systems and retail payment systems (Kahn and Roberds 2009). Wholesale payment systems deal with intermediary institutions, such as banks and/or other financial institutions, in the form of a large-value payment system (LVPS). There are two types of LVPS based on their settlement process: i) the gross settlement system, which is settled simultaneously in real time by using a platform called the RTGS; and ii) the clearing system, which operates on the net settlement basis whereby the settlement is performed after netting all the incoming and outgoing payments at the end of the day. The second is the retail payment system that serves the end customers, such as households and firms. This retail payment system contains many forms of payment instruments, including card-based systems such as ATMs and debit and credit cards and digital payment systems such as Internet banking.

The role of the central bank depends on each mandate in the law of the relevant country.[3] This can range from issuing banknotes and currency, providing the settlement operations, and managing collateral and domestic currency reserve accounts.

Hasan, Renzis, and Schmiedel (2013) documented the importance of the payment system to the economy, arguing that innovation in the retail payment system helps to stimulate the overall economy and growth. They derived this proposition from their test of various retail payment instruments, including card payments and cheques. They found that card payments have the largest impact on the economy.

Merrouche and Nier (2009) argued that an improvement in payment system technology encourages the use of banking deposits (inside money) as a payment medium for customers and thus influences the proportions between holding cash (outside money) and holding deposits (inside money). Furthermore, a well-functioning interbank market will provide end-of-day funds. Therefore, this decreases the urgency for banks to maintain a large amount of excess reserves (outside money).

Banks play a major role in providing both financial intermediation and payment services. Hasan, Schmiedel, and Song (2012) pointed out that innovations in retail payment systems have a positive impact on banks' performance through both fee-based income and interest income. The efficiency of payment systems may affect all banks' ability to provide financial services to customers. It may, in turn, affect the ability of banks to accumulate liquidity. By doing so, the interest rates that the bank pays to the customers may change (Merrouche and Nier 2012). However, vast amounts of literature on banking and monetary policies have ruled out the interplay between these two activities. These studies, such as Fuerst (1992), focus on the role of the supply of money (outside money) from the central bank to the banking sector to ensure financial intermediation.

The banking industry is dealing with the nature of liquidity mismatch. On the one hand, banks cannot easily liquidate their lending before maturity. On the other hand, they face liquidity shocks from the deposit withdrawals. Diamond and Dybvig's (1983) influential study presents a discussion of the role of the banking system in the creation of liquidity by taking into consideration short-term deposits and producing long-term investments.

However, this framework does not take into account the role of outside money. It only identifies the disturbance in the behavior of the deposits in the banking system (inside money). The framework for the conversion from inside money to outside money may influence the supply of loans (Bernanke and Blinder 1988). In a monetary contraction environment, banks will find that their deposits are deteriorating; hence, they will also face decreasing reserves. With given reserve requirements, banks may also decrease their loan supply. If the loan supply decreases and banks are the main sources of financing, then this will affect economic activity.

In the same vein, Diamond and Rajan (2006) highlighted that pressure on deposit withdrawal with a shift to currency without any increase in the money supply from the central bank will diminish the credit supply. By ensuring that the claim of deposit withdrawal is inside the banking system, banks can continue to ensure the supply of loans to the economy without facing a liquidity shock. When banks deal with a liquidity shock, they generate a disintermediation effect by reducing their activities in the system.

[3] The Bank for International Settlement (BIS) provides a detailed survey of the payment systems in various countries on its website: www.bis.org.

Moreover, they shift their portfolio of investments toward more liquid and less productive assets (Ennis and Keister 2003).

By providing payment services to customers in a large-value settlement system, such as the RTGS, a bank can decrease its balance in the central bank reserves by investing in cash and liquidity management. With continuous and individual payment instructions, banks need to have sophisticated liquidity management. Banks depend on two sources to fulfill their payment obligations: reserve balances and/or loans from the central bank and incoming funds acquired from other banks during the day (Galbiati and Soramäki 2011). Using the reserve balance or taking loans from the central bank involves a cost that prompts economic incentives. Relying on incoming funds may not involve a cost, yet it is beyond the bank's control. Therefore, it is very important to have sophisticated liquidity management in place. The more involvement a bank has in the payment system, the greater the investment in liquidity management pay-offs. This requires active participation in the money market—through both borrowing and lending—to determine the balance in the central banks; therefore, it enhances the money market liquidity.

Nguyen and Boateng (2013) found that increasing excess reserves in the People's Republic of China is a signal that banks are preparing for the increased risk, which, in turn, reduces their loan supply. A contraction of the deposit division of a bank can signal an increased risk to reduce the loan supply. Uncertainty in payment flows in the large-value payment system influences the transmission of the monetary policy by increasing the pressure on interbank market rates and banks' reserve balance in the central bank for a precautionary reason (Kamhi 2006). Studies that employed US data have reported another interesting result. Güntner (2015) pointed out that the excess reserve level in the US data is not related to the loan supply. The level of excess reserves only crowds out the money market. The pivotal role of the money market in facilitating the continuation of payment flows and the level of excess reserves and lending to the economy became evident in the 2007—2009 financial crisis.

On the retail payment system level, Wang and Wolman (2016) took US data from various locations in the country. They imposed a nominal threshold whereby customers may use debit cards above that threshold and cash below that threshold. They concluded that the use of debit cards reduces the demand for cash. David, Abel, and Patrick (2016), who used French data, also supported this result. They highlighted the fact that debit cards provide two services for consumers—cash withdrawal and payment—that have contrasting effects on cash holdings and cash usage. They found that payments made through credit cards exceed the use of ATMs for cash withdrawals and have a negative impact on the currency demand. Lippi and Secchi (2009) drew the same conclusion through an estimation from the Italian market.

Turning to the investigation of credit card holdings and households' demand for currency, Duca and Whitesell (1991) argued that credit card ownership produces a lower demand for currency and demand deposits, with no effect on small time deposits. However, Yang and King (2011) put forward a different view regarding the ability of credit cards to reduce the currency demand. The presence of ATMs, online banking, and electronic fund transfer reduce the cost of having to visit banks. Therefore, credit card holdings may not have an impact on the currency demand in aggregate.

3. CONCEPTUAL FRAMEWORK AND DATA

3.1 Loan Supply, Reserves, and Deposits

To gauge the impact of payment system innovation on financial intermediation, we followed Rockoff (1993) and Merrouche and Nier (2009) to develop the conceptual framework. This paper assumed that economic agents want to maintain a fraction of their nominal income in the form of liquid assets. These assets are represented by two assets, Deposit (D) and Cash (C), according to a constant elasticity of substitution production function. Hence, we can present a modified quantity theory as:

$$[(\delta D)^{-\alpha} + C^{-\alpha}]^{-\frac{1}{\alpha}} = kY \quad (1)$$

where δ is an index of the quality of deposits that affect payments and Y is the nominal income and σ = 1/((1+α)) is the elasticity of substitution. This paper assumed that economic agents try to maximize their utility from holding monetary assets by setting the marginal product of deposits, and we can express the currency deposit ratio C/D as a linear function of the quality deposits δ.

Banks lend these two types of assets through two different channels. They lend currency directly without any financial intermediation, and the banking system intermediates deposits. This study followed the previous literature, such as Bernanke and Blinder (1988), which assumes that bonds cannot perfectly substitute loans. It viewed this assumption as practical in the context of the emerging market conditions, particularly those in Indonesia. The local bond market needs development. According to the Asian Development Bank, the corporate bond market in Indonesia accounts for only 2.56% of the total GDP.[4]

A representative bank's balance sheet is:

$$R + L_s = D \quad (2)$$

where R is the total bank's reserves, L_s is the supply of loans, and D is the level of bank deposits. The bank must retain its reserves in the central bank in proportion to its deposit base due to certain reserve requirements; therefore, the total reserves R include the required reserves and the excess reserves ER, so, letting ρ represent the reserve requirement rate:

$$ER = R - \rho D \quad (3)$$

Following the aforementioned discussion, the bank maintains excess reserves to prepare for the customer payment flows, which may create a liquidity risk for the bank. The bank would need to borrow from the central bank at a high penalty rate to cover the payment obligations. This liquidity management can be performed in the interbank market to optimize the cost. Therefore, the interbank market becomes more liquid.

