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Has the COVID-19 Pandemic Reshaped Non-Cash Payments in Indonesia?

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Abstract

This paper aims to quantify whether the COVID-19 pandemic has reshaped Indonesia's non-cash payments (NCP). Covering monthly real-time gross settlement (RTGS) of NCP data published by the Bank of Indonesia spanning the period 2009M01–2023M06, we explore the effect of the COVID-19 pandemic from March 2020 to June 2023 on NCP by implementing the Newey-West experiment of ITSA. The empirical results reveal that the ITSA precisely measures the COVID-19 pandemic impact on NCP transactions. The effect of the pandemic has varied on transaction volume using various proxies of NCP in Indonesia. The pandemic had a significant positive effect on electronic money in the first month. After that, however, the pandemic negatively affected total debit and credit card transactions. The trend of NCPs post-COVID-19 pandemic has been increasing, supported by positive trends in almost all selected sub-components of NCP except inter- and intrabank debit card transactions. These estimation results indicate that Indonesia's central bank should intensively innovate different NCP instruments of the payment system policy toward a non-cash society, especially post-pandemic.

Keywords: COVID-19, non-cash payment, interrupted time series, Indonesia.

1. Introduction

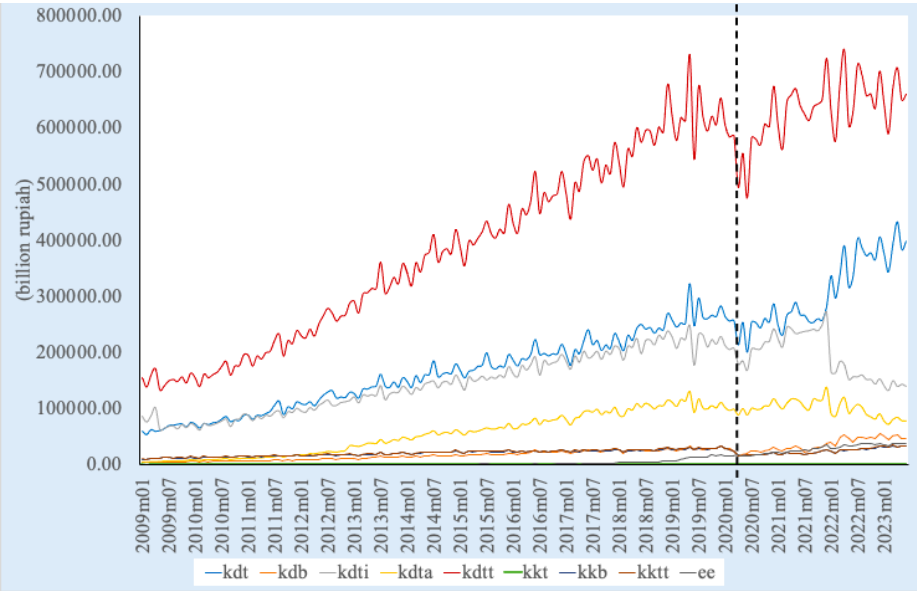
A critical issue of concern among academicians and policymakers is that the COVID-19 pandemic, a wide health crisis of unprecedented magnitude, has led to profound changes in various aspects of daily life, including how financial transactions are conducted. Many research studies revealed that the COVID-19 pandemic, along with advances in financial technology, has encouraged changes in the business and consumer methods of payments (Auer et al., 2020; Ganzha, 2022; Kotkowski & Polasik, 2021; Kraenzlin et al., 2020; Wisniewski et al., 2021; Xiao & Chorzempa, 2020). These behavior changes led to innovative, safe, efficient, and easy-to-use non-cash payment instruments (referred to as NCP). The usage of NCP is not only an effort to uphold COVID-19 protocols, requiring the public to maintain social distance (staying home and limiting human contact) to prevent the spread of the coronavirus, but also to streamline the checkout process, reducing waiting times and enhancing overall business and customer experience (Jonker et al., 2020). NCP allowed consumers to perform economic transactions from the safety of their homes, contributing to keeping the wheels of the economic and business activities running during the pandemic. Unfortunately, there are limited studies that measure the magnitude impact of the COVID-19 pandemic on NCP.

With effective vaccines for COVID-19 not yet found, or the vaccines not yet widely distributed to the public, implementing new-normal habit patterns and a less contact economy was an obligation for economic and business actors to bring economic activities in motion (Carbó-Valverde et al., 2023; Wallingford et al., 2023). In this condition, NCP instruments can be essential in implementing new-normal habits after the COVID-19 outbreak, leading to a less-contact economy. The COVID-19 pandemic acted as a catalyst, amplifying the reliance on NCP methods to respond to health and safety concerns. Although contactless payments are believed to lessen the transmission of COVID-19 compared to cash payments (Auer et al., 2020), it also depends on country-specific factors (Kotkowski &

Polasik, 2021; Schrooten & Varmaz, 2020). The kinds of non-cash instruments that can be optimized to finance a less contact economy are card-based payment instruments, internet banking, electronic money, club cards, e-banking, and so on (Bank Indonesia, 2023).

The COVID-19 pandemic has affected consumer payment behavior, including non-cash types of financial transactions in Indonesia (Bank Indonesia, 2023). Figure 1 shows NCP transactions in Indonesia from 2009M01 to 2023M06. For example, in May 2020, soon after the Government of the Republic of Indonesia officially declared the case of the COVID-19 pandemic infection on 2 March 2020, NCP instruments using automatic teller machines (called ATM) debit cards reached 554.75 trillion IDR or 527.2 million in transaction volume. Credit card utilization recorded 15.09 trillion IDR or 18.6 million in transaction volume. In contrast, electronic money reached 15.03 trillion IDR or 298.19 million in transaction volume. The NCP data pattern change relative to pre-pandemic is in line with the claims of Jonker et al. (2022) and Carbó-Valverde (2023). Even though the NCP patterns descriptively show a sudden change in trend from before to after the COVID-19 pandemic, the precise measure of the magnitude affected by the COVID-19 pandemic on NCP is still debatable. Hence, the substantial question is how the size and the rate of change of the impact the COVID-19 pandemic has on the use of NCP in Indonesia remain inconclusive.

Figure 1. Non-cash payment transactions in Indonesia over the period 2009M01 to 2023M06 in billion IDR



Source: Bank Indonesia (2023)

In this paper, we will address the previous question of how to capture the impact of the COVID-19 pandemic on NCP transactions. To the best of our knowledge, previous inquiries on the COVID-19 pandemic impact on the transactions of NCP in Indonesia are limited (e.g., Trisnowati et al., 2020; Ferlicia et al., 2022; Farida et al., 2023; Kotjoprayudi & Kastaman, 2023). However, most of these existing studies have weaknesses in research methods by directly comparing the data before and during the COVID-19 pandemic to seek the aftereffects of the COVID-19 outbreaks on NCP, which consequently leads to invalid evaluation methods and miscalculation of unobserved empirical results due to the intervention of the COVID-19 pandemic (see Soumerai et al., 2015). Thus, we argue that simply comparing NCP data before and during the COVID-19 pandemic makes is insufficient to conclude that NCP use occurs due to the COVID-19 pandemic. This issue can be scientifically understood due to the unavailable counterfactual data of NCP usage conditions without the COVID-19 pandemic and the lack of statistical model issues. Therefore, the construction of specific research methods that construct counterfactual data to calculate the aftereffects of the COVID-19 pandemic on NCP transactions is crucial. Regarding this problem, we claim that the interrupted time

series analysis (ITSA) proposed by Linden (2015) is a statistically efficient method to resolve how the level and the slope of the NCP transactions have changed in Indonesia before and after the pandemic. Thus, the study examines the hypothesis that the COVID-19 pandemic leads to a degree and instant positive change in the level and the slope of NCP transactions that continue to the post-COVID-19 pandemic intervention.

Therefore, with respect to previous arguments and literature, we primarily contribute to the novelty of the first quasi-experimental study in evaluating the aftereffects of the COVID-19 pandemic on NCP in Indonesia. Additionally, our main findings contribute to enlightening scholars and policymakers on tracking the impact of the COVID-19 pandemic in accelerating the realization of a cashless society, as indicated by economic and business transactions using NCP. Ultimately, it is expected to be widely cultivated business and financial transactions using NCP instruments, known as Less Cash Society (LCS). This study makes a significant contribution in four ways: 1) To seek unprecedented acceleration of trends in the payment landscape toward digital payments and the adoption of contactless methods; 2) to assess how COVID-19 pandemic concerns have driven the adoption of NCP and how these concerns might influence future payment preferences; 3) to provide insights into how the COVID-19 pandemic forces societies to adjust quickly to changes in payment behavior and technology, potentially guiding future changes in cashless financial practices; and 4) to initiates insights into how central banks manage money supply and monetary policy in a cashless-first world.

The rest of this paper is systematized as follows. In Section 2, we investigate the literature on NCP. Section 3 clarifies the methodology and data. We discuss the empirical results in Section 4 and close the paper in Section 5.

2. Literature Review

2.1 Evolution of Non-Cash Payment

NCP systems have become integral to modern economies, revolutionizing transactions and reshaping financial landscapes. Historically, NCP methods have undergone significant transformations. On a global level, since the 1920s, the United States has introduced NCP methods. NCPs were in the shape of shopping cards for customers who bought gasoline, and their functions were limited to card membership. Since then, NCP instruments have been growing. In 1946, Flatbush National Bank of Brooklyn initiated the NCP instrument for public usage as a credit payment system. The term used for this payment system was 'charge it'. This payment system aimed to facilitate transactions between customers of the same bank, namely consumers and shops or merchants (Mafiakartukredit, 2011).

The rise of computers and telecommunications paved the way for digital payment systems, effectively reducing the reliance on physical currency. Technological innovations have driven this evolution, enabling secure and efficient transactions across various platforms. In Indonesia, NCP instruments in the shape of credit cards first appeared in the 1980s. Bank Duta, in cooperation with VISA and Mastercard International, introduced credit card NCP instruments to the public. The target customers of Bank Duta were the upper class, especially those who often traveled abroad. Furthermore, Bank BCA followed the Ambassador Bank in issuing unique credit cards to employees and limited customers. Furthermore, in August 2014, the Governor of Bank Indonesia intensified the usage of NCP instruments. At that time, the Governor of Bank Indonesia propelled the National Non-Cash Movement (referred to as GNNT). GNNT aims to expand public literacy, businesses, and government institutions using NCP or LCS instruments in every business and financial transaction (Bank Indonesia, 2014).

