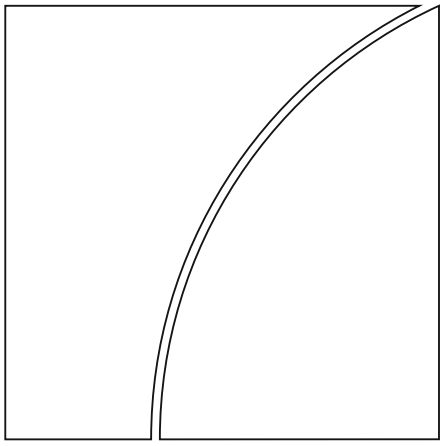

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by Raphael Auer, Giulio Cornelli and Jon Frost

Monetary and Economic Department

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JEL classification: E42, I18, O32, O33.

Keywords: retail payments, cash, Covid-19 pandemic, digital innovation.

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The pandemic, cash and retail payment behaviour: insights from the future of payments database

Raphael Auer, Giulio Cornelli and Jon Frost[1]

Abstract

The Covid-19 pandemic has been a shock to retail payment behaviour. How have the changes differed across countries? What do they imply for the future of cash and digital payments? We assemble a new "Future of Payments" database on retail payment behaviour for up to 95 countries over September 2019 to June 2022. We compare this with measures of the severity of the Covid-19 pandemic, using variation in the timing of waves of cases, changes in mobility and lockdown measures across countries. We find that card-not-present payments, payment app downloads and the volume of cash in circulation all rose in weeks of more stringent lockdowns. Changes were less pronounced in countries with higher mobile penetration. However, recent data suggest that some effects reversed once lockdowns were eased, and mobility rebounded.

Keywords: E42, I18, O32, O33.

JEL classification: retail payments, cash, Covid-19 pandemic, digital innovation.

[1] Raphael Auer is with the Bank for International Settlements (BIS). Giulio Cornelli is with the BIS and the University of Zürich. Jon Frost is with the BIS and is a research affiliate of the Cambridge Centre for Alternative Finance (CCAF). The authors thank Fernando Alvarez, Oliver Gabriel, Leonardo Gambacorta, Chad Harper, Anneke Kosse, Jacob Levy, Jesse McWaters and Orkun Saka for helpful comments and input, and Emma Claggett and Monica Mauron for editorial support. The views expressed here are those of the authors and not necessarily those of the BIS.

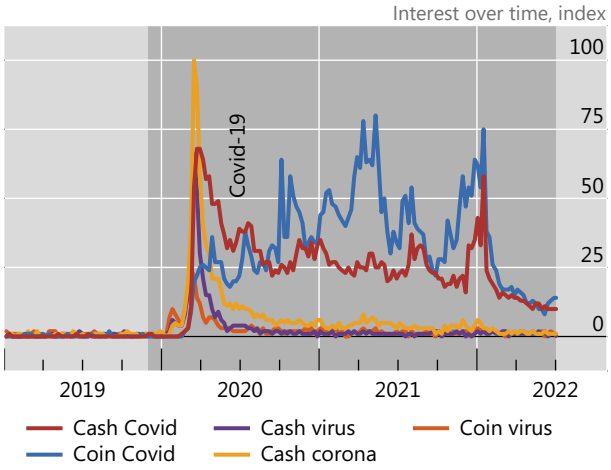
1. Introduction

During the Covid-19 pandemic, consumers rethought the way they pay. Concerns about viral transmission through cash led both consumers and merchants to switch to digital payment methods (Auer et al (2020a); BIS (2021)). While research in microbiology suggests that physical banknotes and coins are no more likely to transmit pathogens than other frequently touched surfaces, cash withdrawals and cash usage declined. Internet searches for "cash and virus" and related terms saw a spike in countries around the world (Graph 1, left-hand panel) – particularly in countries and weeks where Covid-cases were higher, and lockdowns were more stringent (Graph 1, right-hand panel).

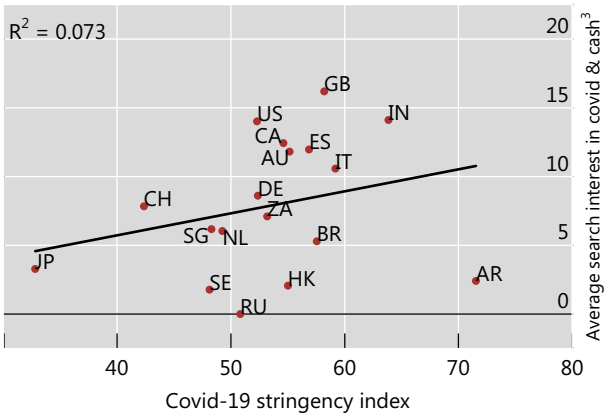
Somewhat paradoxically, cash in circulation actually rose in most countries (Graph 2, left-hand panel). As we document below, this also related to precautionary motives (ie, hoarding). Meanwhile, there was a corresponding shift to digital payments, such as contactless card payments, which do not require users to sign or type in a personal identification number (PIN) at the point of sale (centre panel).[2]