This study combined equations (2) and (3) to obtain the loan supply function:

$$L_s = (1 - \rho)D - ER \quad (4)$$

[4] Data available online. Accessed 18 September 2017. https://asianbondsonline.adb.org.

We can consider the introduction of smooth and efficient payment systems as a permanent positive shock to ρ and D and a permanent negative shock to the banks' desired level of excess reserves ER. Furthermore, there is a positive feedback mechanism that is associated with a higher equilibrium output and loan if the output is a function of the available supply of credit. Another channel of payment systems that affects credit in this framework is the reserve channel subject to the central bank not accommodating the commercial bank's demand or in the absence of massive quantitative easing policies.

3.2 Empirical Methodology

Following the preceding conceptual framework, the first step of this paper's approach was to assess whether the presence of innovation in large-value payment systems, such as the RTGS and the clearing system, reduces the excess reserves. Specifically, this paper used a modified demand equation for excess reserves that Agénor, Aizenman, and Hoffmaister (2004) developed, which we can express as follows:

$$ED_t = a_0 + a_1 ED_{t-1} + a_2 DPS_t + a_3 RR_t + a_4 IB_t + a_5 Yshock_t + a_6 PSREG_t + a_7 HOLIDAY_t + \varepsilon_t \quad (5)$$

where ED_t is the ratio of excess reserves *ER* over the total bank deposit *D* at time *t*; in line with previous studies by Merrouche and Nier (2009, 2012) and Nguyen and Boateng (2013), this study includes both rupiah (local currency) and foreign exchange deposits. DPS_t is the large-value payment system (LVPS) transaction value at time *t* minus its 12-month moving average. This variable purports to capture the payment shocks to the bank. We also employed the total value of the LVPS to capture the overall performance of the bank's liquidity management. A negative sign for the coefficient suggests that banks have already performed liquidity management and reduced the excess reserves; RR_t is the reserve requirement ratio, which acts as a proxy for the effect of the changes in the reserve requirement on the excess reserves; IB_t is the interest rate in the interbank market, which captures the penalty rate if the bank needs to cover the liquidity when there is a shock to the payment flows; and *Yshock* is the deviation of output from the trend, which represents the output shocks in the economy. As Agénor, Aizenman, and Hoffmaister (2004) pointed out, shocks to output will have a positive impact on the excess reserves. Due to the unavailability of monthly data for output, we used the Retail Sales Index as a proxy for output, since studies have reported that this index has a correlation rate between the index and the GDP, which was 0.71% (Bank Indonesia 2009). Furthermore, we included $PSREG_t$, which is the dummy of payment system regulations that restrict the value of customer transactions in the large-value payment systems, both in the RTGS and in the clearing system. There are several instances in which the central bank sets a limit for a customer to conduct a transaction in the RTGS and clearing system in Indonesia. [5]

We expected a negative sign for this variable, which means that limiting the value of individual transactions in both LVPSs will help to minimize the payment shock to banks. We also incorporated the seasonal factor in Indonesia through $HOLIDAY_t$ to capture the cyclical factor because of the seasonal holiday of *Eid al-Fitr*, which is a big celebration in Indonesia, as suggested by Bank Indonesia (2017b), and ε_t is the error term.

[5] Appendix C provides details of the regulations that Indonesia has imposed to limit the transaction value on the LVPS.

Secondly, we investigated the extent to which innovation in retail payments, such as debit cards and credit cards, affects the currency holding in the economy by constructing a currency demand equation in the following manner:

$$CS_t = b_0 + b_1 CARD_t + b_2 Y_t + b_3 INF_t + b_4 CPOP_t + b_5 INFRA_t + b_6 DEPO_t + b_7 HOLIDAY_t + \varepsilon_t \quad (6)$$

where CS_t is the ratio of the total currency in circulation outside of the banking system divided by the saving and demand deposits in the banking system at time *t*; $CARD_t$ is the number of card transactions, which is derived from the number of transactions of each debit card or credit card divided by the number of debit or credit cards in the economy. Rinaldi (2001) highlighted that the number of card transactions could represent the use of cards better. However, this paper divides it by the number of cards to take into the account the introduction of new cards to the economy. We expected the sign of this variable to be negative to capture the substitution effect of card payment instruments and the transaction of the payment instruments. Y_t is the Retail Sales Index, which we used as a proxy for output, and INF_t is the Consumer Price Index (CPI) inflation; $DEPO_t$ is the nominal 1-month time deposit interest rate in the banking system; $CPOP_t$ is the number of debit and credit cards per 1,000 population, which we expected to bear, as in the case of $CARD_t$, a negative sign; and $INFRA_t$ is the total number of ATMs and electronic fund transfer point-of-sales (EFTPOS) terminals.

The final step was to assess the extent to which financial intermediation is related to reductions in excess reserves and currency holding by setting up the following specification:

$$LG_t = c_0 LG_{t-1} + c_1 Channel_t + c_2 YG_t + c_3 INF_t + c_4 BI_t + c_5 RR_t + c_6 XR_t + \varepsilon_t \quad (7)$$

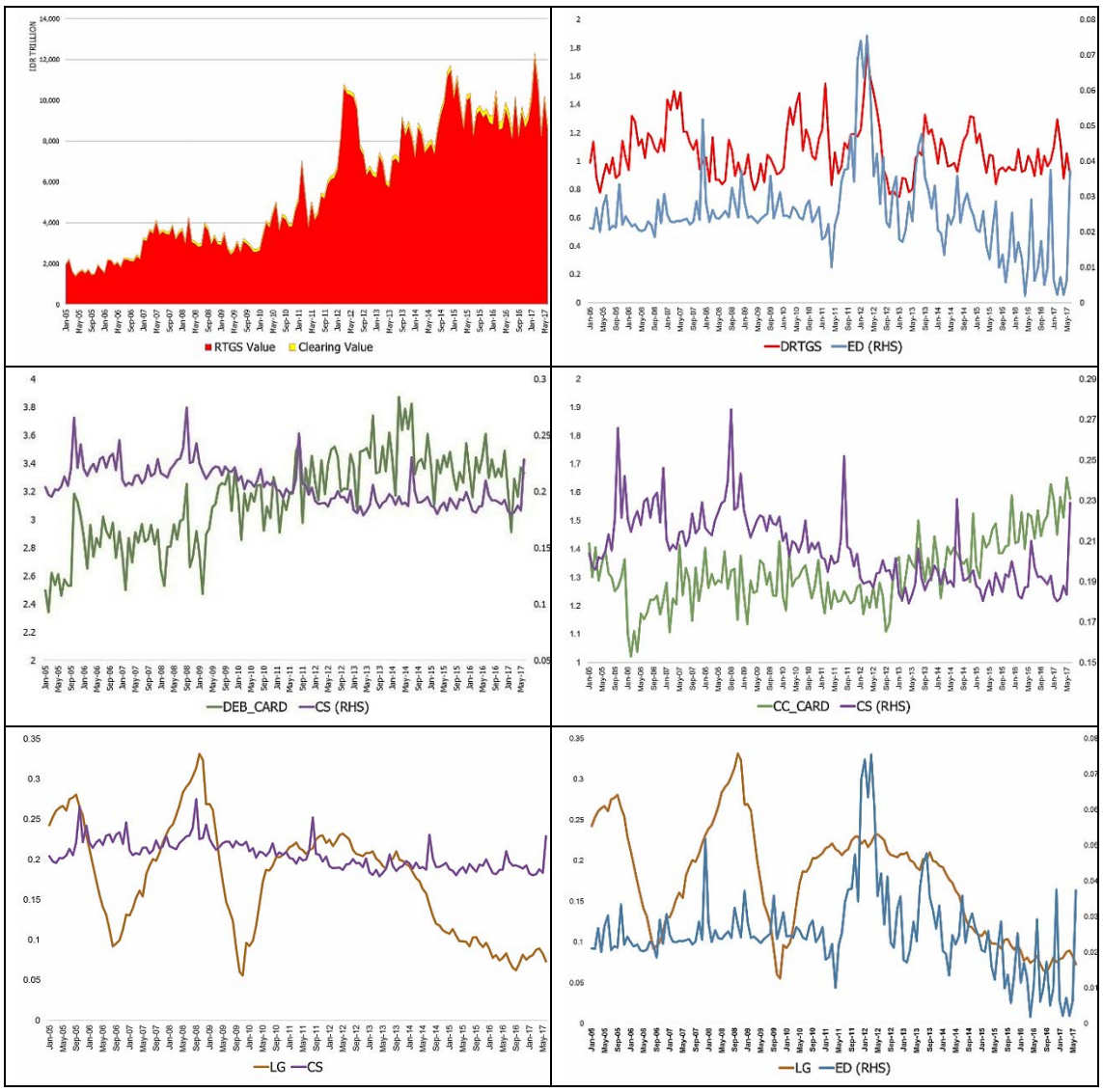
where LG_t is financial intermediation, which the year-on-year growth of loans in the banking system represents; $Channel_t$ is the ratio of excess reserves over the total deposits or the ratio of currency in circulation over the total savings and demand deposits in the banking system. We expected this variable to bear a negative sign, hence indicating the impact of payment system innovations on financial intermediation. YG_t is the year-to-year growth rate of the Retail Sales Index, whereas *BI* is the central bank's policy rate. It is interesting to see the impact of the capital flow on XR, representing financial intermediation. Following other studies, such as Korinek and Sandri (2016), the capital inflows will exert upward pressure on the exchange rate, whilst capital outflows will cause the exchange rate to depreciate.

