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FinTech and the COVID-19 pandemic: Evidence from electronic payment systems

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ABSTRACT

This paper investigates the effects of the coronavirus disease 2019 (COVID-19) pandemic on financial institutions and on consumers' adoption of Financial Technology (FinTech) for payments. This paper documents the following findings in Kenya. (1) The COVID-19 pandemic accelerated the adoption and increased the payment concentration of FinTech. We document an approximately 54% increase in mobile banking transactions, a 19.56% increase in mobile banking agents, and a 14.56% increase in the number of mobile banking accounts. (2) The use of all types of electronic payment cards declined significantly during the pandemic. (3) The pandemic magnified interbank contagion and liquidity risks and reduced both domestic and international electronic fund transfers via both the Real-Gross Settlement System and the Automated Clearing House. Overall, our results indicate that FinTech not only partially alleviated the negative impact of the COVID-19 pandemic during Q1 of 2021 but also accelerated consumers' adoption of FinTech and digital onboarding, especially in Q3 and Q4 of 2022.

1. Introduction

In this paper, we study the short-term effects of the coronavirus disease 2019 (COVID-19) pandemic on electronic payment systems in Kenya. Specifically, we address the question of whether the COVID-19 pandemic accelerated the adoption of Financial Technology (FinTech) payment platforms. The COVID-19 pandemic affected how bank customers accessed financial products and services. The use of electronic payments, including mobile banking and other FinTech platforms, is an important determinant of the cyclical position of the economy and is an indicator of economic growth (Aladangady et al., 2019; Baker, 2018; Galbraith and Tkacz, 2007). Electronic payments represent a unique source of information for short-term economic forecasting (Aprigliano et al., 2019) and are therefore useful in assessing the impact of extreme events such as the pandemic on consumers' choices and spending patterns.

To determine whether the COVID-19 pandemic accelerated the adoption of FinTech and related digital platforms for payments, we examine a country that has significant investments in FinTech and for which a significant fraction of the population uses mobile and digital banking: Kenya. Approximately 80% of Kenya's adult population uses mobile banking (Financial Stability Board [FSB], 2016; Financial Stability Board [FSB], 2017) for purposes such as opening a bank account, executing transactions, purchasing prepaid phone

Abbreviations: Coronavirus disease 2019, COVID-19; Financial Technology, FinTech; Automatic teller machine, ATM; Mobile money, M-PESA; Real-Time Gross Settlement System, RTGS; Automated Clearing House, ACH; Gross domestic product, GDP; Europay, MasterCard, and Visa, EMV; Point-of-sale, POS; U.S. dollars, USD; The Kenya Electronic Payments and Settlement System, KEPSS; Central Bank of Kenya, CBK; Financial Stability Board, FSB; Kenyan shillings, KSH; Herfindahl–Hirschman Index, HHI; Electronic fund transfers, EFTs; Domestic foreign currency checks, DFCCs.

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and credit cards, obtaining micro- and short-term loans, paying utility bills, peer-to-peer lending, and purchasing groceries (Jack and Suri, 2011; Jack et al., 2010). The adoption of FinTech has partially been driven by the limited number of bank branches and automatic teller machines (ATMs). As of the first quarter (Q1) of 2020, there were only 1255 bank branches and 2423 ATM machines in Kenya, a country that is the size of Belgium and France combined. While there are several banking platforms, the most dominant digital banking platform is M-PESA.[1] M-PESA uses short messaging service technology; mobile banking agents exchange cash for "e-money" that can then be transferred from one account to another. M-PESA also issues receipts for each transaction. In a country with weak legal institutions, this significantly reduces *ex-post* transaction costs (Mas and Morawczynski, 2009). Commercial banks in Kenya have partnered with FinTech platforms such as M-PESA to provide a wide range of financial services by means of these channels.

In this paper, we first address the following question: "What were the effects of the COVID-19 pandemic on the adoption of mobile banking and related digital platforms in Kenya?" Using a difference-in-differences estimation strategy and a Tobit model, we demonstrate that the COVID-19 pandemic accelerated the use of mobile banking in Kenya. We empirically show that a concentration in the form of payments has developed as a result of consumers shifting toward mobile banking during the COVID-19 pandemic. We also determine that there has been an increase in the average monthly value per mobile banking transaction; a 1-unit (KSH) increase in transaction value is associated with a 0.403 unit (KSH) increase in the predicted value of payment concentration (HHI). We examine transaction values using comparative univariate analysis and find that the number of mobile banking agents increased by 19.56% between the first and last quarters of 2020, suggesting that the COVID-19 pandemic accelerated consumers' onboarding into the FinTech space and that financial intermediaries have been responding to expected future changes in the form of payments during the COVID-19 pandemic. The estimated increase in transaction values between the first and fourth quarters of 2020 was approximately 53.97%, and the estimated increase in mobile banking accounts was about 14.56%. The rise in mobile banking during the pandemic was further accelerated by favorable regulatory measures imposed by the government. These measures included an increase in daily limits and the elimination of fees and charges. The government required commercial banks to eliminate all charges related to transfers between mobile money wallets and bank accounts and all charges for balance inquiries on all FinTech platforms. The government also reclassified the tax brackets for mobile banking transactions. These results suggest that the adoption of FinTech and other digital platforms combined with favorable regulatory measures might have weakened or reversed the adverse economic effects of the COVID-19 pandemic to some extent.

Second, we examine how the COVID-19 pandemic impacted the use of electronic payment cards, which is important since consumers tend to use different types of electronic payment systems and mobile banking concurrently.[2] The rate of mobile banking adoption during the pandemic also depended on the ease of use of other payment systems. In 2013, Kenya shifted away from magnetic strip–based cards to Europay, MasterCard, and Visa (EMV) chip–enabled cards, which led to an 11.3% increase in the use of electronic payment cards between 2013 and 2020, implying that consumers had more access to other payment systems. While our univariate analysis suggests that during the COVID-19 pandemic, there was a 19.23% year-over-year decline in credit card transaction values, a decline of 7.05% in debit card transactions, and of 40.87% in prepaid card transaction values, we do not find any statistical evidence of changes in the average monthly value per transaction using these forms of payment during the COVID-19 pandemic. However, the pandemic had a negative and statistically significant effect on the average monthly value per transaction at point-of-sale (POS) machines, reflecting a year-over-year decline of 11.16% in transaction values. In the case of charge cards, there is positive but statistically weak evidence of an increase in the average monthly value per transaction. This result is mostly driven by consumers' response to COVID-19 during the first quarter, as there was a 50% increase in charge card transaction values between April and May 2020. Charge cards are an attractive form of short-term borrowing; since they do not charge interest on outstanding amounts, consumers are only required to settle the full amount by the due date. However, as consumers shifted toward mobile banking due to health risks and uncertainty regarding the length of the pandemic, the use of charge cards also declined, especially in the third and fourth quarters of 2020. Overall, our results indicate that there was a decline in both the total value and volume of electronic payment cards in Kenya during the COVID-19 pandemic.

Third, we examine how the COVID-19 pandemic affected interbank linkages and liquidity flows via the Real-Time Gross Settlement System (RTGS) and the Automated Clearing House (ACH) network. The RTGS is the main channel for both domestic and foreign funds transfers in Kenya. Interbank fund transfers take place via both the RTGS and the ACH. A higher rate of interbank transfers reflects a healthy economy and an increase in lending and payment systems transactions. As a result, the effects of the COVID-19 pandemic on the RTGS and ACH has significant implications for the adoption and use of other forms of electronic payment systems in Kenya. We document the fact that the COVID-19 pandemic initially had a significant negative effect on the RTGS. The decline in value and volume transacted via the RTGS between December 2019 and May 2020 was approximately 21.97% and 7.97%, respectively. We also document a year-over-year decline in transaction values via the ACH of approximately 10.68% for debit check transfers and 2.37% for credit electronic funds transfers as well as a decline of 32.59% in foreign-denominated currencies (e.g., currencies denominated in U.S. dollars (USD)). The results from the RTGS and ACH suggest that the COVID-19 pandemic had a significantly adverse effect on domestic, regional, and international interbank liquidity flows and potentially compounded credit and settlement risks in Kenya's

[1] Note that "M" stands for mobile, and "PESA" is a Swahili word meaning "money." M-PESA, therefore, translates into "mobile money."

[2] Although there is no well-defined or exact definition of FinTech, our working definition is based on that of the Financial Stability Board (FSB): FinTech is a "technologically enabled financial innovation that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services." See https://www.fsb.org/work-of-the-fsb/policy-development/additional-policy-areas/monitoring-of-fintech/. https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/fintech/

financial system. These results align with the notion that outbreaks have a contagion effect (Bae et al., 2003; Bhagwati, 1998).

Our analysis considers the effects of the COVID-19 pandemic on electronic payment systems in Kenya. There are several important reasons why Kenya is an ideal setting for a natural experiment. Kenya is a small, indebted, emerging open-market economy with 54% of its domestic debt held by intricately linked domestic commercial banks. The ratio of commercial banks to the population (adult) is approximately 0.79 (1.5), the highest in Africa, implying that Kenya is significantly overbanked. Commercial banks' assets constitute about 49.5% of the country's nominal gross domestic product (GDP).

Kenya exhibits the highest usage and adoption of mobile banking and FinTech platforms in Africa. The banking sector, digital platforms, and the stock exchange are linked through the central bank's managed ACH and RTGS. This suggests that Kenya's financial system is susceptible to potential contagion risks arising from the COVID-19 pandemic.

Kenya is the third-largest economy in sub-Saharan Africa and has strong trade ties with the eastern and southern African regions, Europe, North America, and Asia, with China particularly. As these trade partners face severe shocks and contractions, Kenya is likely to experience a weakening economic environment as well as decreases in net exports and investments flows. Kenya's 2020Q1 growth declined by 5.5% from 2019Q1 and due to the pandemic, its GDP growth estimates were revised downward to only 1.6% from an initial estimate of 5.9% (Central Bank of Kenya, 2020a). The general decline in economic activity has real implications for the adoption of FinTech payments. As a result, Kenya is an ideal setting for a natural experiment demonstrating the effects of the COVID-19 pandemic on electronic payment systems, FinTech adoption, and digital banking in an emerging economy. The external validity and general implications of our results are that African countries and other developing and emerging markets need to invest in FinTech, as such investments might provide a cushioning effect during significant macroeconomic shocks such as the COVID-19 pandemic.

Our main contribution to the extant literature is that the COVID-19 pandemic accelerated digital onboarding and increased the adoption of FinTech (i.e., mobile banking) for payments. Our results are consistent with Fung et al. (2020) and Fu and Mishra (2020), which documented similar trends in the adoption of FinTech during the COVID-19 pandemic. In the case of Kenya, we determine that favorable regulatory measures were an important contributing factor in the adoption of mobile banking and in mitigating the negative economic impact of the COVID-19 pandemic. As a result, mobile banking became the main form of payment during the COVID-19 pandemic. We also observe a decline in the use of electronic payment cards and interbank fund transfers via RTGS. The latter result is consistent with studies that have documented a decline in consumer spending (Central Bank of Ireland, 2020) during the COVID-19 pandemic (Hopkins and Sherman, 2020) and studies that demonstrated that epidemic diseases have a negative effect on the economy (Bae et al., 2003; Allen and Gale, 2000).

The remainder of this paper is organized as follows. Section 2 presents a literature review and describes the hypothesis development. Section 3 describes our data. Section 4 discusses and presents our identification strategy and empirical results. Section 5 presents the main results. Sections 6 and 7 are the discussion and conclusion sections, respectively.

2. Literature review and hypothesis development

Hypothesis 1. (a): The COVID-19 pandemic accelerated the adoption of FinTech platforms (e.g., mobile banking) for payments.

Hypothesis 1. (b): The use of electronic payment cards declined significantly during the COVID-19 pandemic.

There are several important economic rationales of why the COVID-19 pandemic would accelerate the adoption of FinTech for payment and banking purposes. First, COVID-19 is an infectious disease that is easily transmitted. Consumers are self-interested—that is, they care about their health—and are therefore likely to respond to the pandemic by reducing and minimizing contact. Second, the government responded to the onset of the pandemic by introducing strict lockdown measures. As a result, we would expect consumers to shift away from payment methods that require physical contact (such as electronic cards) to contactless payment methods such as mobile banking. The immediate onset of the COVID-19 pandemic led to the closure of businesses and a general slowdown in economic activity. This factor, coupled with the uncertainty regarding the pandemic's duration, would imply that consumers were likely to minimize their use of interest-bearing forms of payment such as credit cards.

In addressing the preceding hypotheses, our paper makes several contributions to the literature. First, we contribute to the literature on the use of payment data for forecasting. Carlsen and Storgaard (2010) found that electronic payment card data are a useful indicator for predicting retail sales in Denmark. Esteves (2007) showed that ATM and POS data are useful indicators for private consumption in Portugal. Galbraith and Tkacz (2007) showed that electronic transactions are a real time indicator of economic activities in Canada. Aprigliano et al. (2019) showed that in the case of Italy, payment data is a useful tool in forecasting GDP. Hopkins and Sherman (2020) and Byrne et al. (2020) demonstrated that in Ireland, payment data flows are a useful tool in understanding consumer spending during the pandemic. We contribute to this stream of within-country research on payment data by showing that electronic payment data can be useful indicators of economic activity in Kenya. Our results shed light on the importance of payment data in emerging economies, particularly in Africa.