Covid-19 has led to concerns about the safety of banknotes and coins — Graph 1

Search intensity of relevant terms shot up…[1]



…and was higher where lockdowns were more stringent[2]



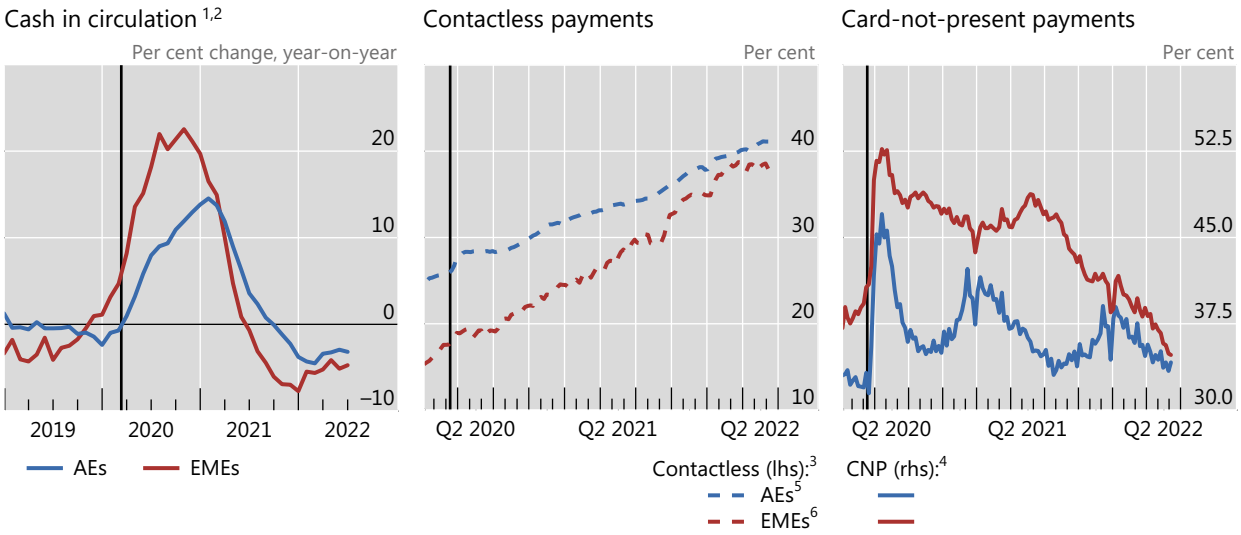
The shaded areas in the left-hand panel indicate Dec 2019–current (Covid-19).

[1] Data accessed on 1 Mar 2021. Data resulting from worldwide Google search queries for selected terms in the period 2008–Jun 2022, indexed to 100 by peak search interest. [2] Country-averages calculated over a sample of 954 observations at the weekly frequency, for AR, AU, BR, CA, CH, DE, ES, GB, HK, IN, IT, JP, NL, RU, SE, SG, US and ZA. Data for 2020. [3] Average of the country-level internet search interest for the terms displayed in the left-hand panel.

Sources: R Auer, G Cornelli and J Frost (2020a): "Covid-19, cash, and the future of payments", *BIS Bulletins*, no 3, April; Hale et al (2020); trends.google.com; authors' calculations.

[2] See also Kosse and Szemere (2022).

The pandemic has led to marked shifts in retail payments, but not all are lasting Graph 2



The black vertical line in the centre panel indicates 11 March 2020, when the World Health Organisation (WHO) declared the Covid-19 outbreak a "public health emergency of international concern".

[1] The lines represent the year-on-year change in the ratio of currency in circulation to GDP. [2] For AEs, simple average of AU, CA, CH, EA, GB, JP, SE and US. For EMEs simple average of AR, BR, CN, HK, ID, IN, KR, MX, RU, SA, SG, TR and ZA. [3] GDP-weighted average of the ratio contactless transaction value to card present net transaction value (both expressed in USD). [4] GDP-weighted average of the ratio of card not present (CNP) transaction value to the total net transaction value (both expressed in USD). [5] Weighted average of AU, CA, CH, DE, ES, GB, IT, JP, NL, SE and US with weights proportional to 2019 GDP. [6] Weighted average of AR, BR, HK, IN, SG and ZA with weights proportional to 2019 GDP.

Sources: IMF, *World Economic Outlook*; World Bank; Datastream; global card networks; authors' calculations.