To test this relationship empirically, especially when estimating the link between financial development and economic development, several economic problems may occur, such as problems in regressor endogeneity as well as the possibility of autocorrelation (Hasan, Renzis, and Schmiedel 2013). The Durbin–Wu test can identify endogeneity issues, in which case adopting a GMM approach, as Hasan, Renzis, and Schmiedel (2013) and Nguyen and Boateng (2013) suggested, will rectify any problems; alternatively, in the absence of endogeneity, we used the OLS model, as Bound, Jaeger, and Baker (1993, 1995) suggested, as OLS provides a better estimation when the excluded instruments are only weakly correlated with the endogenous variables.

3.3 Data

The Bank of Indonesia was the main provider for the monthly dataset of the payment system statistics for the RTGS, clearing, and card payment transactions' volume and value. In particular, the RTGS—which dominates the wholesale payment system—accounts for 96.73% and debit cards account for 95.57% of the total transaction value, respectively, as recorded in June 2017. Titiheruw and Atje (2009) provided an excellent survey of the payment systems in Indonesia. In addition, the data on excess reserves are from the Monetary and Payment System Selected Indicators, whilst we obtained the Retail Sales Index from Bank Indonesia's retail sales survey. All the other data are from Indonesian financial statistics. The sample covers the period from January 2005 to June 2017 (150 observations). We measured the exchange rate as USD/IDR from Bank Indonesia; the average of 1 USD equals 10,507 IDR over the sample period. This implies that a negative sign means appreciation of the domestic currency (IDR) and a positive sign means depreciation of the IDR. Figure 1 plots the selected time series used in this paper.

Figure 1: The Data



4. ESTIMATION RESULTS AND DISCUSSION

4.1 Payment System Innovations and Excess Reserves

Following section 3.2, we started our investigation by using the RTGS and the clearing turnover separately to see the impact of each LVPS on the excess ratio. The Durbin–Wu test indicated the presence of endogeneity; therefore, we adopted a GMM methodology to provide the estimates that Table 1 reports.

Table 1: Estimation Result for the Dependent Variable, ED

	Dependent Variable:	
Independent Variable	**ED**	**ED**
C	–0.010856	0.004693
	(0.009982)	(0.015343)
DRTGS	0.011335**	
	(0.004681)	
DCLEAR		–0.009118
		(0.009544)
RR	0.125351**	0.057081
	(0.054077)	(0.060770)
IB	–0.000318*	–0.000206
	(0.000173)	(0.000214)
YSHOCK	0.008329	0.010482
	(0.005136)	(0.007651)
ED(-1)	0.382659***	0.576900***
	(0.120671)	(0.110606)
RTGSREG_1	–0.009361***	
	(0.002438)	
RTGSREG_2	–0.006460**	
	(0.002502)	
CLEARREG_1		0.002087
		(0.003657)
CLEARREG_2		–0.000658
		(0.003641)
HOLIDAY	0.005953***	0.005979***
	(0.001470)	(0.001547)
R^2	0.55	0.51
DW stat.	1.64	1.86
J-statistics	9.95	8.89
No. of observations	149	149
Instrument specification:	*DRTGS(-1) DRTGS(-2) RR IB YSHOCK ED(-1) ED(-2) RTGSREG_1 RTGSREG_2 HOLIDAY*	*DCLEAR(-1) DCLEAR(-2) RR IB YSHOCK ED(-1) ED(-2) CLEARREG_1 CLEARREG_2 HOLIDAY*

Note: Robust standard errors in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

The yielded evidence suggests that payment shocks to the RTGS (DRTGS) have a positive and significant impact on excess reserves, which is in line with Kamhi (2006), hence implying that payment flows may exert upward pressure on excess reserves but standing in stark contrast to Merrouche and Nier (2009), who found that payment innovations significantly reduce the excess reserve ratio in a sample of Eastern European countries.

One factor that may contribute to the reason for payment shocks causing upward pressure on excess reserves is the shallowness of the interbank market in Indonesia (Warjiyo 2014). The interbank money market has limited transactions, and certain banks concentrate the liquidity (Bank Indonesia 2017b). Thus, the ability of banks to access different sources of funding may compel them to set up sophisticated liquidity management. The banking system may depend only on the central bank to access funding, which causes reluctance to use such a facility because of the 'bank failure' stigma. Therefore, payment shocks, which can happen at any time during the day due to the characteristic of the RTGS, which requires real-time settlement, may drive the banks to accumulate reserves.

The limited ability of the interbank market to provide liquidity makes the interbank market rates prone to shocks. A small demand in the market may cause the rate jumps. Therefore, we found that the interbank rate (IB) has a negative and significant impact on excess reserves, as expected. Banks lend their reserves to the interbank market when the interest rate rises and hold their reserves when the interest rate falls. We also found that the reserve requirement (RR) appears to have a significant positive result, as expected. The RTGS regulations to limit the transaction value in payment systems (RTGSREG_1 and RTGSREG_2) show negative and significant coefficients, as expected. This result indicates that regulations restrain the transaction value and alleviate the impact of payment shocks on excess reserves, as expected.

4.2 The Effect of Card Usage on Currency Holdings

In an attempt to gain an insight into the relationship between payment systems and financial intermediation, we extended our analysis to retail payment systems. We adopted a similar approach to the previous section and tested the impact of debit/ATM cards (DEB_CARD) and credit cards (CC_CARD) on the currency (CS) separately to examine their individual impacts. This approach intended to clarify the debate within the literature regarding the role of each card-based payment system.

We conducted an ADF test to check the stationarity of the variables, the results of which we report in Table 2.

Table 2: ADF Test Result

Variables	I(0)	I(1)	I(2)
CS	**		
CC_CARD		***	
CC_CPOP	*		
DEB_CARD		***	
DEB_CPOP		***	
INFRA		*	

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

An inspection of the respective ADF tests indicated the presence of a unit root in the credit card transaction volume over the number of credit cards (CC_CARD), the debit card transaction volume over the number of debit cards (DEB_CARD), the number of credit cards over the population (CC_CPOP), and the number of debit cards over the population (DEB_CPOP). Following the standard methodological process when dealing with non-stationary variables, we proceeded to check for cointegration by utilizing a Johansen approach. The results of the Johansen test, which Tables 3 and 4 provide, both unrestricted co-integration rank tests (trace and maximum eigenvalue statistics), reject the null of no co-integration at the 5% level of significance.