Second, we contribute to the literature on the role of FinTech in stabilizing financial institutions, particularly during the COVID-19 pandemic. Fung et al. (2020) showed that FinTech increased financial stability in emerging financial markets. Fu and Mishra (2020) established that the COVID-19 pandemic resulted in a relative increase in the rate of daily downloads of finance-related mobile applications. Bao and Huang (2021) showed that during the COVID-19 pandemic, FinTech firms were more likely to extend credit to new and financially constrained borrowers. Crowe et al. (2017) documented that FinTech adoption has been on the rise in the United States and that millennials and the younger generations are adopting mobile banking and other digital platforms at a much higher rate than

Table 1
Summary statistics.

Mean. Std. Dev. 25*th*				$_{75}th$
Mobile payments	234.561	118.825	134.147	324.597
Payment Cards	39,047.360	10,584.82	33,270.890	41,658.50
Debit Cards	38,194.010	10,530.750	32,684.370	40,718.200
POS Machines	8302.805	3663.400	5404.905	10,253.060
Credit Cards	754.451	367.228	446.747	995.684
Prepaid Cards	98.587	68.175	50.431	130.540
Charge Cards	0.337	0.240	0.199	0.427
DFCC(USD)	91.681	24.946	73.960	111.082
DFCC(EURO)	2.572	0.850	1.854	3.169
Debit Cheques	198.418	25.375	181.131	217.961
Credit (EFTS)	43.788	11.902	33.425	52.946
KEPSS/RTGS	2,179,443	480,845.806	1,817,925	2,469,935

This table presents the descriptive statistics for our sample for the period under examination. Mobile payment transaction values are given in billions of Kenyan shillings (KSH). All electronic payment card transaction values are provided in millions of KSH. The transaction values of DFCCs in U.S. dollars and in euros are given in millions of U.S. dollars and euros, respectively. KEPSS/RTGS transaction values are provided in millions of KSH. Debit check and credit electronic fund transfer transaction values are presented in billions of KSH. All values are seasonally adjusted.

the rest of the population. Aker and Mbiti (2010) showed that the adoption of mobile banking in Africa has positive welfare implications for the region. Our paper contributes to this line of research and demonstrates that the COVID-19 pandemic has accelerated consumers' adoption of FinTech for payments. We also show that in the case of Kenya, positive regulatory measures for mobile banking further facilitated the digital onboarding, adoption, and use of FinTech platforms such as M-PESA during the COVID-19 pandemic. Our results make an important contribution to the larger body of literature on technology as a positive engine for economic growth (Demirguc-Kunt et al., 2018; Philippon, 2016; Rysman and Schuh, 2017). Our results on electronic payment systems complement existing studies that have established that such systems are important in monitoring macroeconomic conditions and are determinants of the cyclical nature of the economy (Aladangady et al., 2019; Aprigliano et al., 2019; Baker, 2018).

Third, we examine how the pandemic impacted aggregate fund flows in the economy. Specifically, we address the following question: "What were the short-term effects of the COVID-19 pandemic on liquidity and interbank fund transfers via the Kenya Electronic Payments and Settlement System (KEPSS)/RTGS?" This is an important question to address in conjunction with other payment systems, as aggregate fund flows have real implications for liquidity management and consumer spending patterns (Borio and Van den Bergh, 1993). Allen and Gale (2000) found that a liquidity shock in one region can destabilize the entire economy. Bae et al. (2003) showed that contagion from a flu epidemic had a real economic impact on financial markets and on financial stability in the Latin American and East Asian regions. Based on these results, we conjecture that the COVID-19 pandemic has reduced domestic and international electronic funds transfers. Our paper thus contributes to the literature on contagion and interbank risks (Bae et al., 2003; Degryse and Nguyenn, 2007; Allen and Gale, 2000; Van Lelyveld and Lierdorp, 2006; Diamond and Dybvig, 1983) by showing that the pandemic has negatively impacted electronic fund transfers via both ACH and RTGS transactions in Kenya. Our overall results indicate that epidemics have seriously adverse economic implications in Africa.

3. Data

We obtained our monthly data on electronic payments from the Central Bank of Kenya (CBK). Data on financial access and financial intermediaries were obtained from the FinAccess Household Surveys and the FinAccess Geospatial Mapping Surveys. Data on the COVID-19 numbers were obtained from the website, Our World in Data. The available data on payment systems are aggregated at the national level. Micro-level data are proprietary, so this paper uses mainly univariate analysis and time series trends to assess the short-term impact of the COVID-19 pandemic on electronic payment systems and on the adoption of mobile banking in Kenya.[3]

The first case of the COVID-19 pandemic in Kenya was reported on March 12, 2020. Given the strong economic and trade ties between China and Kenya (i.e., 21% of Kenya's imports originate in China), our COVID-19 pandemic window ranges from December 2019 to December 2020 because the first cases of COVID-19 were reported in Wuhan, China in December 2019. Our analysis pays special attention to the March–April 2020 window, which is considered the height of the COVID-19 pandemic for Kenya as well as the rest of the world, since the World Health Organization declared COVID-19 to be a pandemic on March 11, 2020. Note that our sample period ends in January 2021, as most of the regulatory measures aimed at supporting mobile banking and curbing the impact of the pandemic in Kenya expired by this date.

Table 1 presents the summary statistics for our variables of interest for the time period under examination. Table 1 shows that the average transaction value of mobile payments is about 220.89 billion Kenyan shillings (KSH), which is approximately 2.08 billion USD at the July 24 2020 exchange rate. The distribution of mobile payments ranges from 130.7 billion KSH at the 25th percentile to about

[3] We reached out to the CBK on the usage and availability of data. The CBK made it clear that their data are proprietary. As a result, we use univariate analysis to bolster our main results and provide an important snapshot of the adoption of FinTech in Kenya during the COVID-19 pandemic.

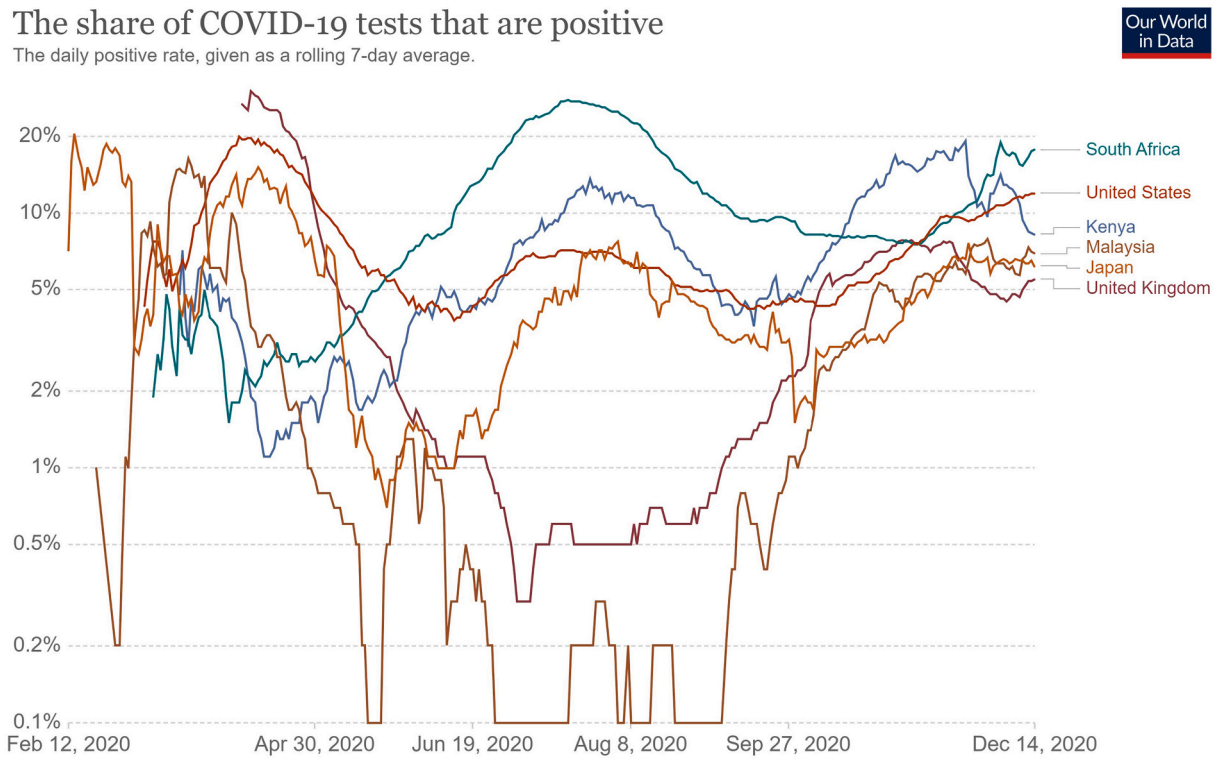

Fig. 1. Positive COVID-19 cases in Kenya.

308.9 billion KSH at the 75th percentile. Fig. 1 shows that the rate of positive COVID-19 tests steadily increased between March and July 2020. There was only one positive case in early March, but this number increased to approximately 1888 cases by the end of May 2020. By December 2021, the short-term positivity rate was about 8.3%, which represents a relative change of 73% compared to the March figure (i.e., 4.3%). Because our data are aggregated at the monthly level (i.e., over a short span of time), we do not control for within-country factors (such as monthly GDP per capita, the ratio of women to men, or the population per square meter) as they tend to be sticky, and any changes would be negligible given our short time horizon.

4. Methodology

4.1. Identification strategy

This paper addresses the following question: "What was the effect of the COVID-19 pandemic on electronic payment systems in Kenya?" The goal is to examine whether the COVID-19 pandemic accelerated the use of some forms of payment systems over others. There are six payment systems in Kenya: mobile banking, debit cards, credit cards, charge cards, POS machines, and prepaid cards. To address the aforementioned question, we constructed a normalized Herfindahl–Hirschman Index (HHI) that enabled us to capture the level of concentration in the payment system; that is, to determine if there was an acceleration in the use of one form of payment over other forms of payment during the pandemic. To construct the HHI, we first computed the sum of squares (*SS*) of each payment system scaled by the total funds (*TF*) across all payment systems, as shown in Eq. (1) below. We then computed a normalized index, as shown in Eq. (2) below.

$$\mathrm{SS_t} = (\mathrm{Mobile_t}/\mathrm{TF_t})^2 + (\mathrm{DebitCard_{it}}/\mathrm{TF_t})^2 + (\mathrm{CreditCard_t}/\mathrm{TF_t})^2 + (\mathrm{ChargeCard_t}/\mathrm{TF_t})^2 + (\mathrm{POS_t}/\mathrm{TF_t})^2 + (\mathrm{PrepaidCard_t}/\mathrm{TF_t})^2 \quad (1)$$

$$\mathrm{HHI}_t = \mathrm{SS}_t - (1/6)/\ 1 - (1/6) \quad (2)$$

If consumers, on average, shift to a single form of payment, then HHI equals 1, and if consumers utilize all forms of payment in equal proportion, then HHI equals 0. Effectively, our HHI measure is censored at 1 and 0, this means that HHI values ranges from 0 to 1, taking care of any potential outliers' effect. A higher degree of HHI is associated with a higher level of payment concentration, and a lower degree of HHI is associated with a lower level of payment concentration. Our construction and interpretation of the index is consistent with the extant literature. Our methodology is specifically informed by and borrowed from Colla et al. (2013) and Lou and Otto (2020), which used the HHI as a measure of concentration. Our choice of the HHI measure is consistent with the notion that limited dependent models are particularly useful for assessing the impact of extreme events such as epidemics and contagions on

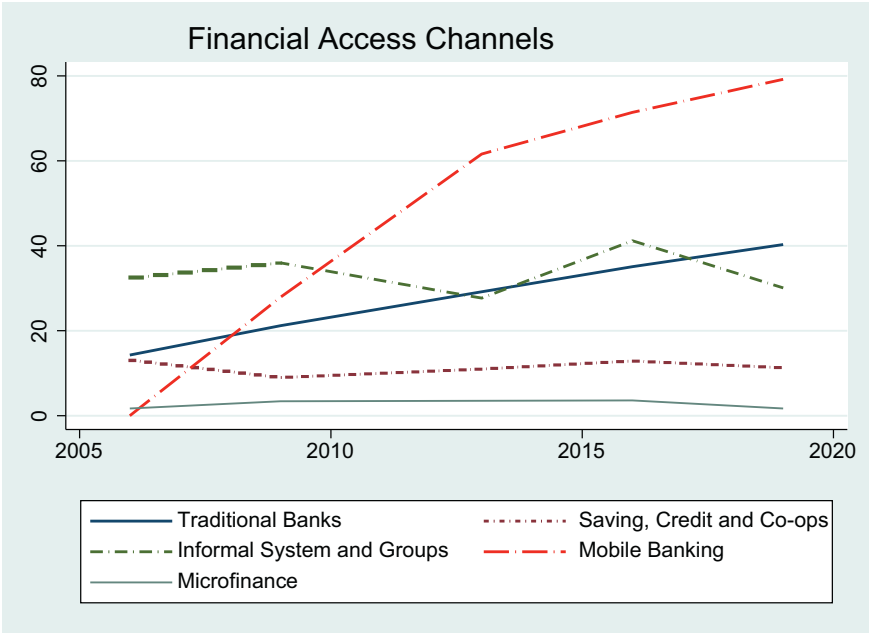

Fig. 2. Financial access channels.
This figure illustrates the evolution of financial access channels over time in Kenya.

financial markets (Bae et al., 2003). Under normal economic conditions, consumers are, on average, equally likely to use any of the six available forms of payment. However, following the onset of the pandemic and the subsequent government lockdown measures and restrictions, consumers became more likely to shift toward mobile banking. To evaluate this hypothesis, we use a difference-in-differences approach to estimate the following Tobit regression model:

$$\mathrm{HHI}_t = \beta_0 + \beta_1 \mathrm{COV\ ID} + \beta\{\mathrm{COV\ ID}^{*}\mathrm{PS}_t\} + \psi^{J}\mathbf{PS} + \epsilon_t \tag{3}$$

HHI_t is computed as shown in Eq. (2). *COVID* is a dummy variable that equals 1 for the period after March 2020 and 0 otherwise that captures the impact of COVID-19 pandemic on fund flows in the economy. *PS* stands for the payment system under consideration. **PS** represents a vector of the value per transaction from each form of payment system. ϵ_{it} is an idiosyncratic error term. Our variable of interest is the interaction term that captures the impact of per unit fund flow from each form of payment system on payment concentration. Thus, a positive (negative) coefficient value is associated with an increase (a decrease) in the use of the payment system under consideration during the pandemic.