However, not all these trends lasted beyond the acute phase of the pandemic. Card-not-present (CNP) transactions, which are commonly used for online purchases (e-commerce), also saw rapid growth around the world (Alfonso et al (2020), yet these fell again as lockdowns ended and mobility increased (right-hand panel). by the end of our sample, CNP payments were near their pre-pandemic levels in advanced economies (AEs), and even slightly below pre-pandemic levels in emerging market economies (EMEs).

These differential patterns document that as economies around the world recover from the Covid-19 shock and adapt to a world of vaccines, new virus strains and occasional new restrictions, some shocks may be expected to slowly subside. Yet others – such as greater familiarity with digital payment methods, or the quicker introduction of new payment methods – could have important, lasting effects on payment systems.

This paper offers a systematic cross-country study of the impact of Covid-19 on payments behaviour. While a number of surveys have documented shifts in retail payment behaviour in specific markets,[3] there has been a gap in higher-frequency, cross-country data on payment markets around the world. The impact of the pandemic – an unexpected, exogenous shock – has varied substantially over time, with various waves of new infections and lockdown measures, and across countries.

[3] See eg Ardizzi et al (2020), Jonker et al (2020) and Khanra et al (2021).

This offers a new opportunity to assess changes in retail payment behaviour in a systematic fashion.

We start by assembling a new database on retail payments for up to 95 countries over September 2019 to June 2022 at weekly or monthly frequency.[4] The database encompasses information on: (i) cash in circulation; (ii) credit card payments, in particular the ratio of card-present, contactless and CNP transactions; (iii) central bank efforts on research and development of central bank digital currencies (CBDCs); (iv) internet searches relevant to gauge interest in payments-related topics, such as "ATM near me", "Cash Covid" and the topic of CBDCs and (v) the use of digital payment apps, ie the number of downloads and daily active users of the top payment apps by country. We also include information on the severity of the Covid-19 pandemic (the stringency of lockdown measures, Google mobility indices, and new cases and total cases relative to the population) and financial and macroeconomic indicators. This "Future of Payments" database draws from both public and proprietary sources and is made freely accessible on the BIS website. It complements other publicly available data sources, such as the annual Red Book statistics.

We next document common trends and the underlying heterogeneity across countries in the pre-pandemic payment behaviours, the extent to which they were affected by the pandemic, how they reacted in terms of containment policies and how payment behaviour changed.[5] In the time dimension, the presence of multiple "waves" of new infections and lockdown measures (that were not synchronised across countries) means that we can assess changes both in periods of intensification and normalisation of the pandemic.[6]

To explore this variation, we use a panel regression approach for 18 countries for which there are full cash, card and payment apps data over December 2019 to December 2020 – the acute phase of the pandemic. We find, first, that the intensity of the pandemic was associated with higher cash in circulation, CNP payments and payment app downloads. Second, we find that increases in digital payments use during the pandemic were smaller for countries that had already had high mobile ownership; access to these mobile tools may have mitigated the shock.

The contribution of our paper is to assemble a novel and public cross-country database of retail payment behaviour and utilise it to document the impact of the pandemic. This is of relevance to a classical literature on the economics of consumer payment choice (Humphrey et al (2001), Klee (2008) and Koulayev et al (2016)). It is also relevant to changes in financial technology use from past epidemics (Aksoy et al (2021)). Finally, it complements studies that find that the availability of means of payment has direct consequences for expenditure patterns (Alvarez and Argente (2020), Brown et al (2020), Felt (2020). Ebner et al (2021)) and the aggregate business cycle (Chodorow-Reich et al (2018)). We go further by assembling comprehensive

[4] Throughout this paper we refer to "countries" to mean both national jurisdictions and economies like Hong Kong that are part of a larger jurisdiction.

[5] For example, a 2020 ad-hoc ECB survey showed that the Portuguese worry a great deal about infection through cash, while the Austrians worry almost not at all (ECB (2020)). Another example is that the US experienced a coin shortage, while Canada saw coin circulation drop.

[6] There is also substantial heterogeneity in the country-time level. For instance, the United States has experienced three distinct waves. Several countries in Eastern Europe were hardly affected by the first wave, but very affected by the second – and China has so far avoided a second wave altogether.

data from the most recent period and giving evidence on changes in the Covid-19 pandemic.

Our database has clear utility for public policy. Assessing these shifts in payment behaviour is important for a number of areas of work by central banks and governments – retail payment strategies, financial inclusion strategies, strengthening the mandate for cash, as well as considerations around retail CBDC issuance. With our findings, we show that there is heterogeneity in changes in retail payment behaviour, and public policy will have to adapt to differing jurisdiction contexts. The database should also be a resource to academic researchers active in payment economics.