Along with the evolution of NCP instruments, research on the usage of NCP instruments is rapidly growing, beginning with the seminal work of Boeschoten and Fase (1989). Today, many studies are carried out on NCP topics, both theoretical foundations and practical findings at the macro or micro level, either in developed countries, e.g., the United States, Belgium, and the Netherlands, or in developing countries, including Indonesia. Klee (2006), based on a data survey of consumer finances, states that self-employment and pension negatively affect debit card use in the United States. In the meantime, Hayashi and Klee (2003) found that consumers' utilization of debit cards is influenced by revenue and technology.

Loix et al. (2005) found that variable gender, education, and income positively influenced the shape of debit and credit card usage in Belgium, while age negatively influenced e-purse usage. Furthermore, Jonker (2005) showed that gender, education, and income positively affect debit card and e-purse usage in the Netherlands. The subsequent finding is that gender significantly negatively affects credit card use, while income positively influences credit card use. Raya and Vargas (2022) ratified gender, income, wealth, and education as drivers of credit card payment. Achsani et al. (2006) observed people using non-cash transaction facilities in Indonesia. They suggested that the chances of adopting NCP instruments at a young age (under 30 years) were higher. The amount of savings and expenses influences the usage of NCP instruments. These findings suggest more significant opportunities for the benefit of NCP instruments in the upper-middle-class, as indicated in savings rates and savings ability. Seldal and Nyhus (2022), in their US study, had findings in the same direction as Achsani et al. (2006). From a different perspective, Rahman et al. (2020) claim that perceived expectancy, technology, hedonic motivation, social influence, and innovativeness are why Malaysians adopt NCP.

2.2 Pandemics and Non-Cash Payment

The study of NCP instruments previously focused more on internal factors of consumer behavior, and very few related to external factors such as catastrophic events and pandemics. The emergence of the COVID-19 pandemic encouraged many researchers to explore whether the pandemic leads to the use of NCP instruments either at the macro or micro level. At the macro level, many papers have been published by scholars to examine the effect of the COVID-19 pandemic on NCP, including Auer et al. (2020) and Syse (2020). Auer et al. (2020) state that the chances of spreading the COVID-19 virus are higher when using banknotes and coins than NCP. Syse (2020) argued that during the pandemic, consumers in Germany prefer contactless payments. In to-date studies, Auer et al. (2023) found that the pandemic and lockdown drove payment app downloads for up to 95 countries.

Furthermore, in the Indonesian macro-level context, some papers tested the NCP due to the COVID-19 pandemic, i.e., Pramastri (2020), Trisnowati et al. (2020), Ferlicia et al. (2022), and Farida et al. (2023). Pramastri (2020) argues that the COVID-19 pandemic has forced Indonesians to make non-cash transactions. This condition is challenging for businesses, especially small and medium enterprises (SMEs). Using NCP instruments can cause SMEs to fail if their adaptability is relatively low to NCP. This failure will result in a decrease in the turnover and profit of SME businesses. Conversely, Trisnowati et al. (2020), Ferlicia et al. (2022), and Farida et al. (2023) examined the effect of the COVID-19 pandemic on non-cash transactions by estimating the NCP data before and after the pandemic and compared the results of the two estimation periods to capture the influence of the pandemic. Trisnowati et al. (2020), Ferlicia et al. (2022), and Farida et al. (2023) concluded significant differences in electronic money transactions before and after the COVID-19 pandemic, while debit and credit cards presented different results. Trisnowati et al. (2020) show no significant differences in debit and

credit transactions before and after the COVID-19 pandemic. Ferlicia et al. (2022) express no fluctuation in debit card transactions before and after the COVID-19 pandemic, while credit card transactions are declining after the COVID-19 pandemic.

At the micro level, intensive studies also discuss the aftereffects of the COVID-19 pandemic on NCP. Most of the recent literature has relied on people's perceptions of adopting NCP due to the COVID-19 pandemic (Huterska et al., 2021; Kotkowski & Polasik, 2021; Wisniewski et al., 2021). Wisniewski et al. (2021) and Ganzha (2022) state that European consumers choose NCP because they think holding cash raises the risk of COVID-19 infection. Furthermore, habits emerged among European consumers during periods of limitations and lockdowns to continue to enhance their choices for NCP transactions. Not only do these features change their appetite for transaction methods, but they also affect proclaimed plans to move away from paper-based payments to NCP after the pandemic ended. Ganzha (2022) specifically shows the effect of the COVID-19 pandemic on cards used for payment by comparing before and during the pandemic.

Francois et al. (2020) found that the COVID-19 pandemic caused migration from cash-to-cash transactions to cryptocurrencies. Surveys conducted in Africa report that consumers wanted electronic payments during the COVID-19 pandemic. Financial transactions in Kenya and Ghana have increased using mobile money, mobile wallets, and bank-to-wallet transactions. Nigeria, Egypt, and South Africa experienced an increase in account-to-account transfers. The Egyptian government increased electronic payment limits to expand the use of digital payments. Using survey data, Carbó-Valverde (2023) confirmed that the COVID-19 pandemic led to a shift in payment behavior in Spain. Additionally, Ainiyah et al. (2023) conducted a survey on the usage of e-money in Banjarnegara, Indonesia; they reported increasing e-money usage during the COVID-19 pandemic. Andriana et al. (2022)

presented the positive effect of the COVID-19 pandemic on the usage intensity of e-wallets in Indonesia.

The prior literature investigations, either at the macro or micro level, led to our main research foundation. Specifically, we argue that the literature did not present the counterfactual data on NCP during the COVID-19 pandemic, which subsequently led to the lack of statistical model issues and biased conclusions. Therefore, this study fills the existing research gap by constructing a robust research approach, known as Newey-West ITSA, to estimate the aftereffects of the COVID-19 pandemic on NCP in Indonesia. The Newey-West ITSA approach will theoretically avoid neglecting unobserved counterfactual data in the recent literature. Thus, the aftereffects of the COVID-19 pandemic on the NCP can be captured robustly.

3. Methods and Data

This study utilizes secondary data on real-time gross settlement (RTGS) transactions using NCP instruments issued by Bank Indonesia (2023) over the period 2009M01–2023M06. The NCP transaction units are in the number of billions of rupiah, which are then transformed into natural logarithmic. The reason we transformed the value of NCP into a natural logarithmic was, firstly, to reduce the effect of outliers and correspond compactly to a normal distribution, and secondly, so that the coefficients on the natural-log dimension possessed direct interpretability as estimated proportional changes (Gelman & Hill, 2007). The NCP proxy is the value of transactions using cash debit cards (KDT), shopping debit cards (KDB), intrabank transfer debit cards (KDTI), interbank transfer debit cards (KDTA), total debit cards (KDTT), cash credit cards (KKT), shopping credit cards (KKB), total credit cards (KKTT), and electronic money (EE).

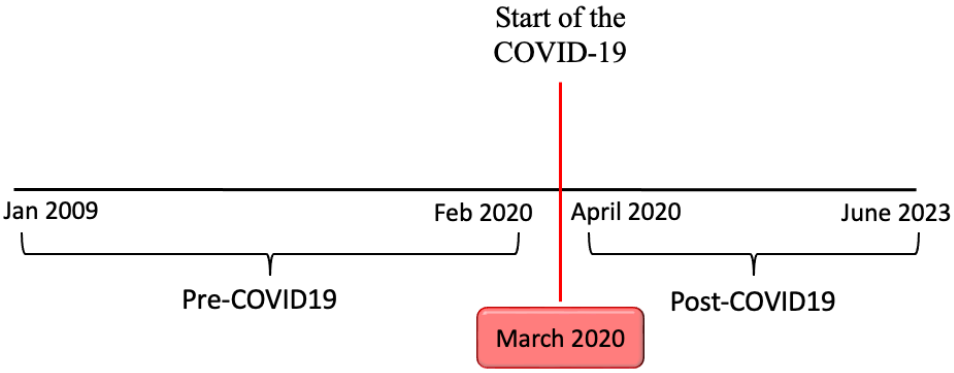
We defined NCP, KDT, KDB, KDTI, KDTA, KDTT, KKT, KKB, KKTT, and EE based on Bank Indonesia Regulation No. 11/11/PBI/2009, as amended by PBI No. 14/2/PBI/2012, PBI No. 20/6/PBI/2018, and PBI No. 23/6/PBI/2021. The NCP is defined as a payment system that uses card-based payment instruments, cheques, funds transfers, and debit notes, as well as card-based and server-based electronic money. Debit cards based on Article 184 of Bank Indonesia Regulation No. 23/6/PBI/2021 are defined as "… a card-based payment instrument that may be used for payments of liabilities arising from economic activity, including shopping transactions, in which the obligation of the cardholder is settled in real-time through a direct debit of the cardholder's account at a bank or nonbank institution authorized to mobilize funds under prevailing laws and regulations." Cash debit cards (KDT) are the value of cash transactions using debit cards. Shopping debit cards (KDB) are the value of shopping transactions using debit cards. The intrabank transfer debit cards (KDTI) are the value of money transfer within the same bank using debit cards. The interbank transfer debit cards (KDTA) are the value of money transfer within different banks using debit cards. Total credit cards (KKTT) are the total value of transactions using debit cards.

Furthermore, credit cards based on Article 182 of Bank Indonesia Regulation No. 23/6/PBI/2021 are stated as "… a card-based payment instrument used for payments of obligations arising from economic activity, including shopping transactions and/or cash withdrawals, in which the payment obligation of the cardholder is settled in advance by the acquirer or issuer and the cardholder is required to execute payment at an agreed term in a lump sum (charge card) or installments." Cash credit cards (KKT) are the value of cash transactions using credit cards. The shopping credit cards (KKB) are the value of shopping transactions using credit cards. Total credit cards (KKTT) are the total value of transactions using credit cards. Electronic money (EE), based on Article 156 of Bank Indonesia Regulation No. 23/6/PBI/2021, is described as "… a payment instrument that meets the

following criteria: a. Issued based on the value of currency deposited with the issuer; b. The electronic store of monetary value is server-based or chip-based."

The COVID-19 pandemic information relies on data published by Satuan Tugas Penanggulangan COVID-19 (2020). The COVID-19 pandemic phase began in March 2020, coinciding with the formal announcement of the first instance of COVID-19 found on 2 March 2020 (2020M03). This sample date corresponds to the 174th month within the 2009M01–2023M06 timeframe (Figure 2). The selection of the sample date is based on available data, assuming that no other noteworthy event may have influenced the NCP during that time period. We also consider the two significant spikes in the COVID-19 pandemic, i.e., COVID-19 Delta in July 2021 and COVID-19 Omicron in February 2022.

Figure 2. Timeline study in months



Source: Authors' illustration.