Table 3: Johansen Test Result for CS, DEB_CARD, Y, INF, DEPO, DEB_CPOP, and INFRA

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted cointegration rank test (trace)				
None*	0.307382	179.4971	125.6154	0.0000
At most 1*	0.250084	125.8746	95.75366	0.0001
At most 2*	0.223115	83.85679	69.81889	0.0025
At most 3	0.147883	46.99728	47.85613	0.0601
Unrestricted cointegration rank test (maximum eigenvalue)				
None*	0.307382	53.62247	46.23142	0.0069
At most 1*	0.250084	42.01786	40.07757	0.0299
At most 2*	0.223115	36.85951	33.87687	0.0214
At most 3	0.147883	23.36452	27.58434	0.1584

* Denotes rejection of the hypothesis at the 0.05 level by trace and maximum eigenvalue; ** MacKinnon, Haug, and Michelis (1999) p-values.

Table 4: Johansen Test Result for CS, CC_CARD, Y, INF, DEPO, CC_CPOP, and INFRA

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
Unrestricted cointegration rank test (trace)				
None*	0.360157	206.14	125.6154	0.0000
At most 1*	0.321835	142.2859	95.75366	0.0000
At most 2*	0.260705	86.74985	69.81889	0.0013
At most 3	0.131105	43.5556	47.85613	0.1196
Unrestricted cointegration rank test (maximum eigenvalue)				
None*	0.360157	63.85405	46.23142	0.0003
At most 1*	0.321835	55.53606	40.07757	0.0004
At most 2*	0.260705	43.19425	33.87687	0.0029
At most 3	0.131105	20.09622	27.58434	0.3345

* Denotes rejection of the hypothesis at the 0.05 level by trace and maximum eigenvalue; ** MacKinnon, Haug, and Michelis (1999) p-values.

Having established the existence of cointegrating relationships, we used the VECM to examine the impact of the payment system innovation on the currency demand. To determine the number of lags, we used a range of standard criteria (see Appendix D).

We carried out an impulse response function analysis using the Cholesky decomposition of the matrix of covariance. In this approach, the order of the variables is important, because a shock to the previous variables has a contemporaneous effect on both the variable itself and the ones that follow (Enders 2004). Following Rinaldi (2001), we assumed that the other variables affect money immediately, but it does not have a contemporaneous effect on any of them. Appendix E presents the graphical representation of the impulse response function.

Tables 5 and 6 provide the short-run as well as the long-run estimates.

Table 5: Short-Run Dynamics for the Impact of Debit/ATM Cards on the Currency Demand

Variables	Coefficient	Std Error	t statistics
ECM_{t-1}	–0.250523	0.116005	–2.159586**
ΔCS_{t-1}	–0.516013	0.175477	–2.940639***
ΔCS_{t-2}	–0.38522	0.188229	–2.046549**
ΔCS_{t-3}	–0.128986	0.17558	–0.734627
ΔCS_{t-4}	0.067105	0.129766	0.517125
ΔDEB_CARD_{t-1}	–0.000683	0.02665	–0.025627
ΔDEB_CARD_{t-2}	–0.012327	0.034528	–0.357023
ΔDEB_CARD_{t-3}	–0.022703	0.032314	–0.70258
ΔDEB_CARD_{t-4}	–0.009563	0.025121	–0.380674
ΔY_{t-1}	0.010701	0.019539	0.547687
ΔY_{t-2}	0.037045	0.020039	1.848679*
ΔY_{t-3}	0.016867	0.019044	0.885642
ΔY_{t-4}	–0.009222	0.018076	–0.510182
ΔINF_{t-1}	–0.133375	0.157203	–0.848428
ΔINF_{t-2}	–0.096249	0.146322	–0.657784
ΔINF_{t-3}	–0.072775	0.141127	–0.515669
ΔINF_{t-4}	–0.180271	0.129726	–1.389633
$\Delta DEPO_{t-1}$	0.015771	0.004898	3.219544***
$\Delta DEPO_{t-2}$	–0.004783	0.006078	–0.786821
$\Delta DEPO_{t-3}$	0.002638	0.006262	0.421209
$\Delta DEPO_{t-4}$	–0.003583	0.005084	–0.70486
ΔDEB_CPOP_{t-1}	0.080807	0.060752	1.330122
ΔDEB_CPOP_{t-2}	–0.090052	0.06739	–1.336284
ΔDEB_CPOP_{t-3}	0.045914	0.061455	0.747116
ΔDEB_CPOP_{t-4}	–0.039089	0.059046	–0.662018
$\Delta INFRA_{t-1}$	–0.006104	0.003391	–1.80002*
$\Delta INFRA_{t-2}$	–0.00295	0.003564	–0.827668
$\Delta INFRA_{t-3}$	–0.005725	0.003639	–1.573137
$\Delta INFRA_{t-4}$	–0.002079	0.003495	–0.594812
HOLIDAY	0.012083	0.002632	4.589937***
R^2		0.52	
S.E. of regression		0.010503	
F-statistic		4.242907 (0)	

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Table 6: Long-Run Estimation Results for the Impact of Debit/ATM Cards on the Currency Demand

CURSAV	Coefficient	Std Error	t Statistics
DEB_CARD_{t-1}	–0.084108	–0.03802	–2.21199**
Y_{t-1}	0.13182	–0.02574	5.12193***
INF_{t-1}	–0.058972	–0.04235	–1.39250
$DEPO_{t-1}$	0.001036	–0.0016	0.64893
DEB_CPOP_{t-1}	–0.032897	–0.02854	–1.15279
$INFRA_{t-1}$	–0.002671	–0.00169	–1.57618
C	–0.288833	–0.10735	–2.69060***

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

An inspection of the results that Table 5 presents suggests that, in the short run, the volume of debit card transactions over the number of debit cards (DEB_CARD) is not significant, hence implying that the use of debit/ATM cards to withdraw money is not as important as the use of cash in daily transactions. The currency demand will not be affected if occasional customers are the majority users of ATMs (Stix 2004). In contrast, if regular customers use ATMs, then the impact of the volume of debit card transactions will have a negative and significant relationship with the aggregate currency demand. In line with this finding, the number of debit cards per 1000 people (DEB_CPOP) appears to have a positive and significant impact, suggesting that, in the short run, customers primarily use debit cards to withdraw currency. However, the card-based payment infrastructure (INFRA) has a negative and significant coefficient, which implies that the availability of the infrastructure may reduce the demand for currency. The unbalanced number of terminals across the country may contribute to this slightly puzzling result (Snellman and Viren 2009). Overall, the number of terminals reduces the aggregate currency demand; however, the use of cards and terminals in withdrawing large amounts of money may cause the conflicting result.

Retail sales (Y) bear a positive coefficient, which confirms that many transactions in the economy still use cash, as Titiheruw and Atje (2009) highlighted. Therefore, this puts upward pressure on currency when there is a positive shock to retail sales. The nominal interest rate (DEPO) has a positive and significant effect on the currency demand (CS), which is in line with Lippi and Secchi (2009). The positive coefficient of the nominal interest rate confirms that technology drives the ambiguous relationship between money and interest rates. Another factor that we may attribute to this relationship between money and interest rates is the heterogeneity of the customers who use debit cards. Customers in rural or remote areas may withdraw a large amount of money to avoid the transaction costs of more frequent visits to the ATM, since the availability of machines is limited and most transactions are still cash based. As for the error correction term (ECM), it indicates that about 29% of the disequilibrium is corrected on a monthly basis.

Although a statistically significant relationship is not observable between the volume of debit card transactions (DEB_CARD) and the currency demand in the short run (CS), a negative and statistically significant relationship is apparent between these two variables in the long run, as Table 6 indicates. The preceding discussion about the short-run impact of debit/ATM cards on the currency demand provides the underlying reason behind this phenomenon. As Stix (2004) pointed out, regular customers may utilize debit cards to substitute cash by exploiting the features of the card through machines, such as transfer or payment. This verifies that regular customers utilize ATMs in the long run.