5. Empirical results

5.1. Mobile banking and mobile payments

The use of financial technologies in Kenya has been significantly on the rise. Fig. 2 demonstrates that the use of mobile banking and other FinTech platforms is much greater and that these platforms are being adopted at a faster rate than any other channel of financial access. The usage of mobile banking increased by 80% between 2006 and 2020, while the usage of traditional banks increased only by 30% over the same period. This drastic increase has been driven mostly by the rise in third-generation and fourth-generation (3G and 4G) networks in the country and the associated lower transaction costs (Rao, 2011; Jack and Suri, 2011).

As a result, mobile banking has become an integral part of Kenya's financial system. Mobile banking and other FinTech platforms are used by consumers to access short-term loans and micro-loans, to conduct bank account transactions, to transfer credit, for peer-to-peer lending, and for making payments for general expenses such as utility bills and groceries. Mobile banking has also become a valuable tool for building credit history, especially for low-income and regionally marginalized consumers. Based on these arguments, we conjecture the following hypothesis:

Hypothesis 1. (a): The COVID-19 pandemic accelerated the adoption of FinTech platforms (e.g., mobile banking) for payments.

Effectively, we are attempting to address the following question: "What were the effects of the COVID-19 pandemic on the adoption of mobile banking and related digital platforms in Kenya?" There are two economic rationales as to why this question is important and why the effects of the pandemic on the adoption of FinTech, such as mobile banking, are not obvious *ex ante*. First, the increased use of mobile banking during the pandemic may have been driven by its ease of use, the limited access to traditional banks due to pandemic

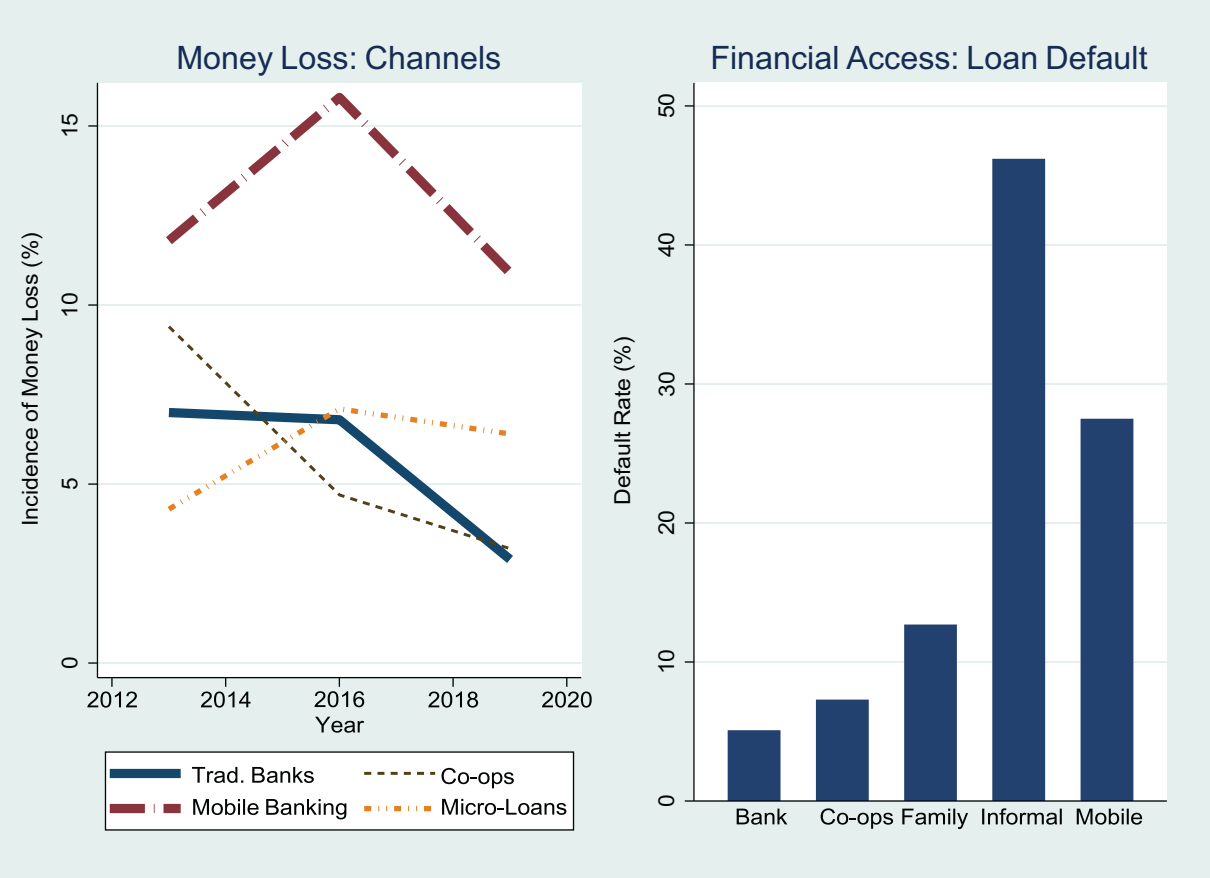

Fig. 3. Money loss via various channels.
These figures illustrate the incidence of money loss and the rate of default across different financial intermediaries and channels.

restrictions in hours of operation, and an increase in the short-term demand for essential goods. Consumers' online spending, e-commerce-related activities, and adoption of mobile banking digital applications might have increased during the pandemic because consumers were likely to minimize face-to-face contact as a result of restrictive social distancing guidelines combined with strong containment and mitigation measures.[4] Additionally, consumers might have been anticipating upward pressure on prices stemming from disruptions in both local and global supply chains. Approximately 21% of Kenya's imports originate in China, so the supply chain disruptions and average higher cost of imports from alternative trade partners indicate upward price pressure. Local firms might have also increased their prices as they experienced declining profit margins. Consumers might have responded to this inflationary pressure by increasing spending as they stockpiled essential goods. These factors would have a positive impact on the utilization and adoption of mobile banking and other FinTech platforms.

Second, Fig. 3 illustrates that mobile banking and other FinTech platforms have the highest incidence of money loss and the highest rate of loan default, second only to the informal banking sector. Given the contraction in economic activity, financial intermediaries might have either increased fees and interest charges or reduced total loan borrowings. In Kenya, transfers between bank accounts and mobile accounts are charged a minimum of 4% interest, where the interest rate is a function of the transferred amount. There are also additional charges for checking balances in mobile banking accounts. Because of the adverse effects of the COVID-19 pandemic on the labor market, the marginal value of a KSH is higher than before the onset of the pandemic. Consumers might prefer to save rather than spend (i.e., exhibit a precautionary saving motive) due to the uncertainty regarding the nature, the length, and the potential future ramifications of the COVID-19 pandemic. Consumers might also be less likely to use mobile banking due to vulnerability from evolving and emerging digital risks.[5] Over 40% of money loss incidences in mobile banking and other FinTech platforms in Kenya are due to data breaches and fraudulent activities such as hacking (Central Bank of Kenya, 2020b). In addition, a sizable portion of mobile

[4] There is anecdotal evidence that consumers worried about COVID-19 being transmitted via cash ("No more dirty cash," *New York Times*, 2020). https://www.nytimes.com/2020/07/06/business/cashless-transactions.html

[5] The government of Kenya passed regulations and laws to curb some of these fraudulent activities. For more information, see the National Payment System Act of 2011 and the Payment System Regulations of 2014.

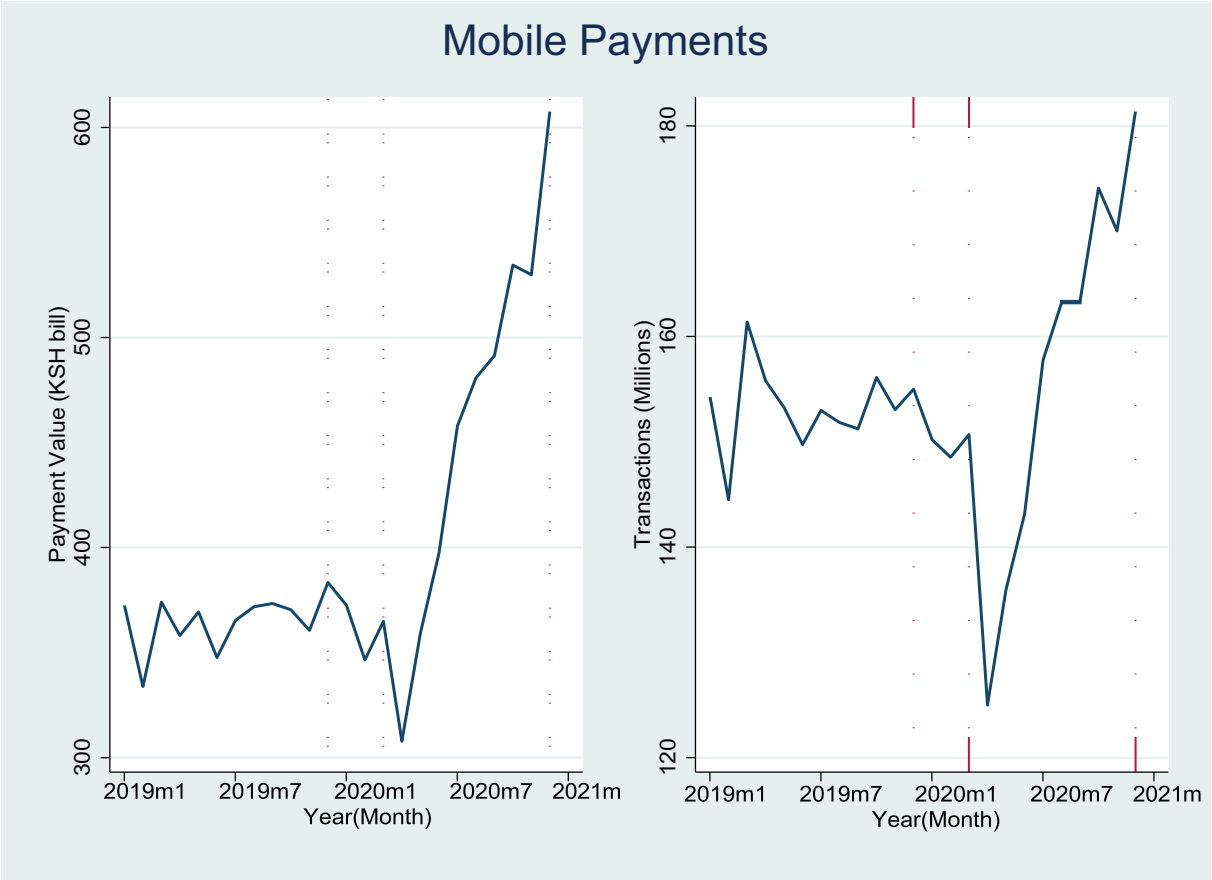

Fig. 4. Mobile banking.
These figures illustrate the effects of the COVID-19 pandemic on mobile banking transaction value and volume.

Table 2
Univariate analysis of electronic payments systems: initial shock of the COVID-19 pandemic on consumers' adoption of payment systems.

	2019 Dec	2020 May	Δ %	Δ{3–4} %	Δ {Dec 2019–2020Q1} %
Mobile Payments	382.930	357.370	**−6.675**	**−15.506**	**−6.983**
Payment Cards	64,750	41,761	**−35.504**	**−32.376**	**−22.469**
Debit Cards	63,719	41,229	**−35.296**	**−32.380**	**−22.436**
POS Machines	18,903	9639	**−49.008**	**−41.857**	**−28.628**
Credit Cards	793	433	**−45.397**	**−15.384**	**−26.837**
Prepaid Cards	239	99	**−58.577**	**−43.176**	**−47.485**
Charge Cards	0.200	0.400	**50.000**	**−38.330**	**−16.672**
DFCC (USD)	76.830	41.490	**−45.997**	**−45.819**	**−37.291**
DFCC (EURO)	1.985	1.011	**−49.068**	**−36.873**	**−37.008**
Debit Checks	215.080	154.560	**−28.138**	**−6.992**	**−29.767**
Credit (EFTS)	68.300	50.370	**−26.252**	**−2.938**	**−25.317**
KEPSS/RTGS	2786.59	2251.403	**−19.206**	**8.516**	**−21.972**
KEPSS Vol	443,026	394,549	**−10.942**	**2.905**	**−7.966**

This table presents the univariate test results for electronic payment systems in Kenya between December 2019 and May 2020. Column 5 reports the difference in transaction value (%) between March and April 2020.

banking customers are denied loans due to overdrawn accounts and loan arrears that negatively impact their credit rating (Central Bank of Kenya, 2020c). These factors would have had a negative effect on the utilization and adoption of mobile banking and other FinTech platforms during the COVID-19 pandemic.