Experimental research is one of the methods that often refers to seeing an impact evaluation on an economy. The impact can be caused by implementing policy or the occurrence of an event, such as natural disasters, pandemics, and so on, which results in economic activity. The best standard method (gold standard) in conducting experimental research is randomized controlled trials (RCTs). However, RCT implementation often makes researchers encounter obstacles in meeting its strict criteria, e.g., design, running, and analysis. Therefore, it requires an alternative design study option that leads to the quasi-experimental approach (Hudson et al.,

2019). The choice of semi-experimental approach can be propensity score matching, difference-in-difference, interrupted time series analysis (henceforth ITSA), instrumental variable, and so on.

Based on data availability, the ITSA method is the toughest semi-experimental research method and often produces outcomes analogous to randomized controlled trials (Cook et al., 1979; Penfold & Zhang, 2013). ITSA concerns the time series data model, which has robust outcomes. It involves the level and the trend of the time series of interest. Then, an external intervention interrupts the level and the trend at the point in time. A counterfactual is constructed from a hypothetical set-up where intervention has not happened, and a pre-existing trend can remain uninterrupted. Later, ITSA allows for an evaluation between the counterfactual and post-intervention period (Baicker & Svoronos, 2019; Schober & Vetter, 2021).

The standard model of ITSA single-case regression is straightforward in the form (Linden, 2015):

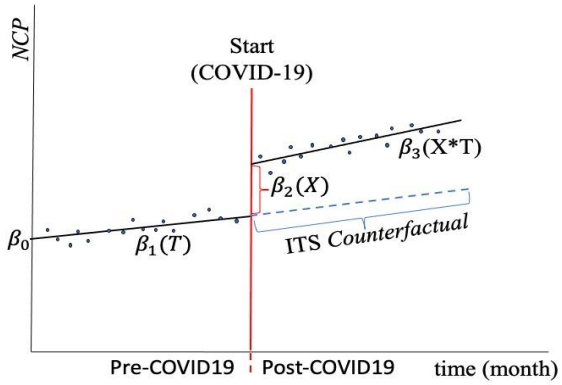
$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \epsilon_t \quad (1)$$

where Y_t is the product at period *t*, X_t is a dummy indicator representing interloping (before-interference periods 0 and otherwise 1), T_t covers the time length of study, and $X_t T_t$ is an interaction term. The β_0 is the expected baseline result level at the initial periods. β_1 represents the estimation of the base trend. β_2 indicates the estimation of change at the level (change in level) subsequently interloping (after-interference segment). β_3 represents the estimated change in trend (change in slope) after interloping (post-interference segment). The significant β_3 denotes an intervention effect over time. Lastly, ϵ_t is an error term. The segmented regression and ITSA model are estimated using the Newey-West method to show the coefficients of ordinary least squares (OLS). Furthermore, we utilize the Newey-West standard errors OLS to deal with the possibility of heteroscedasticity and

autocorrelations. To confirm the existence of autocorrelations, we employ Actest. Then, we select the best lags for model calculation.

Visualization of the interrupted time series approach (Ferron & Rendina-Gobioff, 2015; Linden, 2015) by initiating COVID-19 interventions and NCP, by assuming the positive consequences of the COVID-19 pandemic on NCP, is as follows:

Figure 3. Visualization of single-case ITS standard model



Source: Authors' illustration.

By specializing in the intervention of the COVID-19 pandemic on NCP, the ITSA single-case estimation standard model on equation (1) can be reformulated into segmented regression as follows:

$$NCP_t = \beta_0 + \beta_1 T_t + \beta_2 COVID19_t + \beta_3 COVID19_t T_t + \epsilon_t \quad (2)$$

where NCP_t represents NCP instruments at time t (i.e., monthly), dummy $COVID19_t$ describes the interloping of COVID-19 (before-COVID-19 periods 0 and otherwise 1), and T_t is the time. β_0 denotes the intercept or the evaluated level baseline of NCP at the initial series (before the COVID-19 interruption); it displays the starting point of the NCP. β_1 represents the slope or the estimated baseline trend (pre-COVID-19 slope); it can be inferred as the change in NCP related to a unit augmented by the time unit, pre-COVID-19. β_2 represents the estimated change at the level after a COVID-19 infection (post-COVID-19 change in intercept relative to the counterfactual baseline before the COVID-19 date). β_3 explains the estimated

trend change subsequently, an involvement (change in the slope post-COVID-19 pandemic); it shows the difference between the before and after COVID-19 slopes. The significant β_3 indicates the COVID-19 effect over time. And ϵ_t is an error process that acquires the unpredictability not discussed by the model. Equation (2) assumes that the COVID-19 of March 2020 is an entirely exogenous shock whose impact is captured by the coefficient of β_2 and β_3. Furthermore, the above equation is estimated using the Newey-West ITSA proposed by Linden (2015). The ITSA is a well-known research method for measuring intervention impacts, especially in medical studies (e.g., Biglan et al., 2000; Penfold & Zhang, 2013; Chattopadhyay et al., 2023; Li et al., 2023; Zhang & Rottman, 2023).

4. Results and Analysis

Table 1 demonstrates descriptive statistics on the NCP variables for 2009M01 to 2023M06. The descriptive statistics deliver an overview of an NCP position in the sample. The average total debit card is 432,114.00 billion IDR, with a standard deviation of 180,971.54 billion IDR. The average of total credit cards is nearly 21,156.09 billion IDR, with a standard deviation of 5,721.99 billion IDR. Moreover, the average total electronic money is about 7,814.54 billion IDR, with a standard deviation of 11,953.61 billion IDR.

Table 1. Statistic descriptive

Variable (abbreviation)	Obs	Mean	SD	Min	Max	Measurement	Source of data
KDT	174.00	193,611.02	89,220.32	54,136.06	431,410.88	Billion IDR	Bank Indonesia
KDB	174.00	19,996.70	12,252.45	3,873.90	54,034.05	Billion IDR	Bank Indonesia
KDTI	174.00	154,915.21	54,035.35	61,862.80	270,316.78	Billion IDR	Bank Indonesia
KDTA	174.00	63,431.91	37,755.02	4,302.73	136,236.31	Billion IDR	Bank Indonesia
KDTT	174.00	432,115.00	180,971.54	133,164.62	738,911.06	Billion IDR	Bank Indonesia
KKT	174.00	552.42	179.75	286.13	934.79	Billion IDR	Bank Indonesia
KKB	174.00	20,603.67	5,570.31	8,784.32	33,638.46	Billion IDR	Bank Indonesia

KKTT	174.00	21,156.09	5,721.99	9,070.45	34,373.15	Billion IDR	Bank Indonesia
EE	174.00	7,814.54	11,953.61	21.66	37,832.33	Billion IDR	Bank Indonesia

Source: Authors' calculation.

To handle time series data, detecting unit roots is a crucial part of this study. Since the Augmented Dickey-Fuller (ADF) test and the Phillips and Perron (PP) test ignore the structural break and lead to a biased non-rejection null hypothesis (Baicker & Svoronos, 2019), we employ the Break-Point (BP) test (Perron, 1997) and the Zivot-Andrews (ZA) test (Zivot & Andrews, 1992). The outcomes of unit root tests are displayed in Table 2. Most structural breaks were statistically significant at the beginning of the COVID-19 pandemic (2020M4). The structural breaks in the NCP are preliminarily hypothesized to be caused by the COVID-19 pandemic. These findings lead to the importance of our study to inquire about the magnitude impact of the COVID-19 pandemic on NCP using the Newey-West ITSA.

Table 2. Unit root tests

Variables	Intercept	Month of Break	Intercept and Trend	Month of Break
	Break Point (BP) Unit Root Test			
lnKDT	-3.900	2021M12	-6.125***	2010M02
lnKDB	-3.334	2021M08	-5.436***	2019M05
lnKDTI	2.936	2010M02	-4.210*	2010M04
lnKDTA	-3.238	2011M03	-1.759	2010M02
lnKDTT	-4.210*	2010M04	-4.424	2010M02
lnKKT	-4.382*	2014M07	-4.811*	2020M03
lnKKB	-3.084	2010M02	-5.189**	2020M01
lnKKTT	-3.049	2010M02	-5.351***	2020M01
lnEE	-3.536	2017M09	-5.968***	2017M09
	Zivot Andrews (ZA) Unit Root Test			
lnKDT	-3.680**	2019M06	-3.513***	2020M01
lnKDB	-3.174**	2018M01	-3.458***	2020M01
lnKDTI	-1.737**	2021M04	-4.032	2018M10
lnKDTA	-1.709	2012M03	-2.474	2012M12

lnKDTT	-2.363***	2019M06	-3.164	2015M12
lnKKT	-4.702***	2020M04	-4.629***	2020M04
lnKKB	-4.636***	2020M01	-7.282***	2020M04
lnKKTT	-4.749***	2020M01	-7.543***	2020M04
lnEE	-5.286***	2017M10	-4.584***	2017M10

Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, separately.

Source: Authors' calculation.

The empirical findings of the COVID-19 pandemic impact on Indonesia's NCP employing the single-group ITSA-Newey model for the period 2009M01–2023M06 display varied results. The analysis is divided into two sub-components of NCP transactions. The first shows the projected upshot of the COVID-19 pandemic on the seasonally adjusted natural log of debit card transactions (see Table 3 and Figure 4). The second presents the effect of the pandemic on the seasonally adjusted natural logarithm of credit cards and electronic money (see Table 4 and Figure 5).

Table 3 and Figure 4 present the COVID-19 pandemic effects on transactions using cash debit cards (KDT), shopping debit cards (KDB), intrabank transfer debit cards (KDTI), interbank transfer debit cards (KDTA), and total debit cards (KDT). Before the COVID-19 (pre-COVID-19) pandemic publicized by the Government of Indonesia on 2 March 2020, the starting levels of KDT, KDB, KDTI, KDTA, and KDT were 11.14%, 8.45%, 11.15%, 8.88%, and 11.91%, respectively. The slope of pre-COVID-19 interventions on debit card transactions showed a significant positive impact at the 1% level. The positive effects were presented by each slope of 0.01% of cash debit cards, 0.02% of shopping debit cards, 0.01% of intrabank transaction debit cards, 0.02% of interbank transaction debit cards, and 0.01% of total debit cards.