The paper is organised as follows. The second section describes the construction of our new database on retail payment behaviours through the pandemic. The third section establishes both common trends and heterogeneity in the time and country dimension. The fourth section discusses our regression analysis on changes in payments behaviours for a core dataset of 18 countries. The fifth section discusses trends relevant for policy, in particular around (i) the change in central banks' stance on retail CBDC issuance, (ii) communication on retail payment strategies and (iii) strengthening mandates for the ongoing provision of cash.

2. Construction of the future of payments database

The database is assembled by the authors from a variety of proprietary and public sources. There is a "core" dataset available for 18 countries over the period going from end-December 2019 to end-December 2020, and an "extended" dataset for up to 95 countries over the period going from September 2019 to June 2022. Both cover five topical areas, at a weekly or monthly frequency:

i. Data on cash in circulation and cash withdrawals. Data on cash in circulation are publicly available from national central banks and international organisations, generally at monthly frequency. To make the series comparable and iron out seasonal changes, we calculate the year-on-year change in cash in circulation, expressed in percentage points (pp). For selected markets (eg Australia, India, Netherlands, Russia, Spain, Switzerland and the United Kingdom), data at various frequencies on ATM withdrawals are available, which can help to assess whether changes in cash in circulation are attributable to greater withdrawals or reduced (re-)deposits.

ii. Data on payments collected from two global card networks for 18 countries over September 2019 to May 2022. These proprietary series were obtained by the authors from the networks, subject to data agreements. The indicators cover the ratio of card-present transactions to total net transactions, the ratio of contactless to card-present transactions, and the ratio of CNP transactions to total net transactions. Specifically, card-present transactions are payments authorised by a debit or credit card (or a virtual card on one's smart phone) that is swiped through or held near a card terminal. The most common example are in-store point-of-sale (POS) transactions. Contactless transactions are a subset of card-present transactions and correspond to payments executed by tapping a contactless card over a contactless-enabled POS terminal. Lastly, CNP transactions correspond to payments executed remotely without the presence of a physical card. The typical example is an online purchase. However, this can also

include in-store purchases with a mobile phone-based app that saves card details and uses near-field communication (NFC). Unfortunately, it is not possible to distinguish these from other CNP transactions. These ratios are calculated in terms of the value in local currency, value in USD[7] and the number of transactions. For each, we create an aggregate country-level series with a weighted average of the series from the two card networks, based on estimates of market shares by region. We include small statistical noise to preserve confidentiality.[8]

iii. Data on central banks' work and policy stance on CBDCs. For this, we use public information on CBDC research and development projects, the stance of central bankers' speeches on CBDC issuance and the number of central bankers' speeches on retail and wholesale CBDC (Auer et al (2020b)). Project scores can take a value of 0 (no publicly announced CBDC research), 1 (research), 2 (a pilot) or 3 (a live CBDC). This is now made available in a time series format for the first time, allowing researchers to review changes in CBDC project work over time. The speech stance counts the number of speeches with a positive stance on CBDC issuance from the BIS central bankers' speech database. The authors have coded a speech in which a central bank official announces CBDC work or notes its promise as positive; speeches in which the risks of CBDC issuance are underscored or it is stated that CBDC issuance is not necessary are coded as a negative stance, and others are coded neutral.

iv. Data on internet search interest on cash and Covid-19 transmission, proximity to ATMs, shopping online and CBDCs. This information is publicly available from Google Trends. We used the keywords "cash corona", "cash covid", "cash virus", "coin covid", "coin virus", "ATM near me", "shop online", "buy online", "online supermarket", "CBDC" and the topic "Central Bank Digital Currency".[9]

v. Data on payment apps downloads and usage. These series are proprietary data aggregated by the authors from Sensor Tower, a private data vendor. We report the total number of downloads of all payment apps in the top 25 finance apps in each country, as classified by Sensor Tower from the Google Play and Apple App stores. We have reviewed individual apps for all 18 countries, and selected those

[7] USD values (both card-present and CNP transactions) are calculated from underlying daily data and converted using the daily exchange rate. The weekly "Card present ratio" measured in USD (expressed as weekly USD card-present value / (weekly USD card-present value + weekly USD card-not-present value)) is not necessarily identical to the ratio measured in local currency, for example if the exchange rate is volatile and relatively more card-present transactions take place during weekdays while card-not-present transactions occur during weekends. In practice, however, these differences are small.

[8] For each country, we multiply the value of each indicator for each card network in that country by the market share of that card network in that region (Asia-Pacific/Middle East/Africa, Canada, Europe, Latin America and the United States). The statistical noise is a small random variable that ensures that no party can calculate the exact value of each indicator for any one network based on public data and (any other single network's) proprietary data.