In Fig. 4, we examine mobile banking transaction values and volumes of during the COVID-19 pandemic. Fig. 4 illustrates two effects. First, it shows that there is a precipitous decline in the value and volume of transactions between December 2019 and April 2020. As shown in Tables 2 and 3, the estimated decline in mobile transaction value for this period is about 6.98%. This translates into

Table 3
Univariate analysis of electronic payments systems: the effect of the COVID-19 pandemic on consumers' adoption and use of FinTech.

	1	2	3	4	5	6
Year(Quarter)	20Q1-19Q1	20Q2-19Q2	20Q3-19Q3	20Q4-19Q4	20Q4-20Q1	YOY
Change	Δ	Δ	Δ	Δ	Δ	Δ
Mobile Values	2.091%	−1.303%	27.882%	**49.798%**	**53.967%**	**19.968%**
Mobile Agents	10.390%	6.293%	12.117%	**24.337%**	**19.565%**	**13.402%**
Mobile Accounts	25.483%	16.733%	14.916%	**14.093%**	**14.560%**	**18.299%**
Payment Cards	1.003%	−55.544%	0.009%	**6.387%**	**20.424%**	**−7.345%**
Debit Cards	1.288%	−55.566%	0.390%	**6.917%**	**21.116%**	**−7.055%**
Credit Cards	−8.629%	−33.267%	−19.083%	**−24.757%**	**−16.336%**	**−19.244%**
POS Machines	13.918%	−38.764%	−18.428%	**−10.801%**	**1.023%**	**−11.157%**
Prepaid Cards	−28.798%	−148.636%	−37.941%	**−35.857%**	**−17.494%**	**−40.873%**
Charge Cards	−45.995%	6.103%	−63.063%	**−54.265%**	**−21.992%**	**−43.370%**
RTGS	13.852%	−4.143%	3.955%	**−5.688%**	**2.659%**	**1.664%**
DFCC(USD)	−9.919%	−74.717%	−42.277%	**−33.878%**	**−23.079%**	**−32.597%**
DFCC(Euro)	−10.079%	−54.329%	−15.627%	**−14.399%**	**−5.304%**	**−18.664%**
Credit etfs	2.610%	−10.334%	−5.086%	**2.273%**	**14.285%**	**−2.375%**
Debit etfs	0.272%	−32.506%	−13.416%	**−4.868%**	**−4.882%**	**−10.686%**

{Mobile and Digital Banking}: Intermediate to Long-Term Effects.
This table presents the univariate test results for electronic payment systems in Kenya. The results in Columns (1) through (5) report the differences in the quarterly usage of each electronic payment system between 2019 and 2020. The year-over-year results are presented in Column 6.

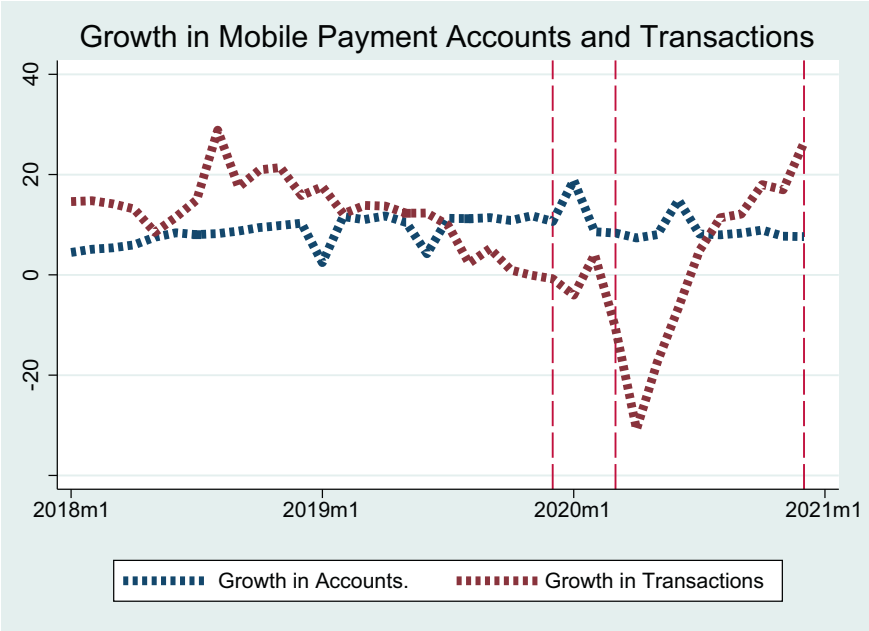

Fig. 5. Mobile banking.
This figure illustrates the month-to-month growth rate in mobile banking accounts and transactions.

a decline of 14.5% in April 2020 transaction value compared to April 2019 transaction value. At the height of the pandemic—that is, between March and April 2020—mobile transactions declined by 15.51%.

Interestingly, the decline in mobile banking transaction value and volume is not entirely driven by monthly changes in the number of mobile banking accounts. Fig. 5 indicates that the month-to-month growth rate in the number of mobile banking accounts remained fairly stable during this period, while the month-to-month growth rate in the number of transactions via mobile banking sharply declined at the onset of the COVID-19 pandemic. These results demonstrate that the pandemic initially had an adverse effect on consumer spending patterns and on the adoption of mobile banking and digital platforms in Kenya.

However, there is a positive note to these results. There was a very sharp upward trend of approximately 53% between April 2020

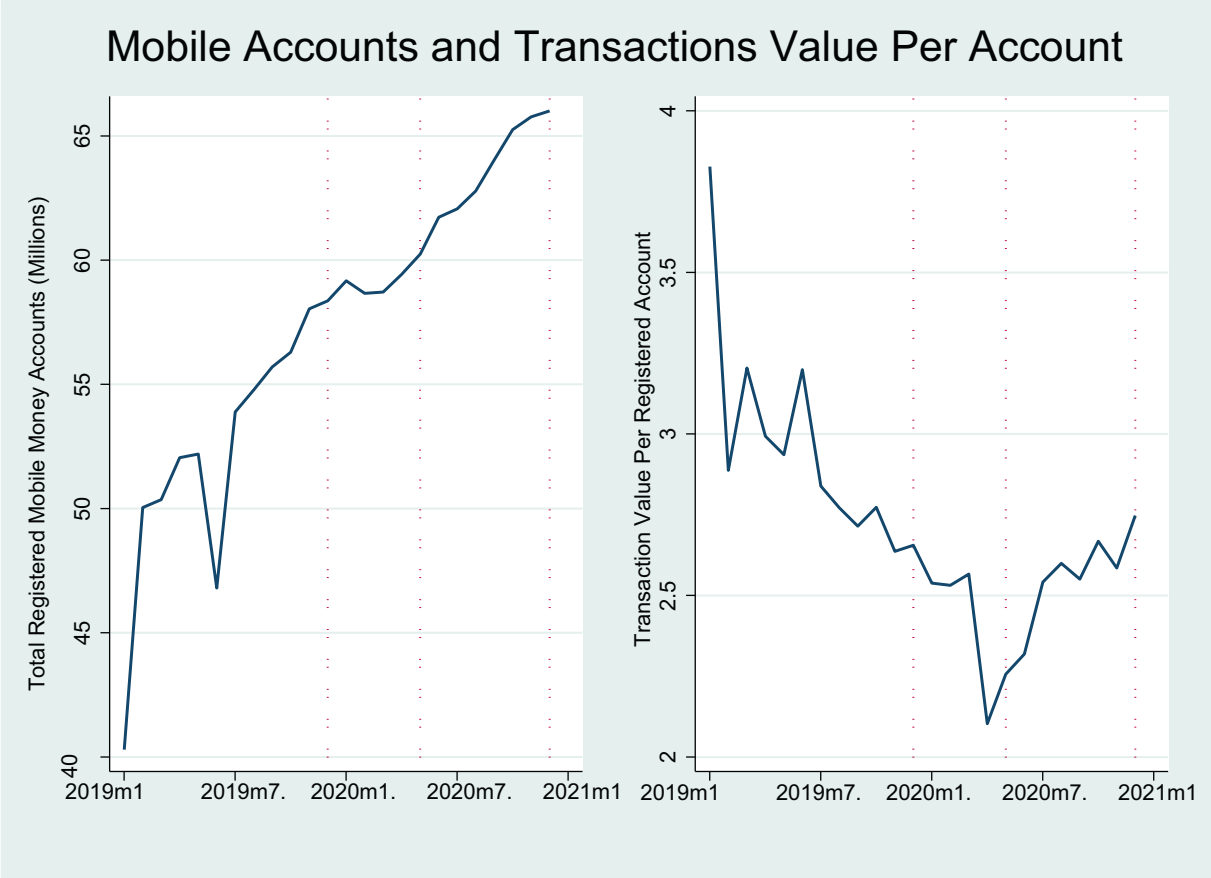

Fig. 6. Mobile banking.
While the total number of registered accounts was on the rise before the pandemic, the rate of usage (i.e., the transaction value per registered account) was on the decline. However, there was a steep increase in both the number of registered accounts and the transaction value per account following the pandemic.

and December 2020 that was driven by an increase in the adoption of mobile banking and the easing of regulatory measures and lockdown restrictions combined with a reduction or elimination of the mobile banking transaction fees and charges levied by most commercial banks.[6] As commercial banks reduced or eliminated the charges and fees on mobile banking and other FinTech platforms, consumers shifted toward these platforms, as illustrated by the upward trend that occurred between April and May following such measures (Central Bank of Kenya, 2020d). Fig. 6 shows that there was an upward trend in both the total number of registered mobile accounts and in the transaction value per registered account. The estimated increase in transactions per account between April and December 2020 was approximately 22%. Fig. 6 indicates that while there was an increase in the number of mobile banking accounts before the pandemic, the transaction value per registered mobile banking account was nevertheless in decline. The estimated upward shift in the transaction value per registered account indicates that a strong reversal occurred during the pandemic.

Fig. 7 illustrates that there was a sharp upward trend in the number of mobile banking agents and in the value per transactions as well as in the transaction value per agent. The number of mobile agents increased by 19.56% between the first and fourth quarters of 2020, an overall year-over-year increase of 13.4%. The estimated value of the increase in the transaction value per agent between the first and last quarters of 2020 was about 69%. Table 3 shows that the value of mobile transactions increased by 53.97% between the first and fourth quarters of 2020, a year-over-year increase of 19.97%. These results may be attributed to the effects of the COVID-19 pandemic and the government's favorable short-term regulatory measures. Specifically, the CBK required that commercial banks eliminate some charges and fees on mobile banking during the pandemic. The CBK also doubled the daily limit to KSH 300,000 (approximately USD at a market exchange rate (USD/KSH) of 106), eliminated monthly limits on mobile transfers, and lowered the tariffs on mobile transactions. In addition, the CBK instituted a 100% elimination of charges on transactions valued under KSH 1000 (approximately USD 10) and on transfers between mobile wallets and bank accounts. The results show that these measures aimed at relaxing the constraints on mobile banking have had a positive effect on consumer spending and the overall economy.

[6] Tier 1 banks—standard chartered banks, cooperative banks, and Stanbic Bank Uganda—eliminated mobile banking charges.