Table 7: Short-Run Dynamics for the Impact of Credit Cards on the Currency Demand

Variables	Coefficient	Std Error	t Statistics
ECM_{t-1}	–0.709561	0.151386	–4.687101***
ΔCS_{t-1}	–0.113333	0.168928	–0.670898
ΔCS_{t-2}	–0.068298	0.175192	–0.389849
ΔCS_{t-3}	0.108619	0.174124	0.623806
ΔCS_{t-4}	0.435473	0.171428	2.540262**
ΔCS_{t-5}	0.318441	0.160298	1.986558**
ΔCS_{t-6}	0.271074	0.125589	2.158426**
ΔCC_CARD_{t-1}	–0.027413	0.02026	–1.353088
ΔCC_CARD_{t-2}	–0.038114	0.02669	–1.428024
ΔCC_CARD_{t-3}	–0.048106	0.031089	–1.547367
ΔCC_CARD_{t-4}	–0.040271	0.030677	–1.31276
ΔCC_CARD_{t-5}	–0.040124	0.026334	–1.52366
ΔCC_CARD_{t-6}	–0.022474	0.017886	–1.256515
ΔY_{t-1}	0.03844	0.019039	2.019065**
ΔY_{t-2}	0.06512	0.01842	3.535315***
ΔY_{t-3}	0.052832	0.02022	2.61281**
ΔY_{t-4}	–0.006267	0.020002	–0.313302
ΔY_{t-5}	0.009728	0.0188	0.517439
ΔY_{t-6}	–0.028587	0.018627	–1.534661
ΔINF_{t-1}	0.010053	0.148104	0.067877
ΔINF_{t-2}	0.183119	0.139914	1.3088
ΔINF_{t-3}	0.029926	0.140219	0.213421
ΔINF_{t-4}	0.131875	0.17723	0.74409
ΔINF_{t-5}	–0.000812	0.156305	–0.005194
ΔINF_{t-6}	0.372353	0.176195	2.113302**
$\Delta DEPO_{t-1}$	0.009027	0.004901	1.841838*
$\Delta DEPO_{t-2}$	–0.007305	0.005719	–1.277438
$\Delta DEPO_{t-3}$	0.007371	0.005772	1.27711
$\Delta DEPO_{t-4}$	–0.007458	0.005753	–1.296271
$\Delta DEPO_{t-5}$	0.005953	0.00591	1.007358
$\Delta DEPO_{t-6}$	–0.003042	0.005373	–0.5662
ΔCC_CPOP_{t-1}	–0.202552	0.081772	–2.477038**
ΔCC_CPOP_{t-2}	0.000603	0.075796	0.007961
ΔCC_CPOP_{t-3}	–0.133471	0.079357	–1.681912*
ΔCC_CPOP_{t-4}	–0.00777	0.059581	–0.130413
ΔCC_CPOP_{t-5}	0.023237	0.051671	0.449714
ΔCC_CPOP_{t-6}	0.019426	0.050091	0.387824
$\Delta INFRA_{t-1}$	–0.012923	0.00451	–2.865446***
$\Delta INFRA_{t-2}$	–0.006618	0.003951	–1.675054**
$\Delta INFRA_{t-3}$	–0.005408	0.003831	–1.411709
$\Delta INFRA_{t-4}$	–0.001835	0.003918	–0.46822
$\Delta INFRA_{t-5}$	0.001227	0.003419	0.359039
$\Delta INFRA_{t-6}$	0.001021	0.003384	0.301821
HOLIDAY	0.014076	0.002415	5.828989***
R^2		0.66	
S.E. of regression		0.00946	
F-statistic		4.488029 (0)	

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

The card-based payment infrastructure (INFRA), which bears a negative coefficient in the long run, also supports this argument, hence suggesting that the availability of infrastructure may reduce the demand for currency. Furthermore, the variable reflecting the number of debit cards per 1000 people (DEB_CPOP) is consistent with the previous

argument. The results obtained in the long run also confirm the dominance of cash in the economy, which we can observe through the positive coefficient for retail sales (Y).

On the basis of the preceding exposition, it has transpired that the currency demand and debit cards are inversely related. Next we explore the relationship between credit cards and the currency demand. Tables 7 and 8 report the results.

Table 8: Long-Run Estimation Results for the Impact of Credit Cards on the Currency Demand

CS	Coefficient	Std Error	t Statistics
CC_CARD_{t-1}	–0.060407	–0.03651	–1.65444*
Y_{t-1}	0.082763	–0.0165	5.01690***
INF_{t-1}	0.221712	–0.10852	2.04299**
$DEPO1M_{t-1}$	0.004047	–0.00186	2.18070**
CC_CPOP_{t-1}	–0.159764	–0.06469	–2.46971**
$INFRA_{t-1}$	–0.009977	–0.00421	–2.37119**
C	–0.959045	–0.26911	–3.56380***

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

The results in Tables 7 and 8 reveal a clearer picture of how card-based payment systems affect the currency demand. Table 7 indicates that the volume of credit card transactions over the number of cards (CC_CARD) is statistically significant in reducing the currency demand (CS) in the short run. This is supported by both the number of credit cards per 1000 people (CC_CPOP) and the card-based payment infrastructure (INFRA) having negative and significant coefficients, which suggest that the number of cards in circulation and the availability of the infrastructure may reduce the demand for currency.

Similar to the finding for debit cards, retail sales (Y) are positive, hence validating the dominance of the use of cash in the economy over other retail payment instruments. The nominal interest rate (DEPO) also has a positive and significant relationship with the currency demand (CS) in the short run. In addition, inflation (INF) exhibits a positive relationship with the currency demand in the short run. A significant and negative cointegrating relationship is also observed, that is, a speedy adjustment of around 68%.

In Table 8, the volume of credit card transactions (CC_CARD) is negatively related to the currency demand (CS) in the long run. This is consistent with the previous findings, such as those of Duca and Whitesell (1991), and differs from the finding of Yang and King (2011). The main difference between Yang and King (2011) and this study is the distinctive economic and banking structures in this paper's sample. Yang and King (2011) took their sample from the US economy, which has a strong cheque culture, whereas this study's sample is a cash-based economy. The use of cheques has been widespread for some time in the US. Hence, we can argue that a card-based system is not directly related. However, in the case of Indonesia, the substituting effect of cash and card payments will occur directly without any intermediaries, such as cheques in the US.

The negative coefficient of the number of credit cards per 1000 people (CC_CPOP) and the number of terminals that customers can use (INFRA) in the long run also support the substituting effect of credit card and cash payment. An increase in credit card possession

is associated with a decrease in the currency demand in the long run. Consistent with the short-run result, the nominal interest rate (DEPO) and inflation (INF) also put pressure on the currency demand, with a positive and significant coefficient in the long run.

The findings of this study regarding credit cards suggest that the card-based payment system has a negative impact on the currency demand. The analysis of the impulse–response function and forecast error variance decomposition do not differ significantly from this proposition. A shock from debit cards has a negative impact on the currency. However, it will increase over time and then decrease to a level lower than the initial one (see Appendix F). Interestingly, the currency demand decreases in reaction to the volume of credit card transactions and starts to increase in the fourth period before returning to the initial level.

4.3 Financial Intermediation

To gauge the impact of excess reserves and the currency demand on financial intermediation, we employed a GMM specification (see Table 9).