[9] Google Trends data are standardised at the country level by the total searches of the country and time they represent. As such, we are looking at comparable series over time. For the internet search interest on cash and Covid-19 transmission, we intentionally skipped the keyword "coin corona" since "corona" is in some instances used as a translation of the Danish "Krone", Swedish "Krona" or Czech "Koruna". In other words, some currencies have "corona" or a similar word in the name. Our fear is that including this term without the addition of "virus" would bias the measure of search interest towards those countries.]

that are specific to payments.[10] The resulting sample includes apps offered by big tech companies, fintechs, incumbent financial institutions and other corporations offering non-tech services (eg retailers). We also provide the number of weekly active users of these payment apps, as estimated by Sensor Tower. Both series are divided by the country population as provided by the World Bank.

In addition, we have collected information on Covid-19 metrics like the number of reported Covid-19 cases (both total and new cases), scaled by 100,000 inhabitants; and the number of new cases. This comes from Our World in Data and Karlinsky et al (2021). We also use the indices of Hale et al (2020), which give information on the stringency of lockdown measures, the evolution of governments' responses, the containment and heath related initiatives and the economic support polices adopted in response of the Covid-19 pandemic. These indices are aggregated from a set of 20 indicators of government responses and take values from 1 (less stringent) to 100 (more stringent).[11] Finally, we use data from the Google Mobility Index on mobility across different category of places like retail and recreational, grocery and pharmacy, parks, transit stations, workplace and residential.

Table 1 gives descriptive statistics of key variables for the core dataset of 18 countries over December 2019 to December 2020, used in subsequent regressions.

Descriptive statistics, core dataset Table 1

Four-week change in:	Observations	Mean	Std Dev	Min	Max
Cash in circulation[1]	954	0.88	2.63	–13.80	14.80
Card-not-present transaction share in transaction count	954	0.46	4.50	–16.72	23.32
Payment app downloads per 100k people[2]	954	3.32	67.83	–143.81	146.09
Top 25 finance app downloads per 100k people	954	16.08	942.12	–11,724.0	14,390.6
Google trends search intensity for "ATM near me"	954	–1.33	20.24	–88.00	75
Covid stringency index	882	5.21	18.07	–26.86	89.81
Google mobility index[3]	774	–2.38	18.00	–82.34	36.94
New cases per 100k people[4]	954	12.66	60.71	–361.91	594.59

[1] To address seasonal patterns, indicator refers to the four-week change in the year-on-year change in cash in circulation. [2] Four-week change in payment app downloads among the country-specific top 25 finance apps as classified by Sensor Tower. Winsorised at the 5th and 95th percentiles. [3] Four-week change in index for simple average of categories retail and recreation, transit and stations and workplaces. [4] Four-week change, winsorised at the 2.5th and 97.5th percentiles.

Sources: Hale et al (2020); Google, *COVID-19 community mobility reports*; Our World In Data; Sensor Tower; Authors' elaboration.

In the Appendix, Table A1 gives descriptive statistics for the extended dataset of 95 countries over January 2020 to June 2022.

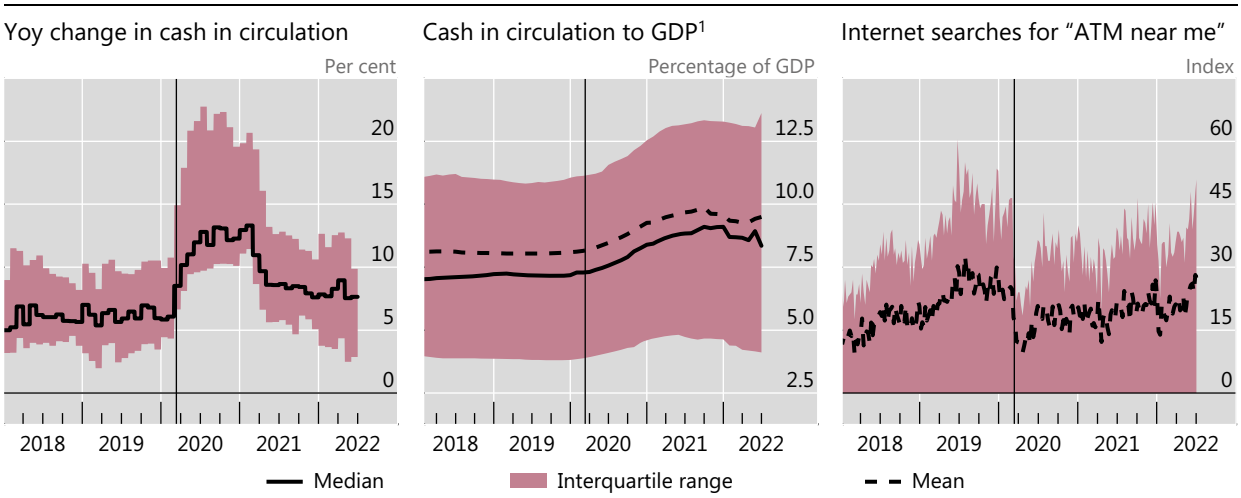
[10] We relied on the support of native speakers in cases where app names were in Arabic, Czech, Chinese, Korean, Japanese, Hindi, Hungarian, Russian and Thai.