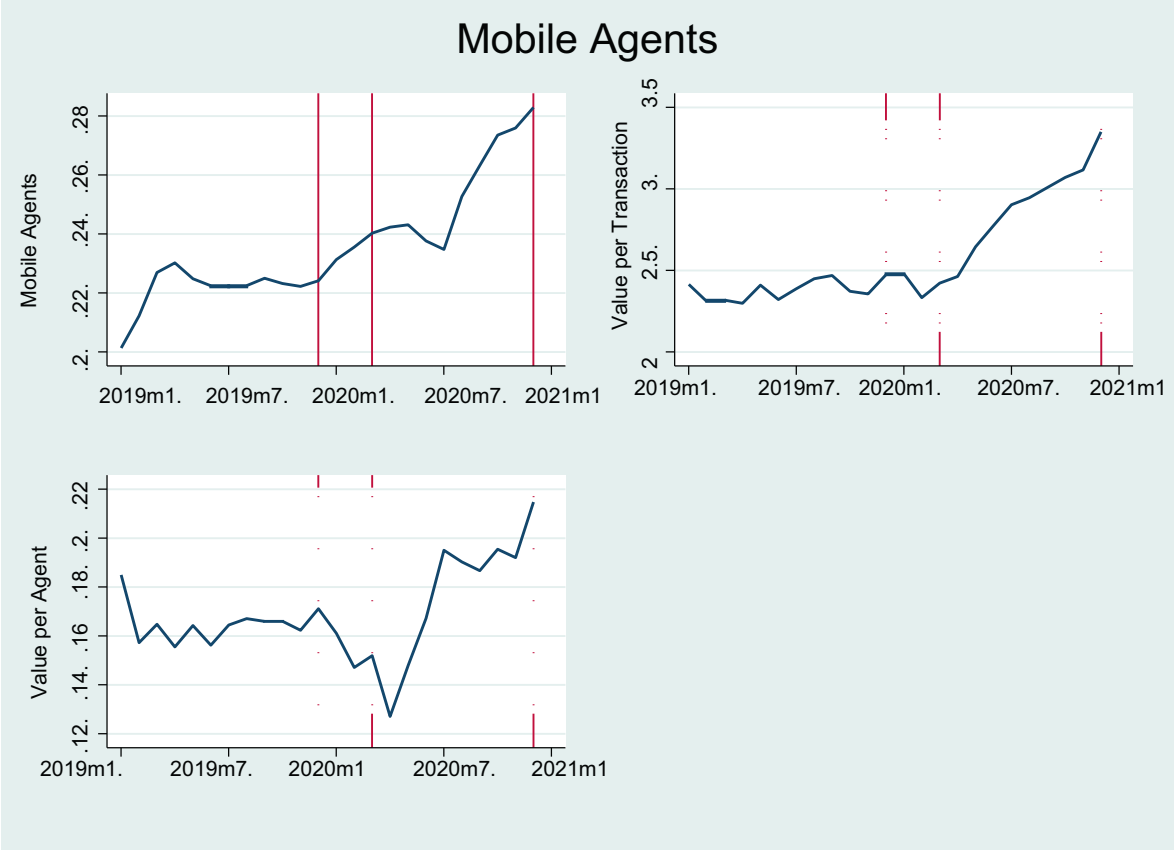

Fig. 7. Mobile banking.
These figures represent the effects of the COVID-19 pandemic on mobile banking value per transaction and the evolution of mobile banking agents.

In Table 4, we applied a difference-in-differences estimation strategy to a Tobit model. The construction of our dependent variable and the estimation strategy are outlined in Eqs. (1) through (3). First, the coefficient of our COVID-19 pandemic dummy is negatively and statistically significant across all models, reflecting the general decline in fund flows due to the decline in economic activity during the COVID-19 pandemic. Second, the coefficient of our interaction term between the average transaction value via mobile banking and our COVID-19 dummy is positive and statistically significant at the 1% level. That is, a 1-unit increase in transaction value is associated with a 0.403-unit increase in the predicted value of payment concentration. These results suggest that, on average, the value per mobile banking transaction increased significantly during the COVID-19 pandemic. Our empirical results indicate that the COVID-19 pandemic accelerated the use of mobile banking in Kenya. Our results, combined with the aforementioned regulatory changes, are consistent with the notion that the improvement in regulatory measures is a significant determinant in the diffusion of FinTech (Philippon, 2016). These results support the notion that FinTech is a critical component of economic growth (Frost et al., 2020) and may be a critical instrument in mitigating the adverse effects of the COVID-19 pandemic on the global economy. Overall, our results are aligned with the notion that the COVID-19 pandemic accelerated the adoption of FinTech platforms such as mobile and digital banking for payments.

5.2. *Electronic payment cards*

One way to estimate the effects of the COVID-19 pandemic on economic activity and on the adoption of FinTech platforms is to examine consumers' spending patterns and relative use of other forms of payments during the pandemic. The existing literature has determined that electronic card transactions are a real-time indicator of the economy's cyclical position (Galbraith and Tkacz, 2009, 2015) and are therefore useful in evaluating the impact of extreme events on the real economy (Galbraith and Tkacz, 2007; Aladangady et al., 2019). In addition, understanding how the COVID-19 pandemic impacted the use of payment cards is important, as consumers are still uninformed on the benefits of using FinTech platforms rather than existing payment systems (Rysman and Schuh, 2017). In Kenya, electronic payment cards and FinTech platforms such as M-PESA are complementary means of payment. In 2013, commercial banks migrated away from strip-based cards to EMV chip–enabled cards. This transition made Kenya's electronic payment cards a more secure form of payment and globally acceptable. As a result of this migration to EMV chip–enabled cards, the total

Table 4
Multivariate analysis of electronic payments systems: the effect of the COVID-19 pandemic on consumers' adoption and use of FinTech.

	(1) HHI	(2) HHI	(3) HHI
COVID	−0.028*	−0.993***	−0.373**
	(−1.890)	(−3.232)	(−2.504)
Mobile Banking X COVID		0.403***	0.278***
		(3.191)	(4.071)
Credit Cards X COVID			−8.145
			(−1.816)
Prepaid Cards X COVID			−0.552
			(−0.262)
Debit Cards X COVID			6.116
			(0.827)
Charge Cards X COVID			2.939*
			(1.855)
POS Machines X COVID			−66.81**
			(−2.752)
Mobile Banking		−0.387***	−0.214***
		(−3.212)	(−3.372)
Credit Cards			−2.382
			(−1.461)
Prepaid Cards			1.463**
			(3.028)
Debit Cards			−14.63***
			(−3.312)
Charge Cards			−1.467
			(−1.554)
POS Machines			35.090***
			(4.542)
Constant	0.478***	1.397***	0.952***
	(52.542)	(4.881)	(7.271)
Model	Tobit	Tobit	Tobit
N	23	23	23
Pseudo R^2	0.038	0.138	0.738

This table presents the multivariate test results for the effects of the COVID-19 pandemic on electronic payment systems in Kenya for the period of January 2019 to January 2021. The dependent variable is the Herfindahl–Hirschman Index (HHI). Construction of the HHI is outlined in Eqs. (1) and (2). The control variables—mobile banking, credit cards, debit cards, point-of-sales (POS) machines, charge cards, and prepaid card—are measured in value per transaction via each form of payment.
Note: T-statistics appear in parentheses; * p: 0.10, ** p: 0.05, *** p: 0.01.

number of cards increased by 23.2% between 2013 and 2019. We therefore conjecture the following hypothesis:

Hypothesis 1. (b): The use of electronic payment cards declined significantly during the COVID-19 pandemic.

The fact that consumers' spending and use of electronic payment cards would decline during the COVID-19 pandemic is not an obvious intuition. On one hand, consumers might be well informed regarding the adverse effects of the COVID-19 pandemic on global supply chains, specifically, on the disruptions in both local and global supply chains. This might lead to an increase in retail spending and the stockpiling of essential items, which would result in an increase in electronic payment card transaction values and volumes.

On the other hand, due to restrictive lockdown measures, restrictions on the movement of labor and capital, an immoderate and sudden rise in external debt[7] coupled with uncertainty regarding the future might imply that consumers would be less likely to spend. Specifically, as consumers revise their expectations about the future, they are more likely to increase savings and reduce consumption. The net result would be a decline in electronic payment card transaction values and volumes.

Electronic payment cards in Kenya can be broken down into five major categories: credit cards, debit cards, charge cards, prepaid cards, and POS machines. Tables 2 and 3 and Fig. 8 present the results of our univariate analysis and time series trends in the transaction values of electronic payment cards. Payment card usage declined precipitously in value—by about 32.4%—from March 2020 to April 2020. This represents a decline of 22.5% between December 2019 and the first quarter of 2020. Table 3 shows that the overall year-to-year decline in the transaction value of electronic payment cards translates into about 7.3%. When we examine the effects of the COVID-19 pandemic on each type of electronic card payment, we find that the transaction values of credit cards declined by about 15.4% between March 2020 and April 2020. This translates into a decline of about 26.84% between December 2019 and the first quarter of 2020. The overall effect is a year-over-year decline of about 19.24% in credit card transaction values. (See Fig. 9.)

Transaction values in the use of debit cards declined by about 32.4% between March and April of 2020. This represents a decline of 22.5% between December 2019 and the first quarter of 2020. The year-over-year decline in debit card transactions is about 7.05%. The use of prepaid cards declined by 58.58% between December 2019 and May 2020, which translates into a year-over-year decline of

[7] Kenya's external debt increased by 5.81% between March and May 2020 (CBK, 2020).

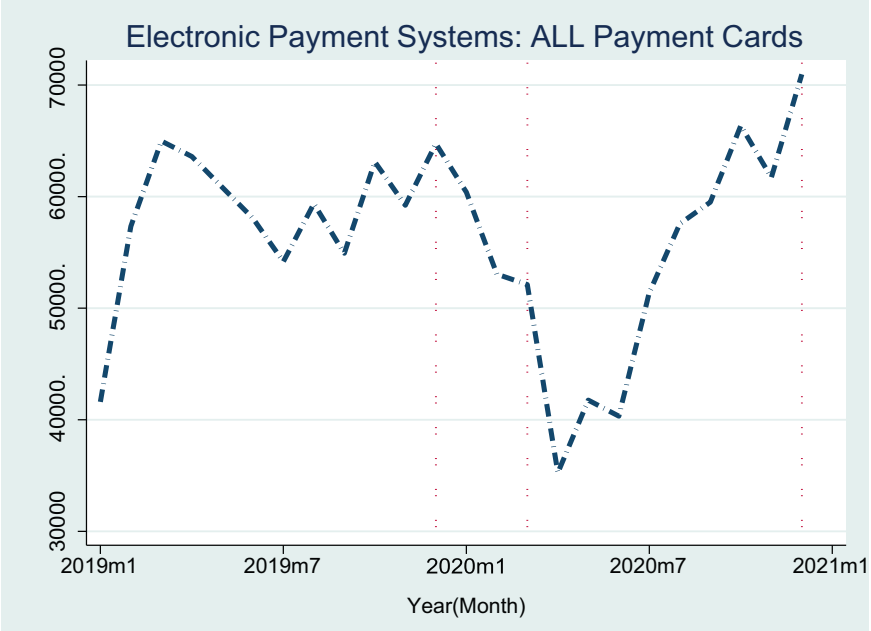

Fig. 8. Payments cards.
This figure illustrates the evolution of electronic payment card transactions and the effects of COVID-19 on total transaction value.

40.9%. The transaction values of POS machines declined by 28.6% between December 2019 and the first quarter of 2020. This represents a year-over-year decline of 11.2%. While the transaction values of charge cards declined by 38.7% between March and April 2020, there was a sudden increase in May 2020. An increase in charge card transaction values of about 50% occurred between December 2019 and May 2020 and again between April 2020 and May 2020. Note that charge cards do not charge interest on the outstanding amount; the consumer is only required to settle the full amount by the due date. The data on charge card usage reflect the fact that consumers were substituting cheaper short-term forms of payment (i.e., like charge cards) for more costly forms of payment, especially during the onset of the COVID-19 pandemic. However, following the introduction of regulatory measures aimed at facilitating the use of mobile banking and as more information became available regarding the duration of the pandemic, consumers shifted away from charge cards to mobile banking. Charge card transaction values subsequently declined by 21.9% between the first and fourth quarters of 2020, an overall year-over-year decline of 43.37%.

The multivariate results presented in Table 4 confirm our observations from the univariate analysis. The value per transaction of POS machine usage significantly declined during the pandemic as captured by the interaction term. The interaction term between our COVID-19 dummy and the debit card value per transaction while positive is statistically insignificant, and the interaction term for both prepaid cards and credit cards is negative but statistically insignificant. The charge card value per transaction is positive but weakly statistically significant at the 10% level.

These results are important for two reasons. First, the overall decline in the usage of electronic payment cards combined with the significant rise in the use of mobile banking suggests that during the COVID-19 pandemic, consumers shifted toward FinTech and digital banking platforms compared to other forms of payment. Second, a decline in consumer spending patterns might translate into systemic risk and an inability of banks and other financial institutions to settle claims (Crockett and McDonough, 1998). This documented decline in the transaction values of electronic payment cards points to a potential disruption in the flow of money and in the clearance of payment instruments due to the COVID-19 pandemic. These results signal that the pandemic was a potential source of contagion, credit, liquidity, and settlement risks.

The next section examines the effects of the COVID-19 pandemic on interbank lending activity and fund transfers. Specifically, we ask whether the COVID-19 pandemic was a potential source of interbank contagion and liquidity risk (Furfine, 2003). Since the RTGS is the largest money transfer system in the country, the results provide important insight into the rate adoption of FinTech relative to other electronic funds transfer systems in Kenya.