Table 3. Estimated results of ITSA for debit card transactions

Variables	KDT	KDB	KDTI	KDTA	KDTT
	(1)	(2)	(3)	(4)	(5)
ITSA – Newey Results of COVID-19 Impact					
Constant	11.137***	8.453***	11.146***	8.883***	11.910***
	(0.024)	(0.028)	(0.026)	(0.071)	(0.022)
Time	0.011***	0.015***	0.010***	0.024***	0.012***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Post-COVID-19 period	-0.350***	-0.651***	-0.088	-0.556***	-0.291***
	(0.033)	(0.062)	(0.075)	(0.089)	(0.037)
Time x post-COVID-19 period	0.004***	0.012***	-0.022***	-0.030***	-0.007***
	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)
Postintervention Linear Trend: March 2020					
Treated	0.058***	0.027***	-0.012***	-0.006***	0.006***
	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)
Observations	174	174	174	174	174

Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, respectively. And the Newey-West standard errors are in parentheses.

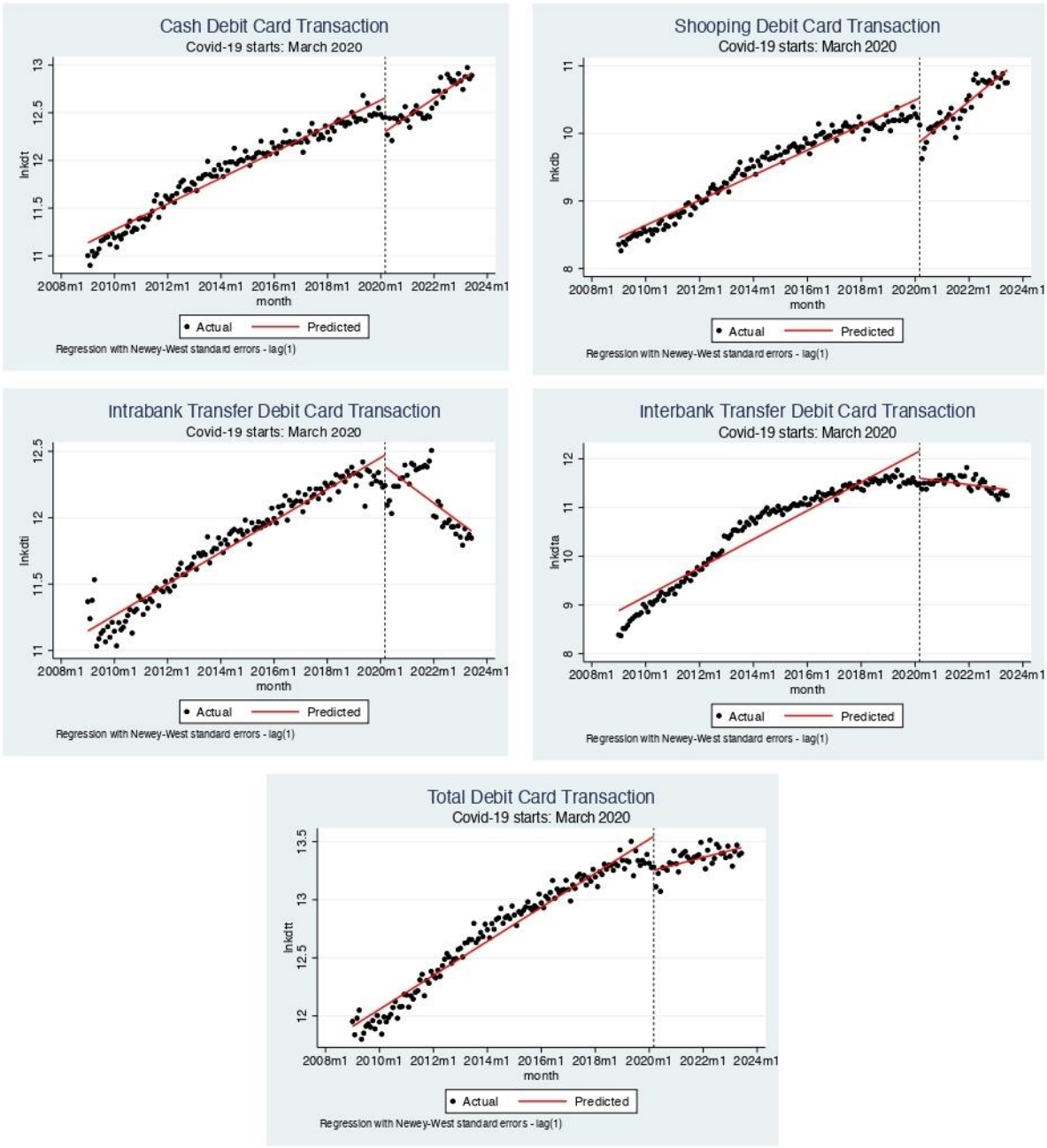
Source: Authors' calculation.

The official pronouncement of the COVID-19 pandemic occurred on 2 March 2020, marking the beginning of the first month of the pandemic. The usage of NCP instruments of debit cards declined, as shown by changes in intercept. The decrease in debit card transactions was indicated by changes in intercepts marked as significantly negative at the 1% level. Predicted results exhibit negative changes in post-COVID-19 levels in transactions using cash debit cards of 0.35%, shopping debit cards of 0.65%, intrabank transaction debit cards of 0.09%, interbank transaction debit cards of 0.56%, and total debit cards of 0.29%. However, the monthly trend of debit card transactions varies by transaction type. The monthly trend of cash debit card transactions and shopping debit card transactions experienced an increase of approximately 0.01% and 0.02%, respectively, and significance at the 1% level. However, the monthly trend of intrabank transaction debit cards and interbank transaction debit cards declines and is statistically insignificant at the 1% level. When the post-COVID-19 intervention trend is

considered, the total debit card transactions increase and are statistically significant at 1%.

Figure 4 depicts the NCP transactions trend using debit cards in the form of cash debit card transactions, shopping debit cards, intrabank transaction debit cards, interbank transaction debit cards, and total debit cards pre-COVID-19 intervention and post-COVID-19 intervention. The trend of post-COVID-19 debit card transactions increased, yet the line trend was still under the trend line before the COVID-19 pandemic. The increasing debit card transactions trend is proxied by cash debit cards, shopping debit cards, and total debit cards. However, the intrabank debit cards and interbank debit card transactions experienced a decreasing trend post-COVID-19 intervention. The decreasing intrabank debit card transactions are sharper than the interbank debit card transactions. This is because real economic and business activity is still in recovery.

Figure 4. Single-group ITSA for the COVID-19 pandemic impact on debit card transactions from March 2020 to June 2023



Source: Authors' calculation.

Indonesia has experienced the COVID-19 pandemic with significant spikes at some points in time, such as COVID-19 Delta in July 2021 and COVID-19 Omicron in February 2022, while at other times there were no spikes. These facts undoubtedly can affect the usage of NCP by the public. Thus, we consider these situations in our estimation strategy by employing ITSA with multiple treatment periods. Since there were two significant spikes of the COVID-19 pandemic, we

chose the highest case spikes of the COVID-19 Omicron in February 2022 as our treatment, simultaneously with the initial COVID-19 pandemic in March 2020.

Table 4. Estimated results of multiple treatment periods ITSA for debit card transactions

Variables	KDT	KDB	KDTI	KDTA	KDTT
	(1)	(2)	(3)	(4)	(5)
ITSA with Multiple Treatment Periods - Newey Results of COVID-19 Impact					
Constant	11.137***	8.453***	11.146***	8.883***	11.910***
	(0.056)	(0.080)	(0.035)	(0.195)	(0.053)
Time	0.011***	0.015***	0.010***	0.024***	0.012***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Post-COVID-19 period	-0.292***	-0.634***	-0.289***	-0.698***	-0.341***
	(0.054)	(0.086)	(0.039)	(0.198)	(0.054)
Time x post-COVID-19 period	-0.003***	0.008***	0.000	-0.016***	-0.002*
	(0.001)	(0.002)	(0.002)	(0.003)	(0.001)
Post-COVID-19 Omicron period	0.158***	0.243***	-0.373***	-0.101***	-0.052***
	(0.011)	(0.020)	(0.021)	(0.014)	(0.009)
Time x post-COVID-19 Omicron period	0.003***	-0.014***	-0.024***	-0.029***	-0.009***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Postintervention Linear Trend: March 2020					
Treated	0.009***	0.024***	0.010***	0.009***	0.010***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Postintervention Linear Trend: February 2022					
Treated	0.012***	0.010***	-0.014***	-0.021***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	174	174	174	174	174

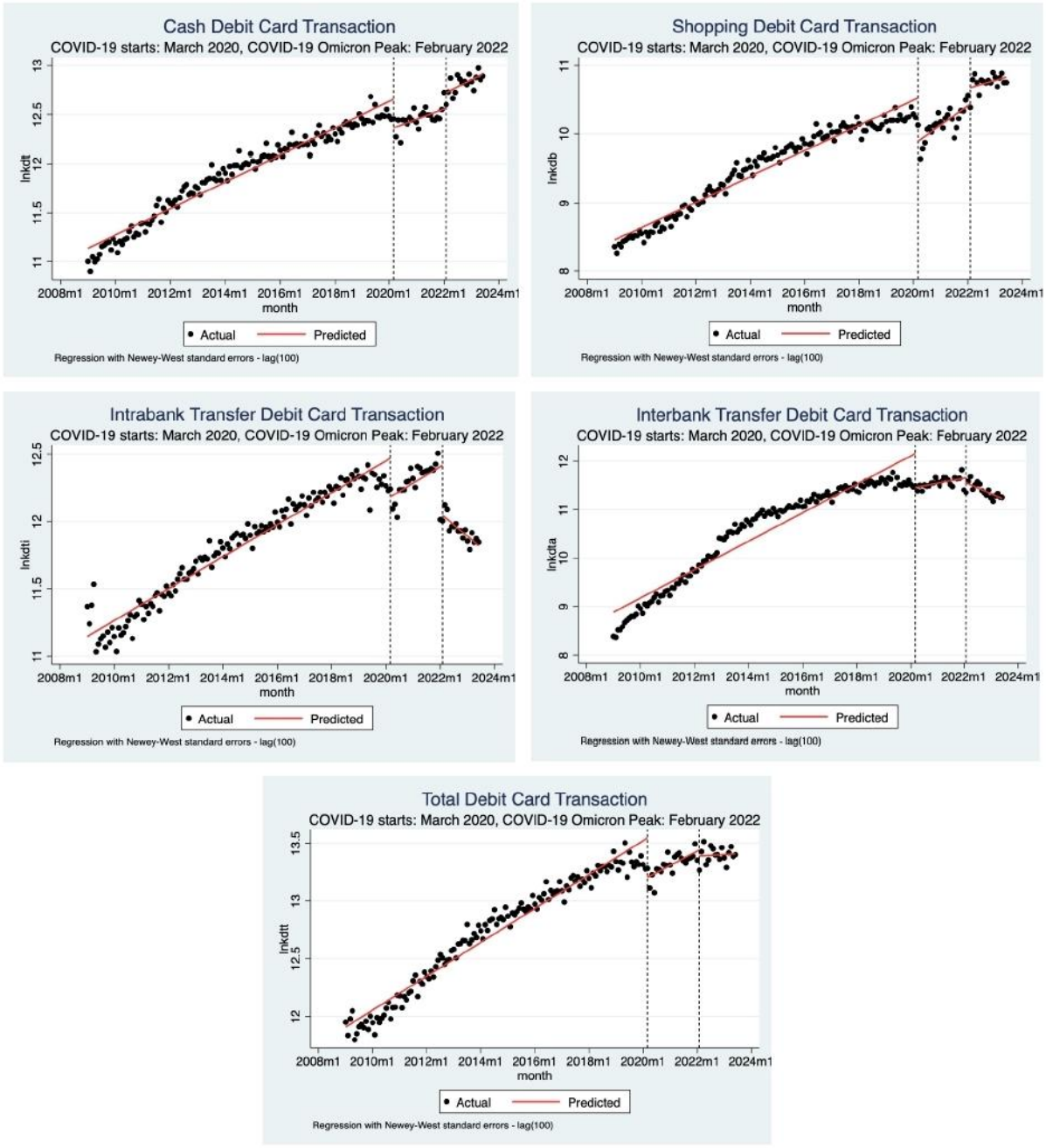
Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, respectively. And the Newey-West standard errors are in parentheses.