[11] For more details see "Methodology for calculating indices" and "Codebook for the Oxford Covid-19 Government Response Tracker."

3. Common trends and heterogeneity in retail payment behaviour

The data make clear that the pandemic had a stark impact on retail payment behaviour. While high-frequency data on cash use in transactions are not available, we can confirm that cash in circulation surged across our sample, with an average 10% year-on-year growth rate by Q2 2020 (Graph 3, left-hand panel). The interquartile range actually narrowed in the first four months, relative to the pre-pandemic period, showing that the increase was of similar magnitude in many economies in the sample; from July 2020 onward it widened, as trends in different countries diverged. By the end of 2021, the median ratio of cash in circulation to GDP reached 8% across our sample, but fell slightly in 2022 (centre panel). Meanwhile, internet searches for "ATM near me" – common for users withdrawing cash, particularly in unfamiliar locations – understandably dropped, with larger dispersion over time (right-hand panel; see also Garratt et al (2020)). By the end of the sample this had rebounded.

Cash in circulation surged, while searches for ATMs dropped — Graph 3



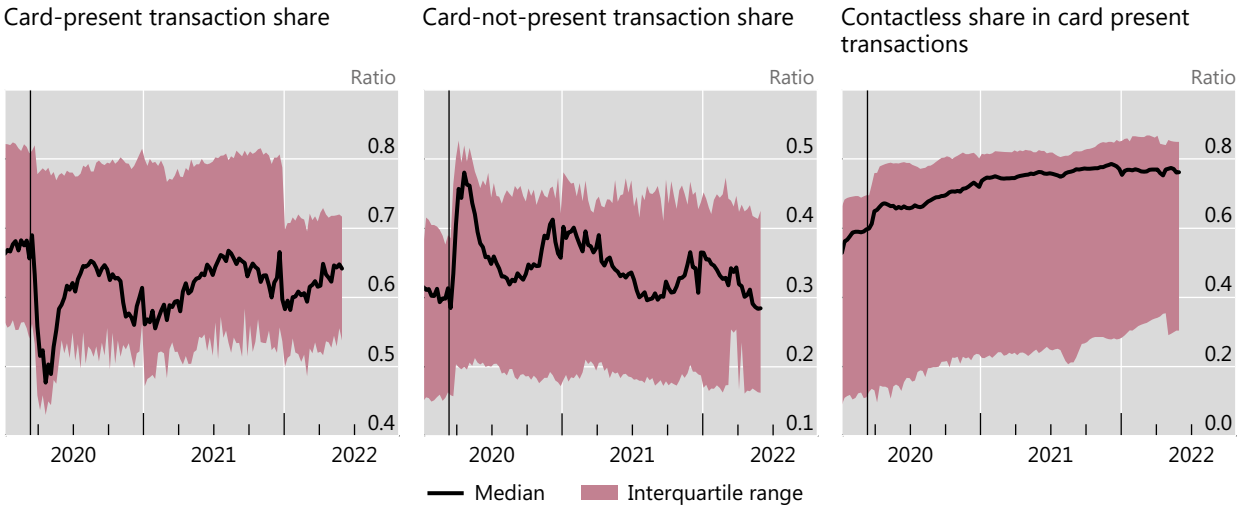
The black vertical lines indicate 11 March 2020, when the World Health Organisation (WHO) declared the Covid-19 outbreak a "public health emergency of international concern". The sample includes up to 95 countries.

[1] 12-month moving average of the ratio of cash in circulation to GDP.

Sources: IMF, *World Economic Outlook*; Datastream; Google Trends; national data; authors' calculations.

Changes in card payments saw an even wider dispersion of outcomes. For countries at the 75th percentile, the card-present share fell only slightly from mid-March to mid-April 2020, showing a broadly constant trend relative to the pre-pandemic period. For the median country, the share dropped around 20 percentage points, from 75% of transactions in the week of 11 March to 54% at the trough in the week of 13 April, prior to a rebound (Graph 4, left-hand panel). CNP transactions for the median country rose by 18 percentage points in the acute phase of the pandemic,

Card payments shifted to remote and contactless[1] Graph 4



The black vertical lines indicate 11 March 2020, when the World Health Organisation (WHO) declared the Covid-19 outbreak a "public health emergency of international concern". The sample includes AR, AU, BR, CA, CH, DE, ES, GB, HK, IN, IT, JP, NL, RU, SE, SG, US, ZA.