We find a statistically negative relationship between the currency demand and financial intermediation, which is in line with our prior expectations. Output growth (YG) is related in a positive way to loan growth. In addition, the exchange rate (XR) has a negative and significant effect on loan growth, suggesting that exchange rate appreciation leads to an increase in loan growth. It is arguable that capital flows may be one of the factors that cause the exchange rate to fluctuate. Massive volatility of capital inflows, following the unconventional monetary policy in advanced countries, for instance, leads to appreciation of the currency because of a strong demand for domestic assets, such as stocks and bonds. The capital inflows provide an abundance of liquidity, which encourages banks to push their lending (Unsal 2013). In contrast, large exchange rate depreciation could be related to deterioration in external funding conditions during a crisis that triggers capital outflows (Chu 2015). Depreciation of the exchange rate cuts the value of collateral and decreases loan growth (Korinek and Sandri 2016). This result confirms that the credit supply may exhibit strong pro-cyclicality to the business cycle, as many studies, such as Rousseau and Wachtel (2002), have highlighted. The observation that this study discerns also confirms the role of the policy instruments—the policy rates (BI) and reserve requirements (RR)—from the central bank to restrict loan growth.

Table 9: The Impact of Excess Reserves and the Currency Demand on Financial Intermediation

	Dependent Variable:	
Independent Variable	**LG**	**LG**
C	0.305485***	0.189406**
	(0.082831)	(0.077351)
CS	–0.255181***	
	(0.096705)	
ED		0.066699
		(0.124826)
YG	0.027836**	0.0229**
	(0.011163)	(0.010965)
INF	0.04273	0.080396
	(0.074952)	(0.075295)
BI	–0.297388*	–0.464078***
	(0.157337)	(0.146732)
XR	–0.021097***	–0.013177
	(0.007847)	(0.008009)
RR	–0.577625***	–0.533172***
	(0.10717)	(0.109832)
LG_{t-1}	0.988249***	0.966476***
	(0.022102)	(0.022737)
R^2	0.97	0.97
DW stat.	1.4	1.4
J-statistics	65.13	75.54
No. of observations	146	146
Instrument specification:	C CS(-1TO-4) YG(0TO-4) INF (0TO-4) BI(0TO-4) LG(-1TO-4) XR (0TO-4) RR(0TO-4) HOLIDAY	ED(-1TO-4) YG(0TO-4) INF(0TO-4) BI(0TO-4) LG(-1TO-4) XR (0TO-4) RR(0TO-4) HOLIDAY

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

However, the findings fail to identify any impact of excess reserves (ER) on financial intermediation, which is in line with the studies by Merrouche and Nier (2009, 2012). As Bathaluddin, Purwanto, and Wibowo (2012) highlighted, Indonesian banks prefer to liquidate their placement in the central bank to hold a large amount of excess reserves. Since the Asian Economic Crisis in 1997, due to Bank Indonesia Liquidity Support (BLBI) and the recapitalization program, excess liquidity has compelled the central bank to employ a borrowing operation instead of a lending operation. By using this type of operation, the banking industry has chosen to place funds in the form of the central bank's instruments with the interest rate income compared with investing funds in the unremunerated reserves account. This appears to be commonplace in many economies around the world, as studies have reported that banks place their excess reserves, which are acquired during the unconventional monetary policy, within the financial system, particularly in the form of government bonds, rather than granting loans (Kregel 2009).

Furthermore, such a development appears to be amplified by the volatility of capital flows following the current global financial crisis. After the emergence of capital inflows, domestic banks have had to face fierce competition whereby they have to compete with foreign funds. Domestic banks need to take on higher-risk forms of finance and face exposure to a liquidity risk when a payment shock occurs or default to the financing side (Korinek 2010). Furthermore, these capital inflows are subject to a sudden reversal, which may cause turbulence in the domestic financial market. As already mentioned in the previous section, the shallowness of the domestic financial market drives banks to maintain a certain amount of reserves with a preference to liquidate their placement in the central bank. Indonesian banks prefer placements in the central bank's monetary operation instruments in the short-term tenor to anticipate the volatility of the capital flows and the currency demand (Bank Indonesia 2017b).

The overall results explain why the currency ratio plays a major role in the credit supply. A shock to the currency ratio, such as a large number of deposit withdrawals and conversion into cash, can affect the credit supply immediately. As demonstrated previously, card-based payment systems may be significant in preventing a rapid contraction in the credit supply by reducing the demand for currency and placing liquidity within the banking system.

5. CONCLUDING REMARKS

This study provides a comprehensive analysis of the importance and significance of payment systems to financial intermediation in Indonesia and demonstrates how regulations that limit the customers' transaction value through payment systems affect this role. The paper evaluates this relationship through both large-value payment systems and retail payment system channels by using excess reserves and the currency demand.

Regarding the large-value payment systems channel, the evidence generated suggests that the RTGS exerts positive pressure on excess reserves. However, regulations that limit the value of customers' transactions help to alleviate this pressure by reducing the payment volatility. We found the clearing system to be relatively insignificant in affecting financial intermediation, along with its limitation. We can argue that the small proportion of this payment system compared with the RTGS may cause this insignificant result. In addition, the regulations to limit the value of transactions, which Indonesia has imposed since the introduction of the RTGS, contribute to the result.

Following the findings concerning the large-value payment system channel, this paper highlights the importance of card-based payment systems in reducing the currency demand in the retail payment system channel. We observe that credit cards have a statistically significant impact on the reduction of the currency demand. Debit cards, however, influence the currency demand adversely only in the short run.

Finally, this study produces empirical evidence showing how the currency demand is inversely related to financial intermediation. The implication of this finding is of paramount importance in that it provides support for policies that promote payment migration to an electronic platform, particularly card-based payment systems, such as a 'less-cash society' (GNNT), which the central bank of Indonesia has implemented. In addition, innovations in the retail payment system may increase the banking competition and efficiency (Sokołowska 2015). In so far as this study adopted a macro-based framework, its analysis was limited to aggregate behavior. It would also be interesting to observe customers' payment behavior based on primary data and explore how different demographic factors may have an impact on the currency demand.

Another interesting finding relates to the impact of excess reserves on financial intermediation. Similar to the preceding studies, such as Merrouche and Nier (2009, 2012) and Bathaluddin et al. (2012), this finding contributes to the enrichment of the debate on the view that monetary policies may have an impact on the supply of credit through their influence on the excess reserves, as Bernanke and Blinder (1988) suggested. The presence of excess liquidity, however, may distort this channel. In the presence of excess liquidity, banks may be less reactive to the tightening of monetary policy (Nguyen and Boateng 2013).

In passing, it should be mentioned that this study did not incorporate the dynamics in the interbank market, whilst the role of capital flows is potentially attributable to amplifying the domestic business cycle. In this context, the central bank needs to enhance its monetary operation framework to contain excess reserves and capital flows and integrate it with the presence of the newly developed macroprudential policies.

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APPENDIX A: LIST OF VARIABLES

Variable	Description	Source
Excess reserves ratio (ED)	The ratio of excess reserves held by private banks over the total deposits	Bank Indonesia
Currency ratio (CS)	The ratio of currency in circulation (outside the banking system) over saving and demand deposits in the banking sector	Bank Indonesia
Deviation of RTGS transactions from average 1 year (DRTGS)	RTGS transactions' value over the moving average of RTGS transactions in 12 months	Bank Indonesia
RTGS limit 1 (RTGSREG_1)	A dummy for the nominal limit for customer transfers in the RTGS system: 0 means no limit; 1 means there is a limit	Bank Indonesia
RTGS limit 2 (RTGSREG_2)	A dummy for the nominal limit for customer transfers in the RTGS system: 0 means no limit; 1 means there is a limit	Bank Indonesia
Deviation of clearing transactions from average 1 year (DCLEAR)	The clearing transaction value over the moving average of clearing transactions in 12 months	Bank Indonesia
Clearing limit 1 (CLEARREG_1)	A dummy for the nominal limit for credit transfers in the clearing system: 0 means no limit; 1 means there is a limit	Bank Indonesia
Clearing limit 2 (CLEARREG_2)	A dummy for the nominal limit for credit transfers in the clearing system: 0 means no limit; 1 means there is a limit	Bank Indonesia
Number of ATM/debit card transactions (DEB_CARD)	The number of debit cards transactions divided by the number of debit cards in the economy	Bank Indonesia
Number of credit card transactions (CC_CARD)	The number of credit card transactions divided by the number of credit cards in the economy	Bank Indonesia
Total number of ATM/debit cards (DEB_CPOP)	The total number of debit cards over 1000 population	Bank Indonesia
Total number of credit cards (CC_CPOP)	The total number of credit cards over 1000 population	Bank Indonesia
Reserve requirement ratio (RR)	The ratio of the reserve requirement for commercial banks held at Bank Indonesia in rupiah over the total deposits	Bank Indonesia
BI rate (BI)	The Bank Indonesia policy rate	Bank Indonesia
Inflation (INF)	The year-on-year CPI inflation in Indonesia	Statistics Indonesia (BPS)
Retail sales (Y)	The Retail Sales Index based on the Retail Sales Survey, which is a monthly survey to obtain prior information about the moving trend of the gross domestic product by private consumption. Bank Indonesia conducts this survey.	Bank Indonesia
Exchange rate (XR)	The average monthly USD/IDR exchange rate	Bank Indonesia
Loan	loan in the banking sector	Bank Indonesia
Total ATM, EFTPOS number (INFRA)	The natural logarithm of the total number of automatic teller machines and EFTPOSs in Indonesia	Bank Indonesia, Financial Service Authority (OJK)
Holiday dummy (HOLIDAY)	A dummy to capture the Indonesian holiday of *Eid al-Fitr*	