Source: Authors' calculation.

Table 4 and Figure 5 display multiple treatment periods of the COVID-19 pandemic effects on transactions using cash debit cards (KDT), shopping debit cards (KDB), intrabank transfer debit cards (KDTI), interbank transfer debit cards (KDTA), and total debit cards (KDT). The first treatment is based on the first official

announcement of the COVID-19 pandemic on 2 March 2020, called the initial COVID-19 pandemic. Subsequently, the second treatment is constructed on the highest peak case of the COVID-19 Omicron pandemic, 16 February 2022. The estimation results of the impact of the initial COVID-19 pandemic on NCP related to debit card transactions show no difference in results from the previous results in Table 3 for almost all level changes of KDT, KDB, KDTI, KDTA, and KDTT, and slope changes of KDB, KDTI, KDTA, and KDTT. The initial COVID-19 pandemic negatively affected the level changes of KDT, KDB, KDTI, KDTA, and KDTT. While the trend changes of KDTI, KDTA, and KDTT were negatively affected by the initial COVID-19 pandemic, the KDB experienced a positive trend change during the initial COVID-19 pandemic. Moreover, the evaluation results of the impact of the highest COVID-19 Omicron on NCP show continually negative effects on the level change of KDTI, KDTA, and KDTT, yet positive effects on the level changes of KDT and KDB. The trend changes of KDB, KDTI, KDTA, and KDTT were negatively affected by the highest COVID-19 Omicron cases; the KDT experienced a positive trend change during the highest COVID-19 Omicron pandemic.

Figure 5. Single-group ITSA with multiple treatment periods of COVID-19 pandemic impact on debit card transactions from March 2020 to June 2023



Source: Authors' calculation.

Table 5 and Figure 6 highlight the impact of COVID-19 on transactions using cash credit cards (KKT), shopping credit cards (KKB), total credit cards (KKTT), and electronic money (EE). Before the COVID-19 (pre-COVID-19) pandemic was announced, the slope of pre-COVID-19 interventions on credit card transactions showed positive effects and was significant at the level of 1%. Each slope sign is

0.01% of cash credit cards, 0.01% of shopping credit cards, 0.01% of total credit cards, and 0.04% of electronic money.

Table 5. Estimated results of ITSA for credit cards and electronic money transactions

Variables	KKT	KKB	KKTT	EE
	(1)	(2)	(3)	(4)
ITSA - Newey Results of COVID-19 Impact				
Constant	5.651***	9.378***	9.402***	3.123***
	(0.032)	(0.022)	(0.021)	(0.090)
Time	0.009***	0.007***	0.007***	0.043***
	(0.000)	(0.000)	(0.000)	(0.002)
Post-COVID-19 period	-0.547***	-0.690***	-0.686***	0.813***
	(0.083)	(0.051)	(0.051)	(0.161)
Time x post-COVID-19 period	-0.001	0.012***	0.011***	-0.018***
	(0.003)	(0.002)	(0.002)	(0.002)
Postintervention Linear Trend: March 2020				
Treated	0.008**	0.010***	0.019***	0.025***
	(0.003)	(0.002)	(0.002)	(0.002)
Observations	174	174	174	174

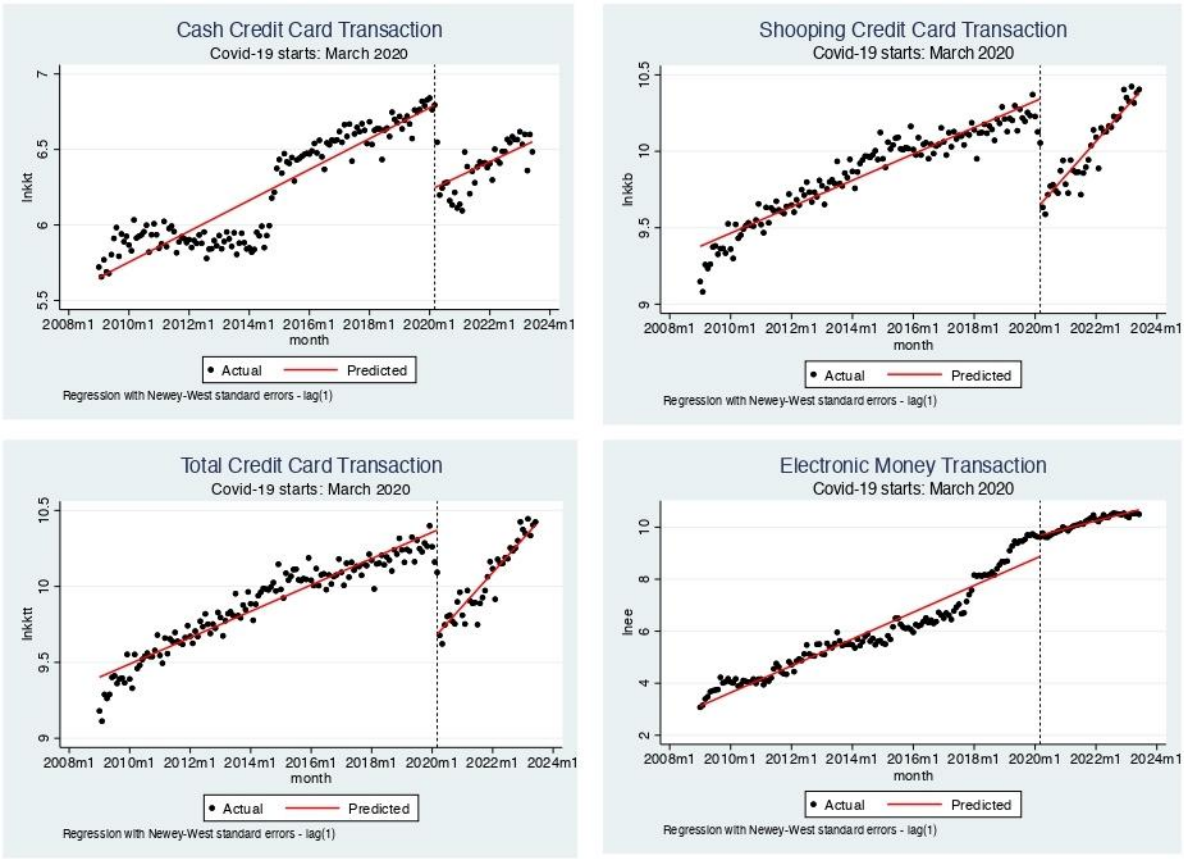
Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, correspondingly. And the Newey-West standard errors are in parentheses.

Source: Authors' calculation.

The first month of the COVID-19 pandemic's impact was publicized, leading to the usage of credit cards and electronic money transactions. The COVID-19 effect on credit card transactions is indicated by changes in intercepting transactions using credit cards. The estimated results found that the aftereffects of COVID-19 on credit card transactions displayed significant negative intercept changes at the 1% level. The calculated results show a negative alteration in the level of transactions using cash credit cards of 0.55%, shopping credit cards of 0.69%, and total credit cards of 0.69%. The decrease in the change in intercept is also seen in the trend of post-COVID intervention on cash credit cards (change in slope). Thus, the influence of the COVID-19 pandemic on cash credit card transactions shows a change in a negative trend, but it is statistically insignificant.

Interestingly, in the first month of the pandemic (i.e., March 2020), electronic money transactions increased by a statistically significant magnitude of 0.81%. However, this was followed by a decrease of 0.025% in the monthly electronic money trend (compared to before the pandemic). When the after-pandemic intervention is counted, electronic money transactions have increased at a statistically significant average rate of 0.03% since March 2020. This could be due to people's preference for shopping transactions using electronic money during the pandemic. The usage of electronic money as an effort to break the chain of the COVID-19 pandemic spread (Septianurmayanti & Prasetyo, 2023).

Figure 6. Single-group ITSA for the impact of COVID-19 on transactions using credit cards and electronic money from March 2020 to June 2023



Source: Authors' calculation.

Figure 6 shows the trend of NCP transactions using credit cards in the form of cash credit card transactions, shopping credit cards, total credit cards, and electronic money pre-COVID-19 interventions and post-COVID-19 interventions. The trend of pre-COVID-19 credit card transactions (pre-2 March 2020) has

increased, while the after-COVID-19 trend line (post-2 March 2020) has decreased. The overall trend of credit card transactions fell in cash credit card transactions, shopping credit cards, and total credit cards. Meanwhile, electronic money transaction trends increased both before and after the pandemic. The trend of increasing electronic money transactions after the pandemic is above the pre-pandemic trend line, aligning with Syse (2020), Ganzha (2022), and Tut (2023).

Furthermore, we also conducted ITSA with multiple treatment periods for credit cards and electronic money transactions. As mentioned before, the multiple treatment periods consist of the initial COVID-19 pandemic in March 2020 and the COVID-19 Omicron in February 2022. Table 6 and Figure 7 underline estimation results of the impact of the COVID-19 pandemic with multiple treatment periods on transactions using cash credit cards (KKT), shopping credit cards (KKB), total credit cards (KKTT), and electronic money (EE).