[1] Based on transaction counts.

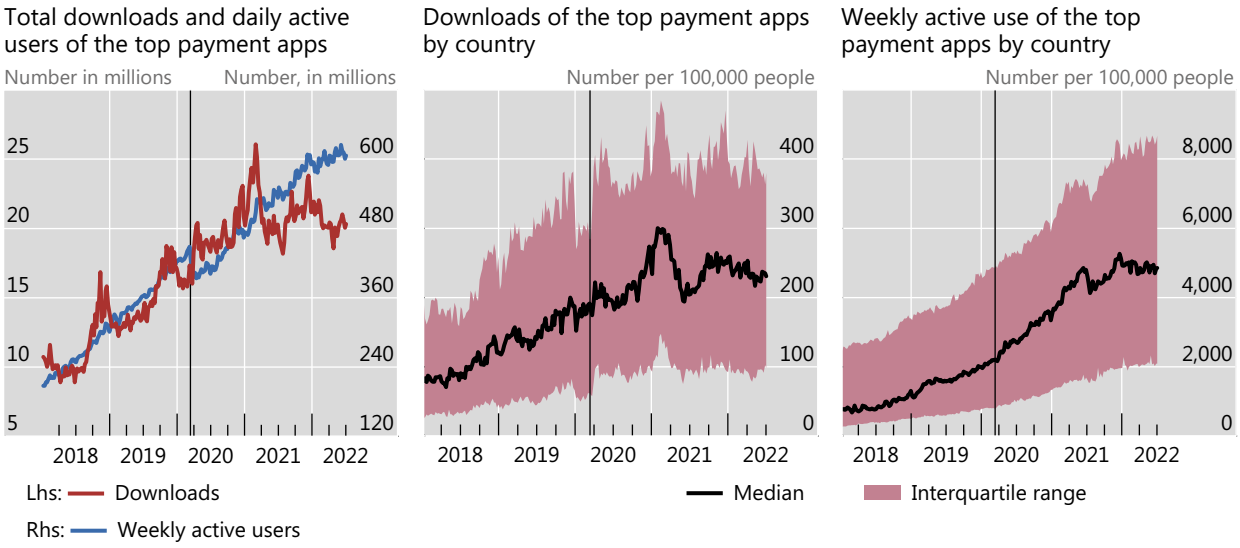
Sources: a global card network; authors' calculations.

but fell again toward the end of the sample (centre panel). At the 75th percentile, the same metric rose by 15 percentage points, while at the 25th percentile it remained largely unchanged. The share of contactless transactions rose in many countries, and remained structurally higher, but it continued to show a wide dispersion over the period of examination (right-hand panel).

The adoption of payment apps accelerated during the pandemic, and payment app use continues to be higher than before the pandemic. Downloads of the largest payment apps, and estimates of actual use, surged at the global level (Graph 5, left-hand panel). Downloads had been rising even before the pandemic, and tended to be higher in November ahead of holidays in many countries and shopping events like Singles Day in China. Yet during 2020 and 2021, there was a further peak in downloads in January-March, as global Covid cases surged, and many households were confined home. In November 2021, as the Covid pandemic intensified in India, weekly active use surged, with a noticeable impact on the global total. Within countries, there was a notable increase in downloads in the first months of the pandemic and again in early and late 2021 (centre panel). Estimates of the number of weekly active users showed steadier growth (right-hand panel).

Payment app downloads and rose

Graph 5



The black vertical lines indicate 11 March 2020, when the World Health Organisation (WHO) declared the Covid-19 outbreak a "public health emergency of international concern". The sample includes up to 95 countries. Based on the country specific top 20 finance APPs for absolute number of downloads as classified by Sensor Tower.