APPENDIX B: DESCRIPTIVE STATISTICS

Variables	Mean	Median	Maximum	Minimum	Std Dev.	Skewness	Kurtosis
ED	0.0255361	0.0240399	0.075440677	0.0019314	0.0119026	1.48170035	4.7441892
DRTGS	1.0675186	1.0400289	1.784332649	0.7511	0.1885868	0.904722966	0.9915821
DCLEAR	1.0670937	1.0458715	1.571035297	0.7187133	0.1369352	1.180998975	2.8885274
YSHOCK	1.0056498	0.9905091	1.317623031	0.7759936	0.0881069	0.940404181	2.0066858
CS	0.2057814	0.2038749	0.274952828	0.1791246	0.0176916	0.916108093	1.2161389
DEB_CARD	3.1430727	3.1894669	3.873796295	2.3444615	0.318634	–0.2955725	–0.430924
Y	119.3724	106.5	232.4	55.91	48.999157	0.568386811	–0.990024
DEPO	7.5702667	7.145	12.01	5.35	1.5770595	1.093341683	0.8358835
ATM_CPOP	272.08856	231.3914	574.0163661	112.8822	134.27069	0.604893676	–0.906009
INFRA	2.1494258	0.1411513	7.882031658	0.0631363	2.9016321	0.852445471	–1.069247
CC_CARD	1.3183943	1.2993122	1.652340979	1.0212316	0.1186498	0.356451979	0.1467754
CC_POP	52.600319	57.726263	68.27055913	25.216054	12.121138	–0.700423572	–0.729577
LG	0.1749987	0.1918965	0.331209442	0.055698	0.067931	0.021442625	–0.9878
YGROWTH	0.0993405	0.1023685	0.338975367	–0.305203	0.1080364	–1.005271013	3.0905041
INF	0.0655709	0.0608774	0.168741961	0.0238571	0.0321818	1.444167087	1.9333098
BI	0.0762293	0.0747	0.1275	0.0575	0.0175417	1.469715907	1.8868199
XRATE	10,507.033	9,610	14,657	8,508	1,723.4661	0.778707691	–0.924868
RR	0.0684	0.075	0.08	0.05	0.0130605	–0.545248396	–1.505474

APPENDIX C: CUSTOMERS' TRANSACTION LIMIT IN INDONESIAN LARGE-VALUE PAYMENT SYSTEMS

Reg No	Date	Title	Clearing Limit	RTGS Limit
4/12/DASP	24 September 2002	Clearing Schedule and Final Settlement Date of the Local Clearing System and Nominal Limit of a Note	• Max. Rp100,000,000.00 for credit transfer	
6/45/DASP	25 October 2004	Nominal Limit for Customer Transfer for RTGS		Min. Rp25,000,000.00 for the following dates: • 8–22 November 2004 • 20–31 December 2004
7/43/DASP	7 September 2005	Nominal Limit for Debit Note and Credit Transfer in Clearing	• Max. Rp10,000,000,00 for debit note • Max. Rp100,000,000.00 for credit transfer	
7/47/DASP	13 October 2005	Nominal Limit for Customer Transfer for RTGS		Min. Rp25,000,000.00 for the following dates: • 24 October–9 November 2005 • 19–30 December 2005
11/13/DASP	4 May 2009	Nominal Value Limit of a Debit Note and Credit Transfer	• Max. Rp10,000,000,00 for debit note • Max. Rp100,000,000.00 for credit transfer	
15/18/DASP	30 April 2013	Amendment of Nominal Value Limit of a Debit Note and Credit Transfer	• - Max. Rp500.000.000 for credit transfer starting from 31 May 2013	
16/18/DPSP	28 November 2014	Amendment of RTGS System		Min. Rp100,000,000.00 for customer transfer
17/35/DPSP	13 November 2015	Nominal Value Limit for Fund Transfer through RTGS and Clearing	• 16 November 2015–30 June 2016 -> no limit • 1 July 2016 -> max Rp500,000,000.00 per transaction	• 16 November 2015–30 June 2016: min Rp500,000,000.00 per transaction • 1 July 2016 -> min Rp100,000,000.00 per transaction
18/7/DPSP	2 May 2016	Fund Transfer and Scheduled Clearing	Debit note unlimited	
18/40/DPSP	30 December 2016	Amendment of Fund Transfer and Scheduled Clearing	Debit note max Rp500,000,000.00 per transaction	

APPENDIX D: LAG ORDER SELECTION CRITERIA TEST

VAR Lag Order Selection Criteria

Endogenous variables: CS DEB_CARD Y INF DEPO DEB_POP INFRA
Exogenous variables: C HOLIDAY

Lag	LogL	LR	FPE	AIC	SC	HQ
0	626.1704	NA	4.25E-13	–8.622119	–8.330699	–8.503697
1	1,803.992	2,206.343	5.29E-20	–24.52102	–23.20963*	–23.98812
2	1,904.372	178.139	2.58E-20	–25.24468	–22.91332	–24.29731*
3	1,958.437	90.61501*	2.44e-20*	–25.31601*	–21.96468	–23.95417
4	1,998.091	62.55251	2.85E-20	–25.18437	–20.81308	–23.40806
5	2,030.497	47.92575	3.75E-20	–24.95067	–19.55941	–22.75988
6	2,066.405	49.56187	4.80E-20	–24.76626	–18.35503	–22.161
7	2,109.241	54.90254	5.71E-20	–24.67944	–17.24825	–21.65971
8	2,149.393	47.50432	7.29E-20	–24.55483	–16.10366	–21.12062

* Indicates the lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at the 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan–Quinn information criterion.

VAR Lag Order Selection Criteria

Endogenous variables: CS CC_CARD Y INF DEPO CC_CPOP INFRA
Exogenous variables: C H_DUMMY

Lag	LogL	LR	FPE	AIC	SC	HQ
0	698.9899	NA	1.52E-13	–9.647745	–9.356325	–9.529324
1	1,758.247	1,984.242	1.01E-19	–23.87672	–22.56533	–23.34383
2	1,887.541	229.4503	3.27E-20	–25.00761	–22.67626*	–24.06024*
3	1,938.968	86.19586	3.21E-20	–25.04181	–21.69048	–23.67996
4	1,994.434	87.49515	3.00e-20*	–25.13287	–20.76158	–23.35656
5	2,032.326	56.0376	3.66E-20	–24.97642	–19.58516	–22.78563
6	2,088.398	77.39498	3.52E-20	–25.07603	–18.6648	–22.47076
7	2,141.734	68.36056*	3.61E-20	–25.13710*	–17.7059	–22.11736
8	2,189.761	56.81985	4.13E-20	–25.12339	–16.67222	–21.68918

* Indicates the lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at the 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan–Quinn information criterion.