5.3. Real-time gross settlement system (RTGS)

The expansion in economic activity, increase in transaction values, and growth in emerging markets has led to the adoption of the RTGS by central banks of emerging and developing economies. The RTGS exhibits economies of scale and scope and reduces settlement risk, as payments are settled one by one in real time, and payments are deemed final and irrecoverable (Borio and Van den Bergh, 1993; Bech et al., 2017). In 2005, the CBK introduced and adopted the KEPSS, which is an automated electronic RTGS that has since

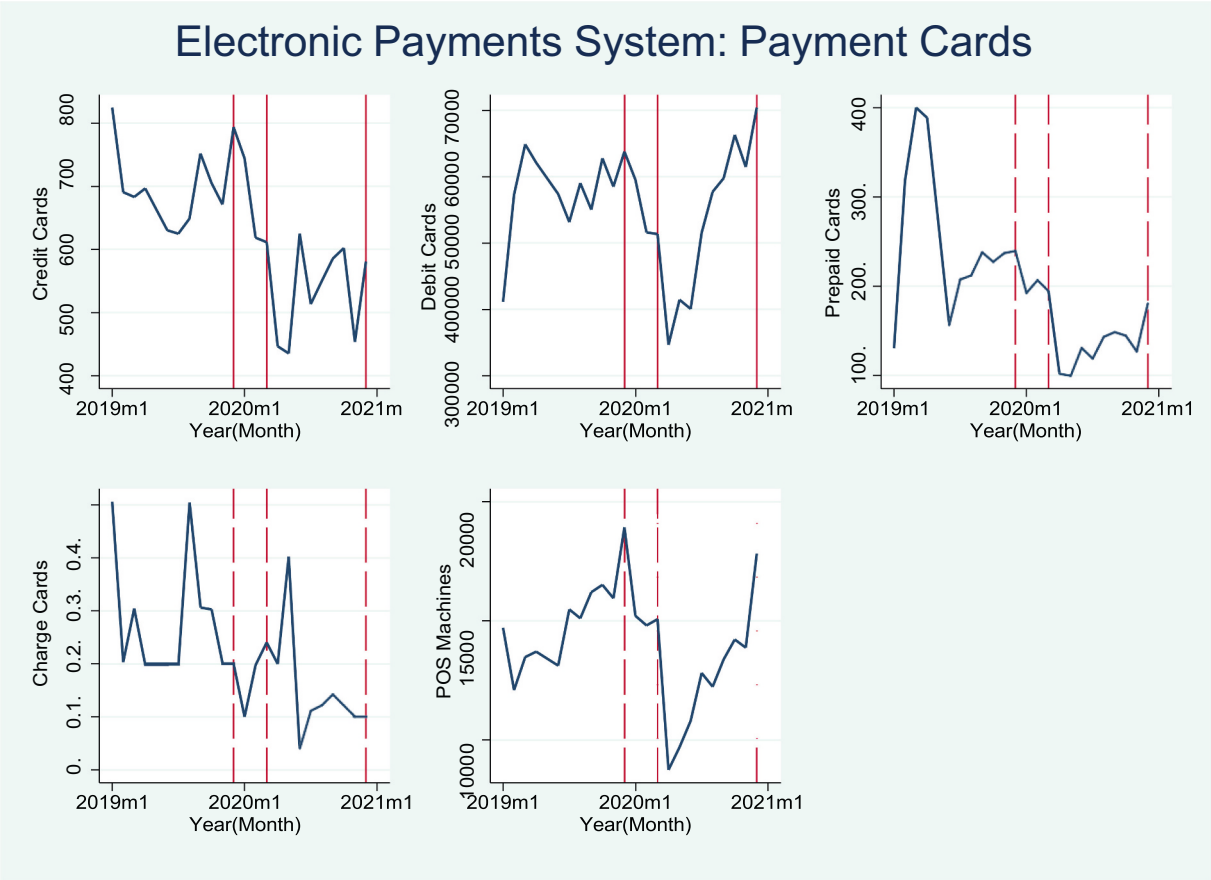

Fig. 9. Payments cards.
These figures illustrate the effects of the COVID-19 pandemic on different electronic payment systems.

connected about 93% of Kenya's commercial banks and financial institutions. Prior to the establishment of the KEPSS, the CBK used a paper-based interbank settlement system that was subject to the systemic settlement risk inherent in large-value net settlements.

The main objective of the KEPSS is to speed up and securely facilitate the real-time interbank transfer of funds. The KEPSS has integrated the banking system and the financial markets in Kenya and is classified as a systemically important payment system, or a SIPS. The adoption of this technology has led to a greater volume of transactions and increased flow in interbank transfers. In 2005, the KEPSS managed KSH 6.5 trillion annually for the 2010–2020 period (Table 1). The KEPSS manages about KSH 21.4 trillion annually, which is approximately 183 billion USD at the current market exchange rate. The CBK has mandated that banks can no longer use checks for any transaction amount greater than KSH 1 million. Transactions greater than 1 million KSH must be conducted through the KEPSS. Over the last few years, transactions amongst brokers in the Nairobi Securities Exchange have also been conducted through the KEPSS. In 2019, the system cleared about 412,322 transactions per month and about 20,600 transactions per day, an increase of approximately 3150% in daily transactions from its inception in 2005. As a result, the KEPSS has not only become an important driver of financial stability, but also a channel for the transmission of shocks and disturbances.

While the centrality of the RTGS might mitigate interbank lending liquidity shocks (Allen and Gale, 2000, Cabrales et al., 2016), the COVID-19 pandemic shock was an exogenous global shock to the interbank networks and, as a result, resulted in positively correlated liquidity shocks, thereby creating contagion risk for Kenya's banking system. We therefore ask the following question: "What were the short-term effects of the COVID-19 pandemic on liquidity and interbank fund transfers via the KEPSS/RTGS?" Given the nature of our data and the fact that only one RTGS exists in Kenya, we use univariate analysis to shed some light on this question. Fig. 10, which plots time series trends of the monthly transaction values and volumes managed by the KEPSS (RTGS) from January 2019 to May 2020, illustrates three key findings. First, there was a decline in both transaction value and volume during the COVID-19 pandemic. Second, the decline was not uniform, as there was a sharp decline in value between December 2019 and January 2020 but then an increase between February and March 2020 and another sharp, precipitous decline between March and May 2020. Specifically, as shown in Table 2, the decline between March and April 2020 in transaction value was about 21.97%. This translates into a decline of about 19.21% from December 2019 to May 2020. Third, the decline in volume from December 2019 to May 2020 was a decline of 10.94%, as shown in Table 2. The decline in volume between March and April 2020 was about 7.96%. However, as the economy slowly reopened, there was a sudden increase in transaction value of about 2.65% between the first and fourth quarters of 2020. This increase translates

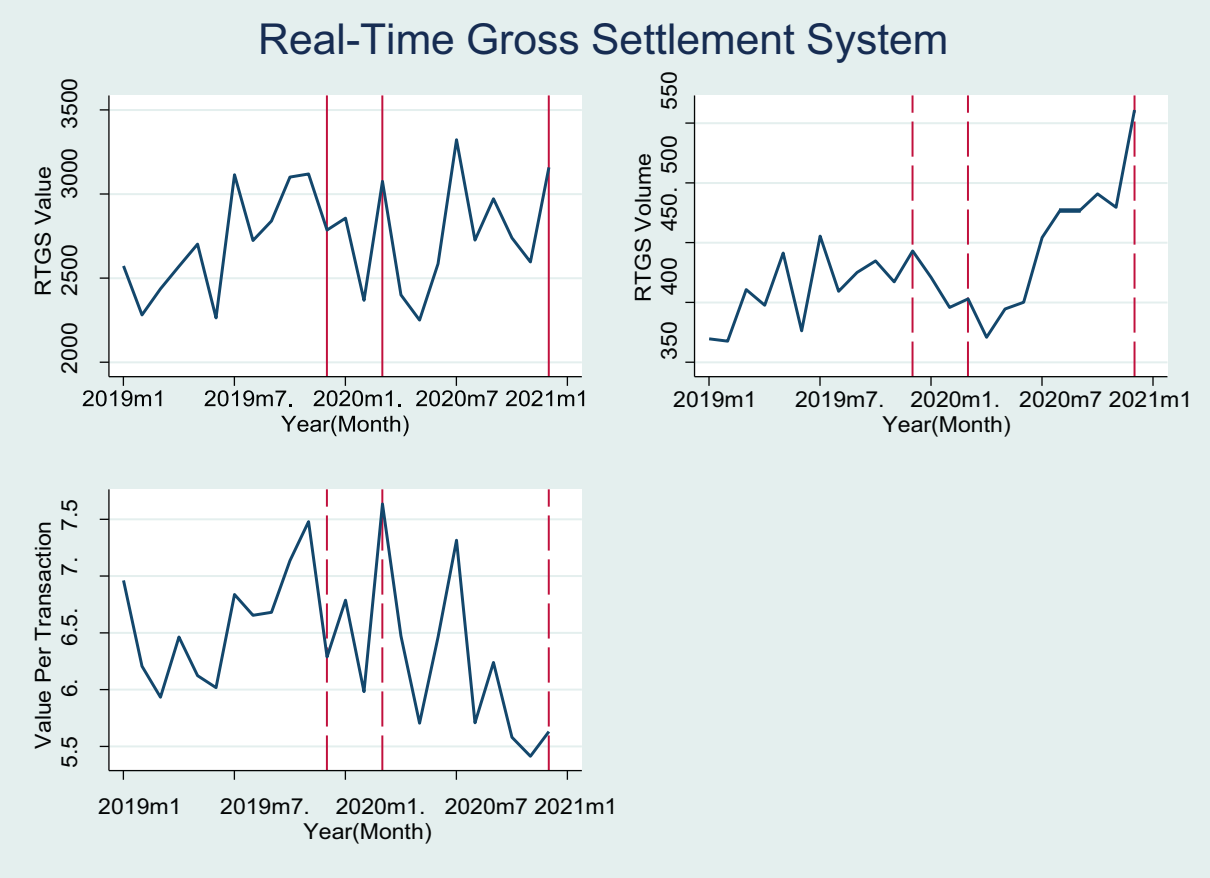

Fig. 10. Real-time gross settlement system.
These figures represent the time-series evolution of the total value and volume of RTGS transactions and the effects of the COVID-19 pandemic on the usage of the RTGS.

into a year-over-year increase of 1.66%. However, Fig. 10 indicates that the value per transaction via the RTGS declined significantly during the COVID-19 pandemic.

Taken together, the decline in transaction value and volume suggests that the COVID-19 pandemic had an adverse effect on interbank lending activities in Kenya. This adverse effect translates into a total decline of 9.28% in the value per unit of transactions from December 2019 to May 2020 and a total decline of 15.22% in the value per unit of transaction from March 2020 to April 2020, a period that is considered to be the height of the COVID-19 pandemic. These results, combined with the decline in interbank lending rates and volume (Fig. 11), point to potential credit, liquidity, and settlement risks emanating from the decline in economic activity resulting from the COVID-19 pandemic.

5.3.1. Automated clearing house (ACH)

The Nairobi ACH is another instrument in Kenya's financial system and the interbank market. Checks and electronic fund transfers (EFTs) less than 1 million KSH are processed through the Nairobi ACH. Debit checks and credit ETFs greater than 1 million KSH are generally processed through the RTGS. As a result, the efficiency of the clearing cycle has improved over the last 7 years from T + 3 to T + 1. The Nairobi ACH has facilitated the consolidation of the banking sector and is therefore an important mechanism in how banks manage risk. As a result, the Nairobi ACH is a potential channel for contagion risk because it is a part of the market structure and an important determinant of interbank links in Kenya. As such, the Nairobi ACH is a source of liquidity and serves as an indirect measure of banks' credit exposure. The existing literature has established that such an integrated structure is prone to contagion risk (Van Lelyveld and Lierdorp, 2006; Muller, 2006).

Fig. 12 demonstrates the impact of the COVID-19 pandemic on EFTs (debit and check) processed via the Nairobi ACH. The results indicate that between December 2019 and the first quarter of 2020, there was a steep decline in EFTs, which translates into a 29.8% decline in debit checks and a 25.3% decline in credit EFTs. As shown in Table 3, Column 5, the value of debit EFTs declined by 4.88%, and the value of credit EFTs increased by 14.29%, between the first and fourth quarters of 2020. This translates into a year-over-year decline of 10.68% for debit ETFs and 2.37% year-over-year decline for credit EFTs.

We next examine the effects of the COVID-19 pandemic on regional and international interbank liquidity flows. Specifically, we

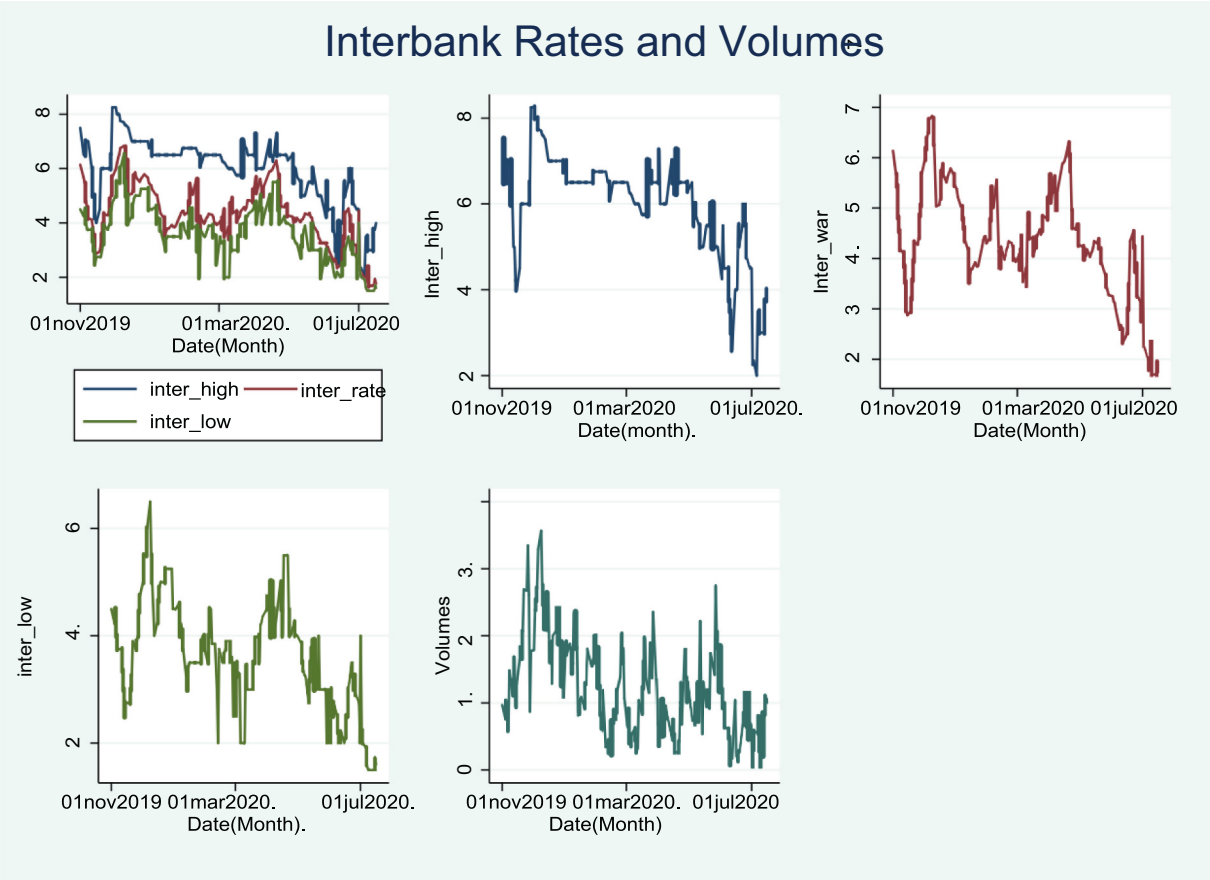

Fig. 11. Real-time gross settlement system.
These figures illustrate the time-series evolution of interbank rates and total interbank volume.