Table 6. Estimated results of multiple treatment periods ITSA for credit cards and electronic money transactions

Variables	KKT	KKB	KKTT	EE
	(1)	(2)	(3)	(4)
ITSA - Newey Results of COVID-19 Impact				
Constant	5.651***	9.378***	9.402***	3.123***
	(0.062)	(0.046)	(0.043)	(0.232)
Time	0.009***	0.007***	0.007***	0.043***
	(0.001)	(0.001)	(0.001)	(0.004)
Post-COVID-19 period	-0.489***	-0.633***	-0.629***	0.711**
	(0.058)	(0.049)	(0.047)	(0.294)
Time x post-COVID-19 period	-0.007**	0.006***	0.005***	-0.008**
	(0.003)	(0.001)	(0.001)	(0.004)
Post-COVID-19 Omicron period	0.111***	0.043**	0.045**	-0.031**
	(0.036)	(0.019)	(0.020)	(0.014)
Time x post-COVID-19 Omicron period	0.007**	0.012***	0.012***	-0.024***
	(0.003)	(0.002)	(0.002)	(0.001)
Postintervention Linear Trend: March 2020				

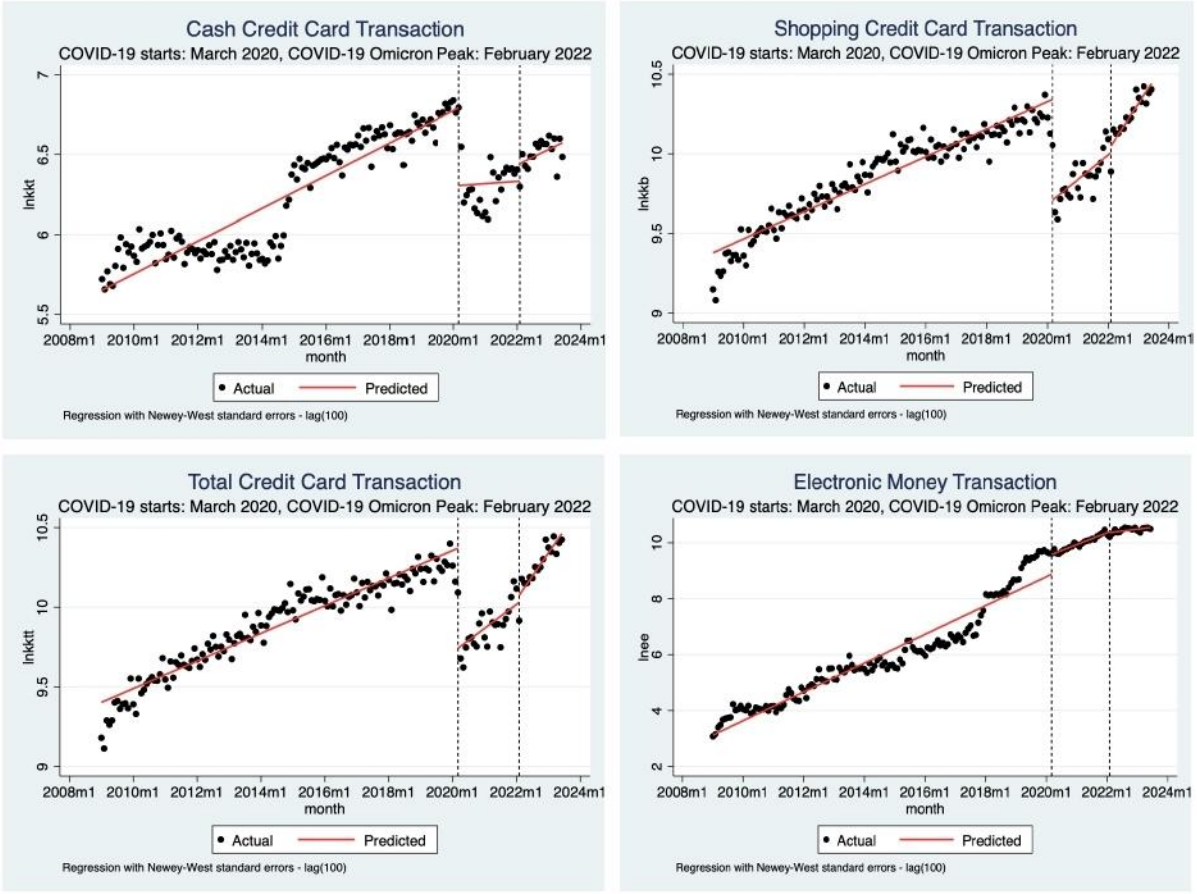
Treated	0.001	0.013***	0.013***	0.035***
	(0.003)	(0.001)	(0.001)	(0.001)
Postintervention Linear Trend: February 2022				
Treated	0.008***	0.025***	0.024***	0.011***
	(0.002)	(0.001)	(0.001)	(0.001)
Observations	174	174	174	174

Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, correspondingly. And the Newey-West standard errors are in parentheses.

Source: Authors' calculation.

The estimation results of the impact of the initial COVID-19 pandemic on NCP related to credit cards and electronic money confirm the previous results in Table 5 for all levels and slope changes of KKT, KKB, KKTT, and EE. The initial COVID-19 pandemic negatively affected the level changes of KKT, KKB, KKTT, and EE. While the trend changes of KKT and EE were negatively disturbed by the initial COVID-19 pandemic, the KKB and KKTT faced a positive trend change during the initial COVID-19 pandemic. Additionally, the assessment results of the impact of the highest COVID-19 Omicron cases on NCP related to credit card and electronic money transactions display positive effects on the level and slope changes of KKT, KKB, and KKTT, yet negative effects on the level and slope changes of EE.

Figure 7. Single-group ITSA with multiple periods for the impact of COVID-19 on transactions using credit cards and electronic money from March 2020 to June 2023



Source: Authors' calculation.

In general, with either a single treatment period or multiple treatment periods, the negative impact of the pandemic on NCP transactions using debit cards and credit cards in Indonesia is related to the decrease in real economic activities. Real economic activity decreased during the COVID-19 pandemic, especially in tourism activities, hotel occupations, transportation activities, trade transactions, and investment sectors (Nasution et al., 2020). Furthermore, manufacturing industries, import, export, and economic growth experienced negative effects during the pandemic (Damuri & Hirawan, 2020). The decrease in real economic activity and rising uncertainty during the pandemic reduced transactions in economic and business activities, including the usage of NCP.

Specifically, the initial COVID-19 pandemic positively impacted NCP transactions using electronic money. The increase in NCP transactions using

electronic money aligns with the increasing interest and preference of the public in shopping and transactions using digital platforms during the pandemic. Our findings align with Auer et al. (2020), Ganzha (2022), Syse (2020), and Trisnowati et al. (2020). Furthermore, NCP transactions have less chance of spreading the COVID-19 virus than banknotes and coins (Auer et al., 2020). Moreover, Syse (2020) and Ganzha (2022) state that consumers prefer contactless payments during the COVID-19 pandemic.

Although Bank Indonesia (2020a) has encouraged NCP transactions during the COVID-19 pandemic, economic actors and households tend to withhold transaction expenditures. This condition is caused by large-scale social restrictions (*Pembatasan Sosial Berskala Besar*, or PSBB), which have reduced the volume of business transactions, including NCP transactions. NCP transactions have the nature of dependency and trust of the community. Our findings show the COVID-19 pandemic forces consumers and businesses to use NCP, but the challenge is how to speed up a cashless society after the pandemic. Therefore, to increase public dependence and trust in NCP, it is essential to innovate the NCP system alongside the pandemic (Sudha et al., 2020). Accelerating NCP must also be accompanied by creating a new model for the post-COVID-19 banking business (Carletti et al., 2020). Additionally, the acceleration of NCP also requires integrated efforts from local governments by implementing local government transaction electronification, social assistance electronification, and transportation electronification (Bank Indonesia, 2020b).

4.1 Robustness Check

To ensure the robustness of the primary empirical findings, we apply Prais-Winsten AR(1) regression with robust standard error for NCP and sub-components. As a part of the generalized least squares, the Prais-Winsten AR(1) is used to internalize the AR(1) serial correlation of the errors in an estimation model to de-

correlate the error terms (Bottomley et al., 2023). The comprehensive robustness findings are recapped in Tables 7 and 8.

The robustness checks confirm the negative and statistically significant influences of the COVID-19 pandemic on debit cards, credit cards, and electronic money transactions in the first month (change in level), as revealed in Tables 7 and 8. Likewise, the change in trend shows a positive effect of the pandemic on cash debit card transactions and shopping debit card transactions. Meanwhile, the change in the trend of intrabank debit cards and interbank debit card transactions continued to decrease post-pandemic. However, the change in the trend of total credit card transactions is positive and statistically significant post-pandemic. Thus, robustness checks ratify mostly the previously main empirical findings.

Table 7. Robustness check for debit card transactions

Variables	KDT	KDB	KDTI	KDTA	KDTT
	(1)	(2)	(3)	(4)	(5)
Prais-Winsten AR(1) regression -- iterated estimates					
Constant	11.141***	8.476***	11.158***	8.819***	11.919***
	(0.029)	(0.047)	(0.046)	(0.263)	(0.029)
Time	0.011***	0.015***	0.010***	0.024***	0.012***
	(0.000)	(0.001)	(0.001)	(0.003)	(0.000)
Post-COVID-19 period	-0.277***	-0.379**	-0.058	-0.039*	-0.223***
	(0.087)	(0.150)	(0.059)	(0.022)	(0.064)
Time x post-COVID-19 period	0.002	0.004	-0.023***	-0.042***	-0.009***
	(0.003)	(0.006)	(0.002)	(0.011)	(0.002)
AR Parameter					
ρ	0.517	0.708	0.579	0.932	0.533
Observations	174	174	174	174	174
R-squared	0.951	0.893	0.941	0.769	0.961
Durbin-Watson (original)	1.010	0.754	0.826	0.185	0.980
Durbin-Watson (transformed)	2.334	2. 260	2.331	2.657	2.367

Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, respectively. And robust standard errors are in parentheses.

Source: Authors' calculation.

Table 8. Robustness check for credit card and electronic money transactions

Variables	KKT	KKB	KKTT	EE
	(1)	(2)	(3)	(4)
Prais-Winsten AR(1) regression -- iterated estimates				
Constant	5.705***	9.381***	9.405***	2.988***
	(0.071)	(0.025)	(0.024)	(0.244)
Time	0.007***	0.007***	0.007***	0.046***
	(0.001)	(0.000)	(0.000)	(0.003)
Post-COVID-19 period	-0.106	-0.637***	-0.639***	-0.001
	(0.137)	(0.105)	(0.100)	(0.037)
Time x post-COVID-19 period	-0.012*	0.010***	0.010***	-0.009
	(0.006)	(0.004)	(0.003)	(0.012)
AR Parameter				
ρ	0.826	0.341	0.320	0.928
Observations	174	174	174	174
R-squared	0.752	0.882	0.884	0.485
Durbin-Watson (original)	0.589	1.345	1.382	0.200
Durbin-Watson (transformed)	2.265	2. 079	2.066	2.135

Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, respectively. And robust standard errors are in parentheses.