APPENDIX E: ROBUSTNESS TEST

Endogeneity Test

Null hypothesis: DRTGS are exogenous

Specification: ED C DRTGS RR IB YSHOCK ED(-1) RTGSREG_1 RTGSREG_2 HOLIDAY

Instrument specification: C DRTGS(-1) DRTGS(-2) RR IB YSHOCK ED(-1) ED(-2) RTGSREG_1 RTGSREG_2 HOLIDAY

Endogenous variables to treat as exogenous: DEV_RTGS

	Value	df	Probability
Difference in J-stats	3.051261	1	0.0807

J-statistic summary:

	Value
Restricted J-statistic	12.17313
Unrestricted J-statistic	9.121868

Endogeneity Test

Null hypothesis: DCLEAR are exogenous

Specification: ED C DCLEAR RR IB YSHOCK ED(-1) CLEARREG_1 CLEARREG_2 HOLIDAY

Instrument specification: C DCLEAR(-1) DCLEAR(-2) RR IB YSHOCK ED(-1) ED(-2) CLEARREG_1 CLEARREG_2 HOLIDAY

Endogenous variables to treat as exogenous: DCLEAR

	Value	df	Probability
Difference in J-stats	0.241072	1	0.6234

J-statistic summary:

	Value
Restricted J-statistic	9.098977
Unrestricted J-statistic	8.857905

Heteroskedasticity and Serial Correlation Test for CS DEB_CARD Y INF DEPO DEB_CPOP INFRA

Test	Test Stat.		P Value
Heteroskedasticity: White test			
Chi-sq	1,603.927	Prob. chi-square (1,652)	0.7976
VEC residual serial correlation LM tests		Probs from chi-square with 49 df	
Lags: 1	50.15354		0.4274
2	42.15553		0.7448
3	57.74944		0.1834
4	42.767		0.7225

Heteroskedasticity and Serial Correlation Test for CS DEB_CARD Y INF DEPO DEB_CPOP INFRA

Test	Test Stat.		P value
Heteroskedasticity: White test			
Chi-sq	2,397.211	Prob. chi-square (2,436)	0.7085
VEC residual serial correlation LM tests		Probs from chi-square with 49 df	
Lags: 1	50.35882		0.4195
2	65.12036		0.0613
3	65.76833		0.0551
4	56.31361		0.2202
5	53.40957		0.3087
6	56.49819		0.2152
7	55.64499		0.2389

Endogeneity Test

Null hypothesis: ED are exogenous

Specification: LG C CS YG INF BI XR RR LG(-1)

Instrument specification: C CS (-1) CS (-2) CS (-3) CS (-4) YG YG(-1) YG(-2) YG(-3) YG(-4) INF INF(-1) INF(-2) INF(-3) INF(-4) BI (-1) BI (-2) BI(-3) BI (-4) LG(-1) LG(-2) LG (-3) LG (-4) XR XR(-1) XR (-2) XR (-3) XR (-4) RR RR(-1) RR(-2) RR(-3) RR(-4) HOLIDAY

Endogenous variables to treat as exogenous: CURSAV

	Value	df	Probability
Difference in J-stats	5.838016	1	0.0157
J-statistic summary:			

	Value
Restricted J-statistic	72.93654
Unrestricted J-statistic	67.09852

Endogeneity Test

Null hypothesis: ED are exogenous

Specification: LG C ED YG INF BI XR RR LG(-1)

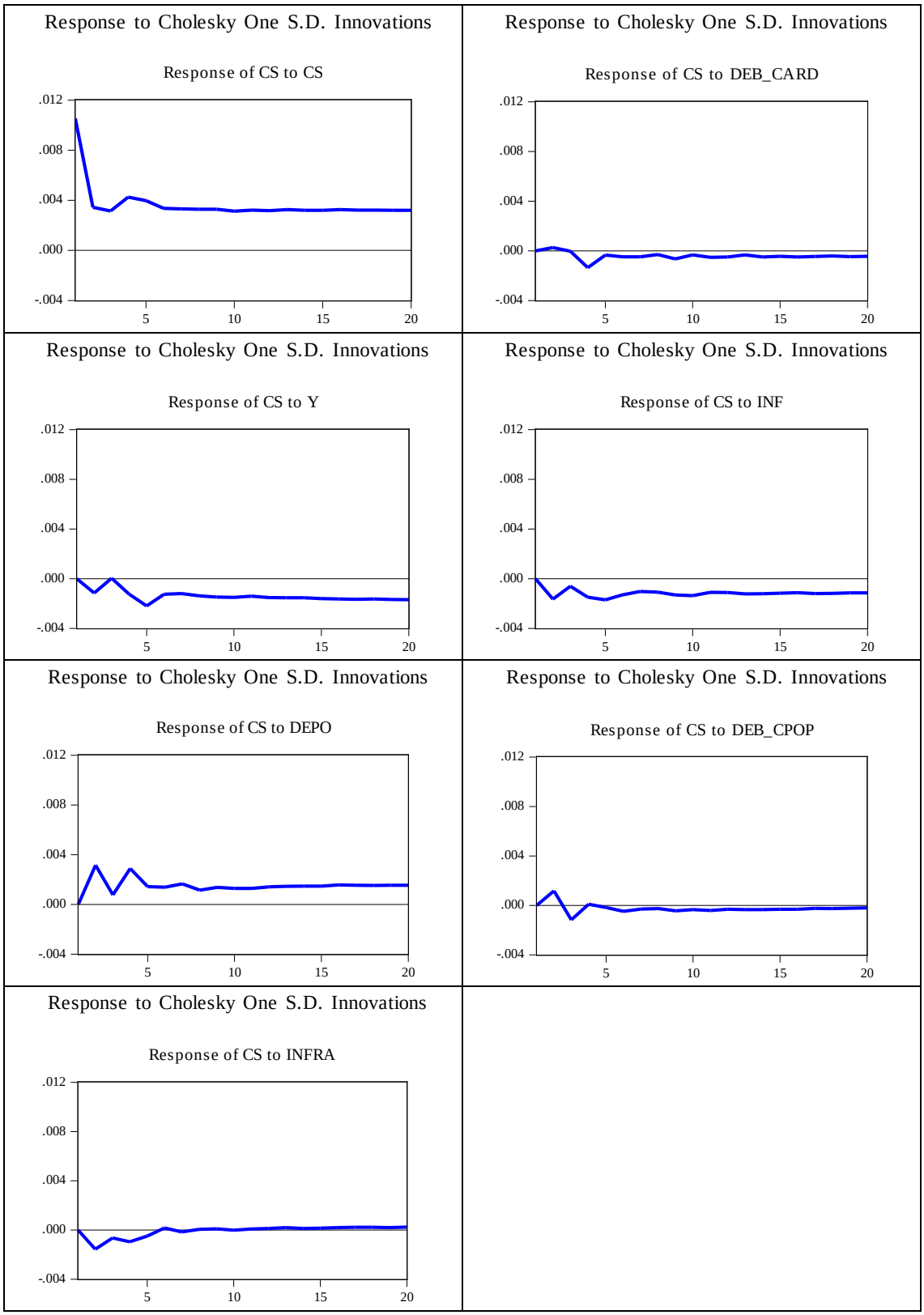
Instrument specification: C ED(-1) ED(-2) ED(-3) ED(-4) YG YG(-1) YG(-2) YG(-3) YG(-4) INF INF(-1) INF(-2) INF(-3) INF(-4) BI BI(-1) BI(-2) BI(-3) BI(-4) LG(-1) LG(-2) LG (-3) LG (-4) XR
XR(-1) XR (-2) XR (-3) XR (-4) RR RR(-1) RR(-2) RR(-3) RR(-4) HOLIDAY

Endogenous variables to treat as exogenous: ERDEP

	Value	df	Probability
Difference in J-stats	0.203625	1	0.6518
J-statistic summary:			

	Value
Restricted J-statistic	75.83774
Unrestricted J-statistic	75.63412

APPENDIX F: SELECTED IMPULSE RESPONSE OF THE VARIABLE CS



Appendix F *continued*