observe interbank domestic foreign currency check inflows via the Nairobi ACH. These checks reflect cross-border payment transfers and international trade activities. The checks are generally denominated in either euros or USD. Given that Kenya is a former British colony and has close trade ties to the United Kingdom, about 4% of the domestic foreign currency checks (DFCCs) are denominated in British pounds, and most trade settlements from the Eurozone are denominated in either euros or USD. Fig. 13 shows that there was a general decline in both the value and volume of DFCCs. The year-over-year decline in DFCCs in USD and euros was 32.6% and 18.66%, respectively. These results indicate a general decline in both the number of interbank money market monthly deals and in total deal value during the COVID-19 pandemic and reflect a dampening of international and regional trade, a contraction in the economies of Kenya's trade partners, and a disruption in global supply chains due to the COVID-19 pandemic.

The pandemic's effects on the RTGS and on the ACH demonstrate that the COVID-19 pandemic had an adverse influence on interbank liquidity flows. The estimates of the reduction in monetary transaction value and volume suggest that the COVID-19 pandemic was a negative shock to the economy and had a significantly negative impact on Kenya's entire financial system. There is a concern that these liquidity shortages and exposures might lead to credit and potential contagion risk, which would negatively impact the solvency of some local commercial banks (Kaminsky and Reinhart, 2000).[8] The existing literature has determined that such knock-on effects can amplify interbank exposure and might potentially trigger banks failures (Wells, 2004).

5.4. External validity

Our main hypothesis is that the COVID-19 pandemic accelerated the adoption of FinTech (mobile banking) in Kenya. However, it is unclear whether our main results are generalizable to other countries. To address this concern, we use payment data from Uganda, a

[8] In recognition of potential contagion and liquidity risks resulting from the COVID-19 pandemic, the CBK undertook the following short-term measures: (a) lowering the central bank rate to 7.25% from 8.25%, (b) reducing the cash reserve ratio to 4.25% from 5.25%, and (c) making an additional KSH 35.2 billion (USD 290 million) in liquidity available to distressed banks (CBK, 2020, Cytonn Report, 2020).

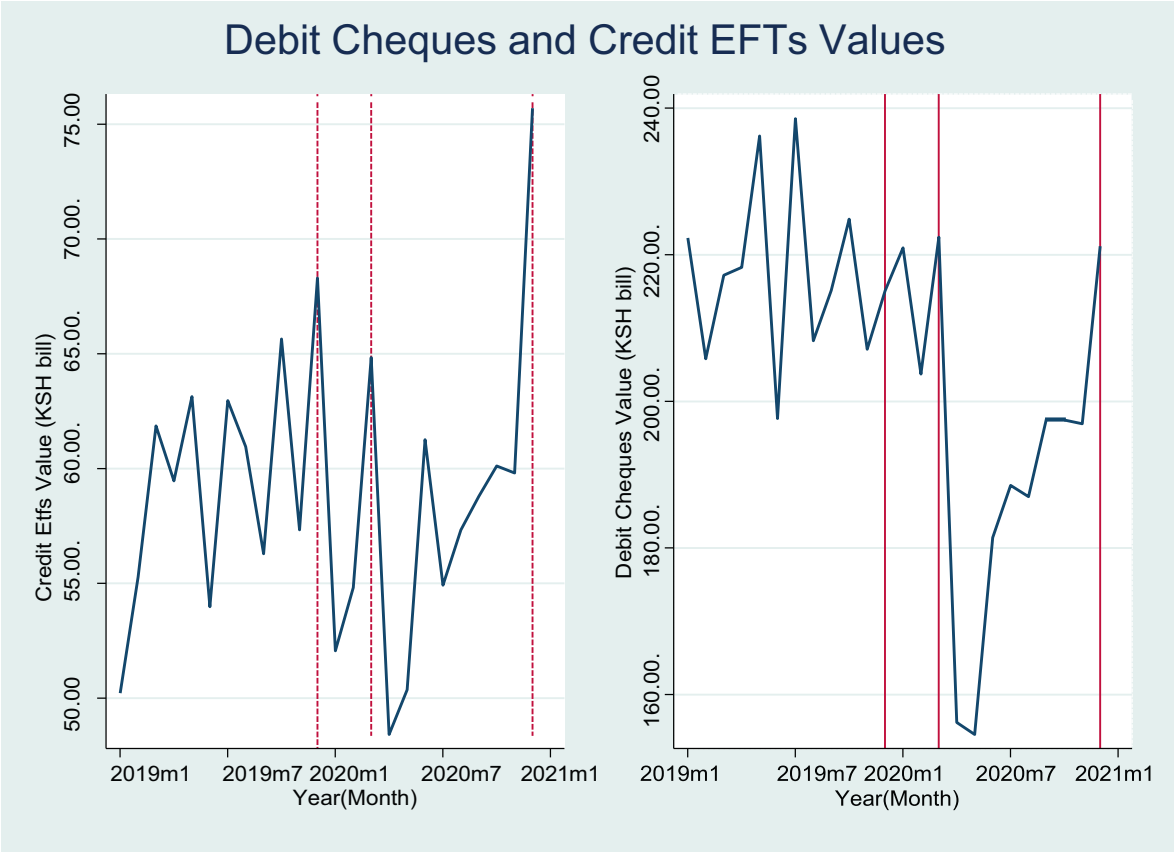

Fig. 12. Debit cheques and credit EFTs values.
These figures illustrate the time-series evolution and effects of the COVID-19 pandemic on debit and credit electronic fund transfers (EFTs).

close neighbor and trade partner of Kenya, to reexamine the question under study.[9] Fig. 14 shows that there was a significant upward trend in the use of mobile banking in Uganda during the COVID-19 pandemic. This time series trend is consistent with our main results for Kenya. Overall, the results on mobile banking in Uganda support the notion that the COVID-19 pandemic accelerated the adoption of FinTech for payments.

6. Discussion

This paper examines the effects of the COVID-19 pandemic on electronic payment systems in Kenya. We first investigate whether the pandemic accelerated consumers' adoption of FinTech and other digital platforms for payments. If this is the case, then we should observe an increase in the value per transaction conducted via mobile banking during the COVID-19 pandemic. This would suggest that due to restrictions and other measures implemented during the pandemic, consumers shifted to mobile banking from other forms of payment. The results confirm our hypothesis that the COVID-19 pandemic led to payment concentration via mobile banking in Kenya. We also observe that the pandemic initially (2020Q1) had a negative impact on mobile banking. However, following the implementation of favorable regulatory measures on mobile banking and as uncertainty regarding the length of the pandemic increased, we find that the negative effects of the pandemic on mobile banking were reversed and that there was a significant increase in the adoption of mobile banking, especially in the third and fourth quarters of 2020. We document a significant increase in mobile banking transaction value, in the number of mobile banking agents, as well as in the number of mobile banking accounts opened during the pandemic. Our results support the notion that the COVID-19 pandemic accelerated the adoption of FinTech for payments.

Second, we determine that the COVID-19 pandemic had a negative impact on the use of all electronic payment cards. We observe some positive for charge card transactions effects in the first quarter of 2020 and some positive effects for debit card transactions in the last quarters of 2020. We argue that this is because consumers who use charge cards do not incur interest on outstanding amounts but are only expected to settle the full amount by the due date. Consumers also shifted away from high-interest forms of payment toward

[9] While data on mobile banking systems are available, data regarding other electronic payment systems are not.

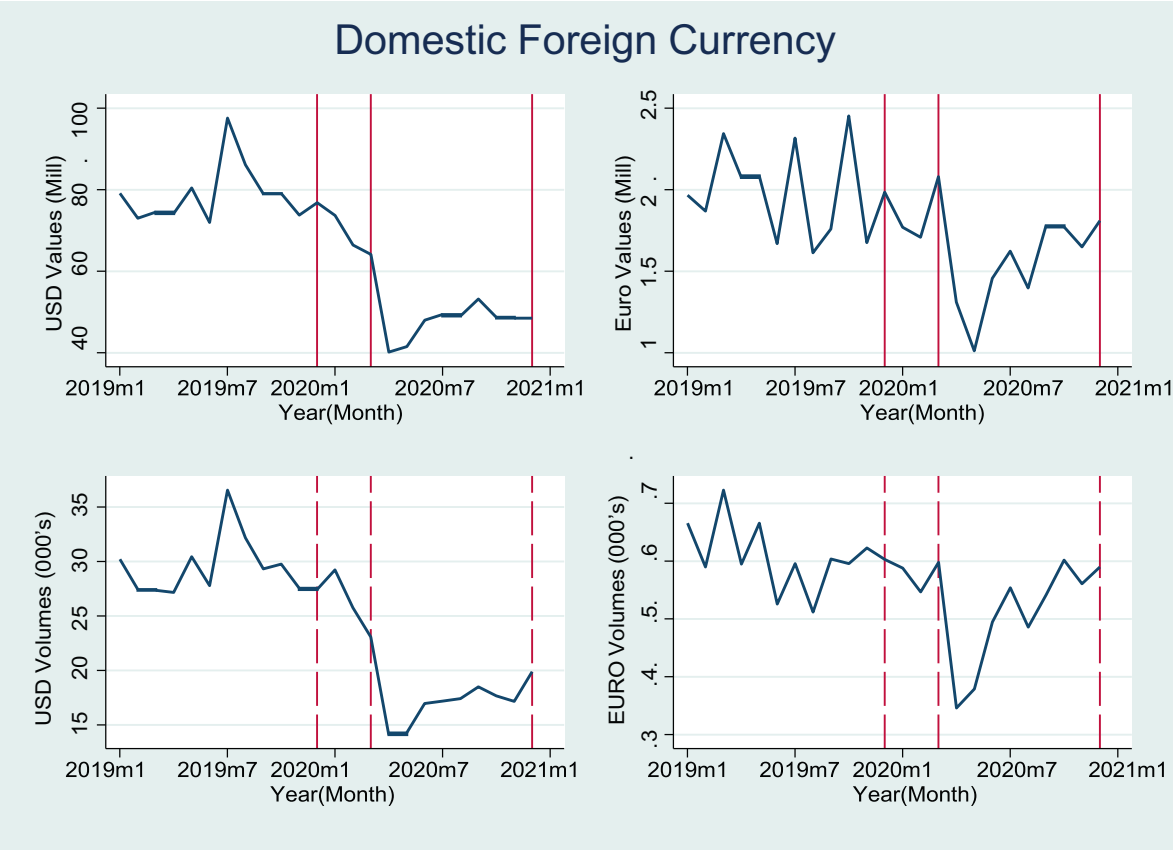

Fig. 13. Domestic foreign currency cheques transaction values.
These figures illustrate the time-series evolution of the transaction value of the domestic foreign currency checks (DFCCs) processed through the Automated Clearing House (ACH).

low-interest forms of payment. This is an important shift in consumers' spending behavior, as the average monthly interest rate on a credit card in Kenya is about 3.5%. Banks receive a spread of about 11%, which is 40% greater than the global average. A shift toward cheaper forms of payment indicates that the COVID-19 pandemic increased the marginal value of the KSH for the average consumer. The positive results for debit cards were driven by the slow reopening of the economy. The results regarding electronic payment cards suggest that consumers are shifting away from more expensive forms of payment toward cheaper and more convenient forms of payment. The decline in transactions via electronic payment cards further supports our main hypothesis: consumers shifted toward FinTech (mobile banking) during the COVID-19 pandemic.

Third, we document a decline in interbank fund transfers via the RTGS and ACH. Our results suggest that the pandemic had a negative impact on all of the main money transfer systems in Kenya, except for mobile banking. The results for interbank fund transfers reflect the potential risks that Kenya's banking system endured during the COVID-19 pandemic.