Source: Authors' calculation.

Furthermore, we also conduct the robustness checks for the multiple treatment periods of Prais-Winsten AR(1) regression with robust standard error for NCP and sub-components. The complete robustness outcomes are summarized in Tables 9 and 10. Table 9 presents the robustness checks for the impact of the multiple treatment periods of the COVID-19 pandemic on debit card transactions, while Table 10 demonstrates the robustness checks for the impact of the multiple treatment periods of the pandemic on credit card and electronic money transactions. Although some of the impacts of multiple treatment periods of the pandemic are statistically not significant on NCP, the signs of level and trend changes confirm the baseline report in Tables 4 and 6. The main reason why some levels of change in the initial COVID-19 pandemic and levels and trends of change in the highest COVID-19 Omicron Cases are not significant is that the number of observations after the

multiple treatment periods is too small (Hawley et al., 2019). We can compare these results to robustness checks in Tables 7 and 8, which only observe a single treatment of the COVID-19 pandemic with relatively more observations post-intervention.

Table 9. Robustness check of ITSA with multiple treatment periods for debit card transactions

Variables	KDT	KDB	KDTI	KDTA	KDTT
	(1)	(2)	(3)	(4)	(5)
Prais-Winsten AR(1) regression -- iterated estimates					
Constant	11.139***	8.475***	11.153***	8.818***	11.919***
	(0.028)	(0.050)	(0.031)	(0.265)	(0.029)
Time	0.011***	0.015***	0.010***	0.024***	0.012***
	(0.000)	(0.001)	(0.000)	(0.003)	(0.000)
Post-COVID-19 period	-0.237**	-0.344**	-0.227***	-0.038*	-0.242***
	(0.095)	(0.155)	(0.072)	(0.021)	(0.087)
Time x post-COVID-19 period	-0.003	0.001	-0.005	-0.042*	-0.007
	(0.006)	(0.011)	(0.007)	(0.022)	(0.006)
Post-COVID-19 Omicron period	0.055	-0.051	-0.268***	-0.044	-0.046
	(0.102)	(0.128)	(0.098)	(0.047)	(0.072)
Time x post-COVID-19 Omicron period	0.010	0.011	-0.023**	0.005	-0.002
	(0.011)	(0.020)	(0.009)	(0.038)	(0.009)
AR Parameter					
ρ	0.501	0.725	0.363	0.932	0.961
Observations	174	174	174	174	174
R-squared	0.952	0.889	0.936	0.770	0.526
Durbin-Watson (original)	1.082	0.843	1.341	0.208	1.028
Durbin-Watson (transformed)	2.316	2.245	2.152	2.664	2.362

Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, respectively. And robust standard errors are in parentheses.

Source: Authors' calculation.

Table 10. Robustness check of ITSA with multiple treatment periods for credit card and electronic money transactions

Variables	KKT	KKB	KKTT	EE
	(1)	(2)	(3)	(4)
Prais-Winsten AR(1) regression -- iterated estimates				
Constant	5.691***	9.380***	9.404***	3.011***
	(0.067)	(0.025)	(0.024)	(0.235)
Time	0.008***	0.007***	0.007***	0.046***
	(0.001)	(0.000)	(0.000)	(0.003)
Post-COVID-19 period	-0.083	-0.570***	-0.573***	-0.006
	(0.118)	(0.140)	(0.134)	(0.030)
Time x post-COVID-19 period	-0.022**	0.003	0.003	0.008
	(0.009)	(0.009)	(0.008)	(0.017)
Post-COVID-19 Omicron period	-0.042	0.010	0.016	-0.118***
	(0.056)	(0.109)	(0.106)	(0.029)
Time x post-COVID-19 Omicron period	0.033	0.017	0.017	-0.034
	(0.023)	(0.012)	(0.011)	(0.024)
	AR Parameter			
ρ	0.813	0.348	0.323	0.922
Observations	174	174	174	174
R-squared	0.763	0.887	0.888	0.526
Durbin-Watson (original)	0.589	1.356	1.397	0.196
Durbin-Watson (transformed)	2.536	2.080	2.064	2.134

Note: ***, **, and * are statistically significant at the 1%, 5%, and 10%, respectively. And robust standard errors are in parentheses.

Source: Authors' calculation.

5. Conclusion

Research has estimated the impact of the COVID-19 pandemic on NCP in Indonesia. Evaluating the pandemic impacts on NCP is the ITSA-Newey Model on NCP transaction data published by Bank Indonesia from 2009M01 to 2023M06. Empirical findings of the impact on NCP show varying results. The pandemic negatively affected debit card and credit card transactions in the first month.

The main reason is that in the first month after the official announcement of the COVID-19 pandemic, followed by large-scale social restrictions (PSBB), undermined the business and economic activities engaging with high social intensity, especially in the travel and tourism business, shopping centers, and modern stores that intensively practiced debit and credit cards for transactions. On the contrary, the COVID-19 pandemic positively impacted NCP transactions using electronic money. The increasing number of electronic money transactions was due to the expansion of features and merchants for online transactions, which do not require physical contact. The trend of NCPs post-pandemic has been increasing, supported by positive trends in almost all selected sub-components of NCP, but not in inter- and intrabank debit card transactions.

Additionally, we also employ the Newey-West ITSA with multiple treatment periods to capture the high spikes of the COVID-19 Omicron cases. The findings present that the highest COVID-19 Omicron cases led to a decrease in the usage of debit cards and electronic money transactions and an increase in credit card transactions. The two years of the public experiencing the pandemic, from the first case of COVID-19 to the highest Omicron cases, led to a decrease in public money-saving in the form of debit and electronic money, which has pressured the public to use credit cards. The increasing usage of credit card transactions was also caused by economic pressure and financial insecurity during the COVID-19 Omicron cases. The increase in credit card transactions was a result of Bank Indonesia's relaxing credit card policies. Apart from that, banks also implemented relaxing policies for the public to maintain cash flow and reduce the impact of the economic slowdown due to the pandemic. The increase in credit card transactions was also due to people's acceptance and preference for online shopping, the spread of digital payments, and the acceleration of digital banking.

The research findings show that to accelerate the reshaping of Indonesia's less-cash society post-pandemic, it is necessary to have a comprehensive and

coordinated policy response to improve public interest and trust in NCP through NCP system innovation, to create a new post-pandemic banking business model, and to implement government transaction electronification, social assistance electronification, and transportation electronification. Furthermore, our empirical findings support accelerating the implementation of the central bank digital currency (CBDC) architecture involving Wholesale Rupiah Digital (w-CBDC) and Retail Rupiah Digital (r-CBDC) in July 2024. The limitation of this study is that the publishable data is for the national level only, making it impossible to conduct an experimental design with control and treatment across regions in Indonesia. Thus, we recommend future studies to conduct control and treatment regions using the gold standard RCT approach.

References

Achsani, N. A., Oktaviani, R., Wijayanto, H., Sumedi, Angraeni, T., Mulyati, H., … Rukmitasari, D. (2006). *Persepsi, preferensi dan perilaku masyarakat dan lembaga penyedia jasa terhadap pembayaran non tunai*.

Ainiyah, G. Z., Aziz, M. N., Permatasari, K. D., & Medikonis, Y. Y. (2023). Peningkatan penggunaan e-money di masa pandemi COVID-19. *MEDIKONIS: Jurnal Media Ekonomi Dan Bisnis*, *14*(1), 27–41.

Andriana, R., Falabiba, A., Dilla, F. P., Pramestyan, M. E. M., & Rakhmawati, D. Y. (2022). Pengaruh pandemi covid-19 terhadap intensitas penggunaan e-wallet. *Jurnal Pendidikan Tata Niaga*, *10*(3), 1766–1772.

Auer, R., Cornelli, G., & Frost, J. (2020). COVID-19, cash, and the future of payments. *BIS Bulletin*, (3), 3.

Auer, R., Cornelli, G., & Frost, J. (2023). *The pandemic, cash and retail payment behaviour: Insights from the future of payments database* (CESifo Working Paper, 10258). Cambridge: Bank for International Settlements. https://doi.org/10.2139/ssrn.4352370

Baicker, K., & Svoronos, T. (2019). *Testing the validity of the single interrupted time series design* (Becker Friedman Institute for Economics Working Paper No. 2019-97). University of Chicago. https://doi.org/10.2139/ssrn.3424248

Bank Indonesia. (2014). *Bank Indonesia mencanangkan gerakan nasional non tunai*. Retrieved from https://www.bi.go.id/id/ruang-media/siaran-pers/pages/sp_165814.aspx

Bank Indonesia. (2020a). *Edukasi sistem pembayaran non tunai saat COVID-19*. Retrieved from https://www.bi.go.id/covid19/Pages/Edukasi-Sistem-Pembayaran-Non-Tunai-Saat-COVID-19.aspx

Bank Indonesia. (2020b). *Program elektronifikasi*. Retrieved from https://www.bi.go.id/id/fungsi-utama/sistem-pembayaran/ritel/elektronifikasi/default.aspx#floating-3

Bank Indonesia. (2023). *Statistik sistem pembayaran*. Retrieved from https://www.bi.go.id/id/statistik/sistem-pembayaran/apmk/Contents/PenyelenggaraAPMK.aspx

Biglan, A., Ary, D., & Wagenaar, A. C. (2000). The value of interrupted time-series experiments for community intervention research. *Prevention Science*, *1*(1), 31–49. https://doi.org/10.1023/A:1010024016308

Boeschoten, W. C., & Fase, M. M. G. (1989). The way we pay with money. *Journal of Business & Economic Statistics*, *7*(3), 319. https://doi.org/10.2307/1391529

Bottomley, C., Ooko, M., Gasparrini, A., & Keogh, R. (2023). In praise of Prais-Winsten: An evaluation of methods used to account for autocorrelation in interrupted time series. *Statistics in Medicine*, *42*(8), 1277–1288. https://doi.org/10.1002/sim.9669

Carbó-Valverde, S., Cuadros-Solas, P. J., Rodríguez-Fernández, F., & Sánchez-Béjar, J. J. (2023). Mobility restrictions and payment choices: The case of the Covid-19 pandemic. *Journal of Behavioral and Experimental Finance*, *40*, 100850. https://doi.org/10.1016/j.jbef.2023.100850

Carletti, E., Claessens, S., Fatás, A., & Vives, X. (2020). *The bank business model in the post-covid-19 world*. IESE Banking Initiative.