7. Conclusion

In conclusion, our results suggest that the COVID-19 pandemic accelerated digital onboarding and the adoption of FinTech for payments. The government's implementation of favorable regulatory measures was also an important contributing factor in the adoption of mobile banking and in mitigating the negative economic impact of the COVID-19 pandemic. In Kenya, mobile banking became the main form of payment during the COVID-19 pandemic. The external validity and general implications of our results are that African countries and other developing and emerging markets should invest more heavily in FinTech, since such investments might provide a cushioning effect during extreme events such as the COVID-19 pandemic.

CRediT authorship contribution statement

Daniel Tut: Conceptualization, Formal analysis, Methodology, Formal analysis, Software, Validation, Writing – original draft, Writing – review & editing.

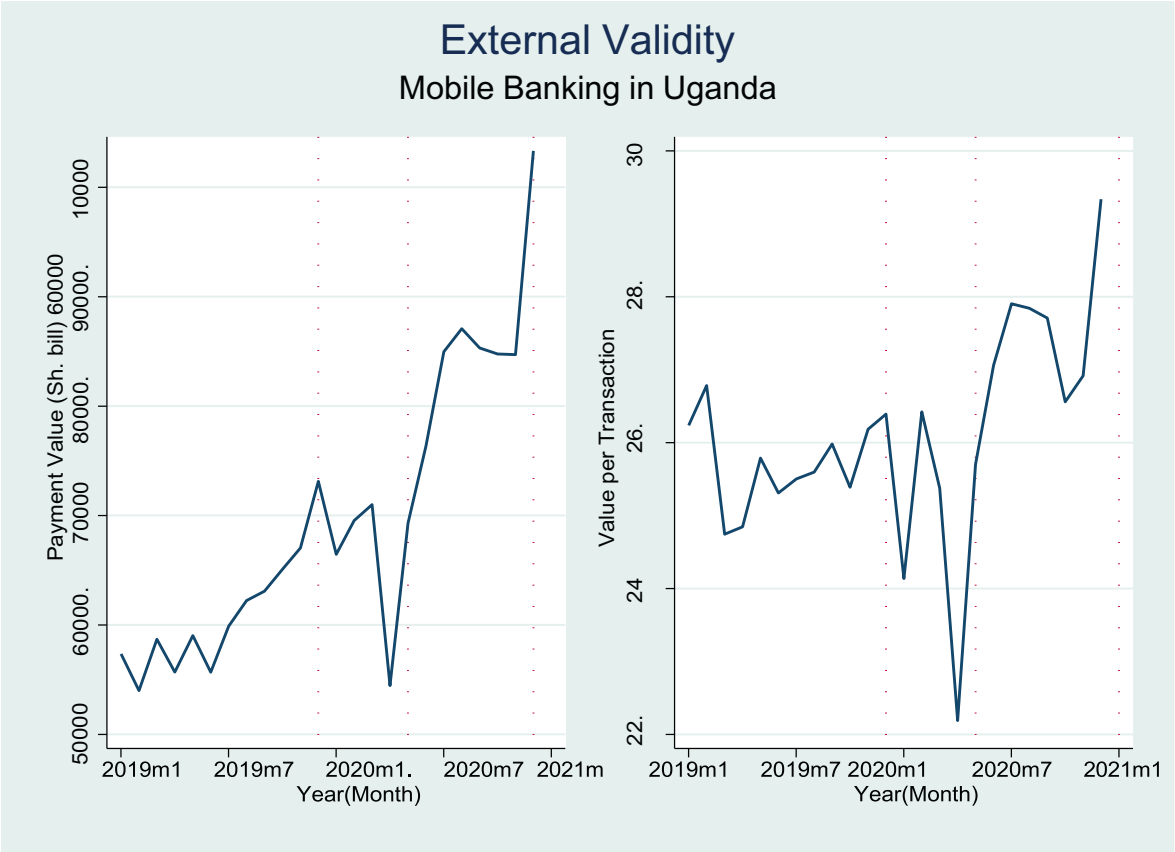

Fig. 14. Mobile banking in Uganda.
These figures illustrate the time-series evolution of the total transaction value and the value per transaction for mobile banking in Uganda for the period between January 2019 and January 2021.

Declaration of Competing Interest

I have no potential conict of interest to disclose.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ememar.2023.100999.

References

Aker, J., Mbiti, I., 2010. Mobile phones and economic development in Africa. J. Econ. Perspect. 24 (3), 207–232. https://doi.org/10.1257/jep.24.3.207.
Aladangady, A., Aron-Dine, S., Dunn, W., Feiveson, L., Lengermann, P., Claudia, S., 2019. From Transactions Data to Economic Statistics: Constructing Real-Time, High-Frequency, Geographic Measures of Consumer Spending. NBER Working Paper No. w26253. Available at SSRN: https://ssrn.com/abstract=3454354.
Allen, F., Gale, D., 2000. Financial contagion. J. Polit. Econ. 108 (1), 1–33. https://doi.org/10.1086/262109.
Aprigliano, A., Ardizzi, G., Monterforte, L., 2019. Using payment system data to forecast the Italian GDP. Int. J. Cent. Bank. 15, 55–80.
Bae, K., Karolyi, G., Stulz, R.M., 2003. A new approach to measuring financial contagion. Rev. Financ. Stud. 16, 717–776. https://doi.org/10.1093/rfs/hhg012.
Baker, S., 2018. Debt and the response to household income shocks: validation and application of linked financial account data. J. Polit. Econ. 126 (4), 1504–1557. https://doi.org/10.1086/698106.
Bao, Z., Huang, D., 2021. Shadow banking in a crisis: evidence from FinTech during COVID-19. J. Financ. Quant. Anal. 56 (7), 2320–2355. https://doi.org/10.1017/S0022109021000430.
Bech, M.L., Shimizu, Y., Wong, P., 2017. The quest for speed in payments. BIS Q. Rev. 57–68.

Bhagwati, J., 1998. The capital myth: the difference between trade in widgets and dollars. Foreign Affairs 77 (3), 7–12. https://doi.org/10.2307/20048871.
Borio, C.E., Van den Bergh, P., 1993. The Nature and Management of Payment System Risks: An International Perspective, No. 36. Bank for International Settlements, Basel.
Byrne, S., Hopkins, A., McIndoe-Calder, T., Sherman, M., 2020. The Impact of COVID-19 on Consumer Spending. Economic Letters 15/EL/20, Central Bank of Ireland.
Cabrales, A., Gale, D., Gattardi, P., 2016. Financial contagion in networks. In: Bramoulle, Y., Galeotti, A., Rogers, Brian (Eds.), Oxford Handbook of the Economics of Networks. Oxford University Press, Oxford and New York, pp. 543–568. https://doi.org/10.1093/oxfordhb/9780199948277.001.0001.
Carlsen, M., Storgaard, P., 2010. Dankort payments as a timely indicator of retail sales in Denmark. In: Danmarks Nationalbank Working Papers, No. 66, Danmarks Nationalbank, Copenhagen. https://www.econstor.eu/bitstream/10419/82313/1/621225231.pdf.
Central Bank of Ireland, 2020. The potential economic impact of COVID-19 pandemic based on baseline and severe scenarios. In: Quarterly Bulletin No. 3/QB3 - July 2020. https://tinyurl.com/2nyp697z.
Central Bank of Kenya, 2020a. Emergency measures to facilitate mobile money transactions. In: Press Release, March 2020. https://tinyurl.com/2r7k2n6v.
Central Bank of Kenya, 2020b. Implementation of the emergency measures to mitigate the adverse impact of the Corona virus (COVID-19) pandemic on loans and advances. In: Banking Circular No. 3 of 2020. https://tinyurl.com/2rtbp5uy.
Central Bank of Kenya, 2020c. Key Monetary and Financial Indicators - CBK, Weekly Bulletin, 2020. March 27, 2020. https://tinyurl.com/4k7ab3x3.
Central Bank of Kenya, 2020d. Monetary Policy Committee Meeting, CBK, March 23, 2020. https://tinyurl.com/yc4m263w.
Colla, P., Ippolito, F., Li, K., 2013. Debt specialization. J. Financ. 68 (5), 2117–2141. https://doi.org/10.1111/jofi.12052.
Crockett, A., McDonough, W., 1998. Managing change in payment systems. In: BIS Policy Paper, no. 4. https://www.bis.org/publ/plcy04.pdf.
Crowe, M., Tabila, E., Mcguire, B., 2017. Mobile Banking and Payment Practices of US Financial Institutions: 2016 Mobile Financial Services Survey Results in Seven Federal Reserve Districts. Federal Reserve Bulletin of Boston, p. 14. December. https://tinyurl.com/wnayppy4.
Degryse, H., Nguyenn, G., 2007. Interbank exposures: an empirical examination of contagion risk in the Belgian banking system. Int. J. Cent. Bank. 3 (2), 123–171. https://econpapers.repec.org/article/ijcijcjou/y_3a2007_3aq_3a2_3aa_3a5.htm.
Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., Hess, J., 2018. The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. World Ban, Washington DC. https://doi.org/10.1596/978-1-4648-1259-0.
Diamond, D., Dybvig, P., 1983. Bank runs, deposit insurance and liquidity. J. Polit. Econ. 91, 401–419. https://doi.org/10.21034/qr.2412.
Esteves, P.S., 2007.. Are ATM/POS Data Relevant When Nowcasting Private Consumption? Banco de Portugal Working Paper, p. 25. https://econpapers.repec.org/paper/ptuwpaper/w200925.htm.
Financial Stability Board [FSB], 2016. Fintech: Describing the Landscape and a Framework for Analysis. March. https://www.fsb.org/wp-content/uploads/R270617.pdf.
Financial Stability Board [FSB], 2017. Financial Stability Implications from FinTech. June. https://www.fsb.org/2017/06/financial-stability-implications-from-fintech/.
Frost, J., Gambacorta, L., Gambacorta, R., 2020. The Matthew effect and modern finance: on the nexus between wealth and inequality, financial development and financial technology. Work. Pap. No. 871.
Fu, J., Mishra, M., 2020. The Global Impact of COVID-19 on Fintech Adoption. Swiss Finance Institute Research Paper, pp. 20–38.
Fung, W., Yan, W., Lee, J., Yeh, J.H., Yuen, F.L., 2020. Friend or foe: the divergent effects of FinTech on financial stability. Emerg. Mark. Rev. 45, 2020. https://doi.org/10.1016/j.ememar.2020.100727.
Furfine, C.H., 2003. Interbank exposures: quantifying the risk of contagion. J. Money Credit Bank. 111–128.
Galbraith, J., and G. Tkacz (2007). Electronic Transactions as High-Frequency Indicators of Economic Activity. Technical report, Bank of Canada. https://www.bankofcanada.ca/wp-content/uploads/2010/02/wp07-58.pdf.
Galbraith, J., Tkacz, G., 2009. A note on monitoring daily economic activity via electronic transaction data. In: CIRANO Working Papers, 2009–23.
Galbraith, J., Tkacz, G., 2015. Nowcasting GDP with electronic payments data. In: Statistics Paper Series 10. European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpsps/ecbsp10.en.pdf.
Hopkins, A., Sherman, M., 2020. How has the COVID-19 pandemic affected daily spending patterns?. In: Central Bank of Ireland, QB2 https://tinyurl.com/3c3a7dye.
Jack, W., Suri, T., 2011. Mobile Money: The Economics of M-PESA NBER Working Paper Series. National Bureau of Economic Research, Cambridge, EUA. https://econpapers.repec.org/paper/nbrnberwo/16721.htm.
Jack, W., Suri, T., Townsend, R., Robert, M., 2010. Monetary theory and electronic money: reflections on the Kenyan experience. FRB Richmond economic quarterly, vol. 96, no. 1. First Quarter 2010, 83–122. Available at SSRN: https://ssrn.com/abstract=2189122.
Kaminsky, G.L., Reinhart, C., 2000. On crises, contagion and confusion. J. Int. Econ. 51, 145–168. https://doi.org/10.1016/S0022-1996(99)00040-9.
Lou, Y., Otto, C.A., 2020. Debt heterogeneity and covenants. Manag. Sci. 66 (1), 70–92. https://doi.org/10.1287/mnsc.2018.3141.
Mas, I., Morawczynski, O., 2009. Designing mobile money services: lessons from M-PESA. Innovations 4 (2), 77–92. MIT Press. https://doi.org/10.1162/itgg.2009.4.2.77.
Muller, J., 2006. Interbank credit lines as a channel of contagion. J. Financ. Serv. Res. 29, 37–60. https://doi.org/10.1007/s10693-005-5107-2.
Philippon, T., 2016. The Fintech Opportunity (No. w22476). National Bureau of Economic Research. https://doi.org/10.3386/w22476.
Rao, M., 2011. Mobile Africa Report 2011: Regional Hubs of Excellence and Innovation. https://tinyurl.com/yc59rarr.
Report, Cytonn, 2020. Cytonn Note on the Monetary Policy Committee (MPC) Meeting. June 2020. https://cytonn.com/topicals/cytonn-note-on-mpc-june-2020.
Rysman, M., Schuh, S., 2017. New innovations in payments. NBER Innov. Pol. Econ. 17 (1), 27–48. https://doi.org/10.1086/688843.
Van Lelyveld, I., Lierdorp, F.R., 2006. Interbank contagion in the Dutch sector. A sensitive analysis. Int. J. Cent. Bank. 2, 99–134.
Wells, S.J., 2004. Financial interlinkages in the United Kingdom's interbank market and the risk of contagion. In: Bank of England Working Paper No. 230. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=641288.