Chattopadhyay, S., Ghosh, D., Maiti, R., Das, S., Biswas, A., & Chakraborty, B. (2023). A study of the impact of policy interventions on daily COVID scenario in India using interrupted time series analysis. *Epidemiologic Methods*, *12*(1). https://doi.org/10.1515/em-2022-0113

Cook, T. D., & Campbell, D. T. (1979). *Quasi-Experimentation: Design & Analysis Issues for Field Settings*. Rand McNally.

Damuri, Y. R., & Hirawan, F. B. (2020). Mengukur dampak COVID-19 pada pertumbuhan ekonomi dan perdagangan Indonesia 2020. *CSIS Commentaries DMRU-015*, (March), 1–8.

Farida, F., Binastuti, S., Silfianti, W., & Hermana, B. (2023). The impact of Covid-19 on electronic payment system: Lesson learned from Indonesian banking. *Technium Social Sciences Journal*, *40*, 200–212. DOI: 10.47577/tssj.v40i1.8295

Ferlicia, S., Suhel, & Andaiyani, S. (2022). Non-cash instruments and money supply in Indonesia during pandemic Covid-19. *Signifikan: Jurnal Ilmu Ekonomi*, *11*(2), 383–398.

Ferron, J., & Rendina-Gobioff, G. (2015). Interrupted time series design. *Wiley StatsRef: Statistics Reference Online*, *2*, 1–6. https://doi.org/10.1002/9781118445112.stat06764.pub2

Francois, B., Girancourt, J. De, Kuyoro, M., & Ofosu-amaah, N. A. (2020). How the COVID-19 crisis may affect electronic payments in Africa. Retrieved from https://www.mckinsey.com/~/media/mckinsey/industries/financial services/our insights/how the covid 19 crisis may affect electronic payments in africa/how-the-covid-19-crisis-may-affect-electronic payments-in-africa.pdf

Ganzha, D. (2022). The effect of COVID-19 on cashless payments. *Sociology Study*, *12*(6). https://doi.org/10.17265/2159-5526/2022.06.001

Gelman, A., & Hill, J. (2007). *Data analysis using regression and multilevel/hierarchical models* (1st ed.). Cambridge; New York: Cambridge University Press.

Hawley, S., Ali, M. S., Berencsi, K., Judge, A., & Prieto-Alhambra, D. (2019). Sample size and power considerations for ordinary least squares interrupted time series analysis: A simulation study. *Clinical Epidemiology*, *11*, 197–205. https://doi.org/10.2147/CLEP.S176723

Hayashi, F., & Klee, E. (2003). Technology adoption and consumer payments: Evidence from survey data. *Review of Network Economics*, *2*(2), 175–190. https://doi.org/10.2202/1446-9022.1025

Hudson, J., Fielding, S., & Ramsay, C. R. (2019). Methodology and reporting characteristics of studies using interrupted time series design in healthcare. *BMC Medical Research Methodology*, *19*(1), 1–7. https://doi.org/10.1186/s12874-019-0777-x

Huterska, A., Piotrowska, A. I., & Szalacha-Jarmużek, J. (2021). Fear of the COVID-19 pandemic and social distancing as factors determining the change in consumer payment behavior at retail and service outlets. *Energies*, *14*(14), 4191. https://doi.org/10.3390/en14144191

Jonker, N. (2005). *Payment instruments as perceived by consumers—A public survey* (DN B Working Paper 53). De Nederlandsche Bank.

Jonker, Nicole, van der Cruijsen, C., Bijlsma, M., & Bolt, W. (2022). Pandemic payment patterns. *Journal of Banking & Finance*, *143*, 106593. https://doi.org/10.1016/j.jbankfin.2022.106593

Klee, E. (2006). Families' use of payment instruments during a decade of change in the U.S. payment system. *Finance and Economics Discussion Series*. https://doi.org/10.17016/feds.2006.01

Kotjoprayudi, R. B., & Kastaman, K. (2023). Use of contactless payment system to prevent the spread of Covid-19 in Indonesia. *Accounting Information Systems and Information Technology Business Enterprise*, *8*(1), 16–30.

Kotkowski, R., & Polasik, M. (2021). COVID-19 pandemic increases the divide between cash and cashless payment users in Europe. *Economics Letters*, *209*, 110139. https://doi.org/10.1016/j.econlet.2021.110139

Kraenzlin, S., Meyer, C., & Nellen, T. (2020). COVID-19 and regional shifts in Swiss retail payments. *Swiss Journal of Economics and Statistics*, *156*(1), 14. https://doi.org/10.1186/s41937-020-00061-x

Li, Y., Liu, X., Li, X., Xue, C., Zhang, B., & Wang, Y. (2023). Interruption time series analysis using autoregressive integrated moving average model: evaluating the impact of COVID-19 on the epidemic trend of gonorrhea in China. *BMC Public Health*, *23*(1), 2073. https://doi.org/10.1186/s12889-023-16953-5

Linden, A. (2015). Conducting interrupted time-series analysis for single- and multiple-group comparisons. *Stata Journal*, *15*(2), 480–500. https://doi.org/10.1177/1536867x1501500208

Loix, E., Pepermans, R., & Van Hove, L. (2005). Who's afraid of the cashless society ? Belgian survey evidence. *Preliminary Journal*, 1–50.

Mafiakartukredit. (2011, June). Sejarah singkat kartu kredit di dunia. Retrieved from http://www.mafiakartukredit.com/2011/06/sejarah-singkat-kartu-kredit-di-dunia.html

Nasution, D. A. D., Erlina, E., & Muda, I. (2020). Dampak pandemi COVID-19 terhadap perekonomian Indonesia. *Jurnal Benefita*, *5*(2), 212. https://doi.org/10.22216/jbe.v5i2.5313

Penfold, R. B., & Zhang, F. (2013). Use of interrupted time series analysis in evaluating health care quality improvements. *Academic Pediatrics*, *13*(6 SUPPL.), S38–S44. https://doi.org/10.1016/j.acap.2013.08.002

Perron, P. (1997). Further evidence on breaking trend functions in macroeconomic variables. *Journal of Econometrics*, *80*(2), 355–385. https://doi.org/10.1016/S0304-4076(97)00049-3

Pramastri, M. A. (2020). Going cashless in the "new normal": Challenges for Indonesia's SMEs. Retrieved from https://cfds.fisipol.ugm.ac.id/article/548/normalisasi-pembayaran-di-era-new-normal

Rahman, M., Ismail, I., & Bahri, S. (2020). Analysing consumer adoption of cashless payment in Malaysia. *Digital Business*, *1*(1), 100004. https://doi.org/10.1016/j.digbus.2021.100004

Raya, J. M., & Vargas, C. (2022). How to become a cashless economy and what are the determinants of eliminating cash. *Journal of Applied Economics*, *25*(1), 543–562. https://doi.org/10.1080/15140326.2022.2052000

Satuan Tugas Penanggulangan COVID-19, C. (2020). Data COVID-19. Retrieved from https://covid19.go.id/

Schober, P., & Vetter, T. R. (2021). Segmented regression in an interrupted time series study design. *Anethesia and Analgesia Statistical Minute*, *132*(3), 696–697. https://doi.org/10.1213/ANE.0000000000005269

Schrooten, M., & Varmaz, A. (2020). Determinants of non-cash payments in the Eurozone: Culture matters. *Vierteljahrshefte Zur Wirtschaftsforschung*, *89*(4), 29–38. https://doi.org/10.3790/vjh.89.4.29

Seldal, M. M. N., & Nyhus, E. K. (2022). Financial vulnerability, financial literacy, and the use of digital payment technologies. *Journal of Consumer Policy*, *45*(2), 281–306. https://doi.org/10.1007/s10603-022-09512-9

Septianurmayanti, C. V., & Prasetyo, A. D. (2023). The impact of Covid-19 pandemic on electronic money transactions. In *Proceedings of the 3rd Annual Management, Business and Economics Conference (AMBEC 2021)* (pp. 48–59). https://doi.org/10.2991/978-94-6463-026-8_6

Soumerai, S. B., Starr, D., & Majumdar, S. R. (2015). How do you know which health care effectiveness research you can trust? A guide to study design for the perplexed. *Preventing Chronic Disease*, *12*, 150187. https://doi.org/10.5888/pcd12.150187

Sudha, G, Sornaganesh, V., Thangajesu Sathish, M., & Chellama, A. V. (2020). Impact of Covid-19 outbreak in digital payments. *Peer-Reviewed, Refereed, Indexed Journal with IC*, *87*(8), 86.

Syse, H. (2020). Paying in times of crisis. *Journal of Military Ethics*, *19*(1), 1. https://doi.org/10.1080/15027570.2020.1778880

Trisnowati, Y., Muditomo, A., Manalu, E. P. S., Kesuma P., Z., Adriana, D., & Dwiyani H. R. (2020). The COVID-19 pandemic's impact on Indonesia's electronic retail payment transactions. *2020 International Conference on Information Management and Technology (ICIMTech)*, 504–509. https://doi.org/10.1109/ICIMTech50083.2020.9211232

Tut, D. (2023). FinTech and the COVID-19 pandemic: Evidence from electronic payment systems. *Emerging Markets Review*, *54*, 100999. https://doi.org/10.1016/j.ememar.2023.100999

Wallingford, J., Martinez, E. M., & Masters, W. A. (2023). COVID-19 mobility restrictions and stay-at-home behaviour in 2020 were associated with higher retail food prices worldwide. *Global Food Security*, *37*, 100702. https://doi.org/10.1016/j.gfs.2023.100702

Wisniewski, T. P., Polasik, M., Kotkowski, R., & Moro, A. (2021). Switching from cash to cashless payments during the COVID-19 pandemic and beyond. *SSRN Electronic Journal*, (2017), 1–41. https://doi.org/10.2139/ssrn.3794790

Xiao, Y., & Chorzempa, M. (2020). How digital payments can help countries cope with COVID-19, other pandemics: Lessons from China. Retrieved from https://www.weforum.org/agenda/2020/05/digital-payments-cash-and-covid-19-pandemics/

Zhang, Y., & Rottman, B. M. (2023). Causal learning with interrupted time series data. *Judgment and Decision Making*, *18*, e30. https://doi.org/10.1017/jdm.2023.29

Zivot, E., & Andrews, D. W. K. (1992). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics*, *10*(3), 251. https://doi.org/10.2307/1391541