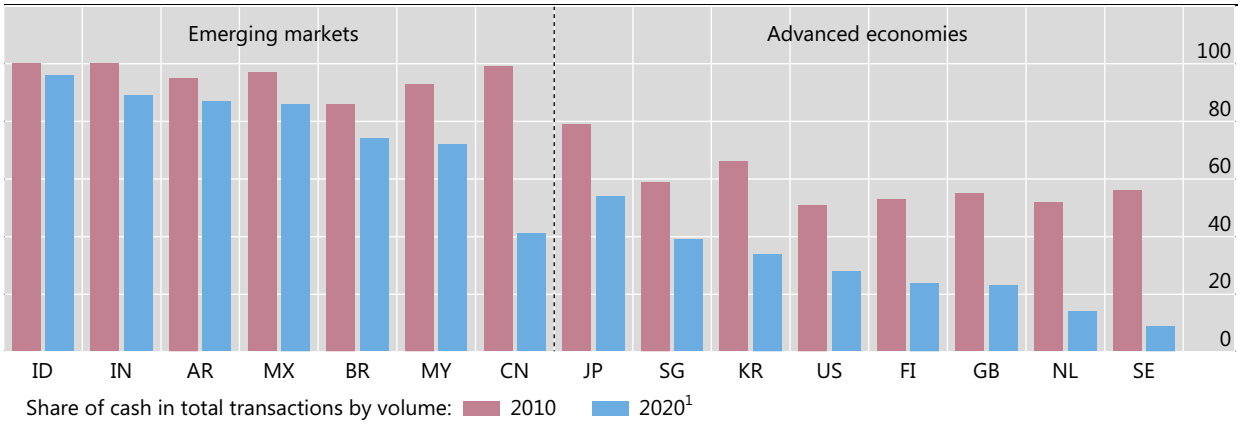
Sources: Sensor Tower; authors' calculations.

These changes occurred against the backdrop of several slower, structural changes around the world. In particular, cash use had already been declining in many jurisdictions (Graph 6) – both AEs and EMEs. Yet indicators such as the persistence of small-denomination bills show that in many jurisdictions, cash remains an important means of payment; indeed, "cash is still king" (Bech et al, 2018). Credit card payments were forecast to increase relative to global output (RBR, 2021); the forecasts for uptake have now been revised upward.

Cash use had been declining before the pandemic

In per cent

Graph 6



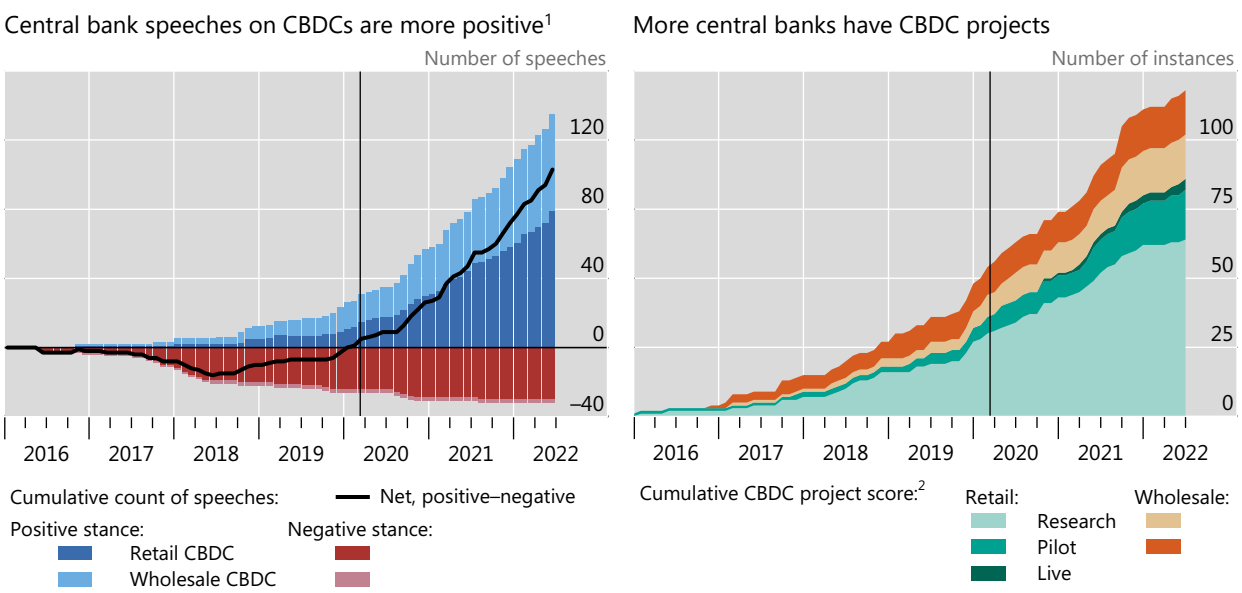
[1] Estimated.

Source: McKinsey (2020): *Global payments report*, October.

A particularly notable shift during the pandemic was the rising interest in, and experimentation on, CBDCs. These could be a new, third form of central bank money, in addition to cash and the central bank reserves available to commercial banks. They are being investigated for their potential to lower payment costs, enhance financial inclusion, protect privacy and promote innovation (Auer, Frost, Lee, Martin and Narula (2021)). Work on CBDCs had been underway for several years, yet it accelerated in 2020 (Auer et al (2020c)). In April 2020, the People's Bank of China (PBC) launched the pilot of its electronic Chinese yuan (e-CNY) in the cities of Shenzhen, Suzhou, Chengdu, Xiong'an and the "2022 Winter Olympics Office Area" in Beijing. In October 2020, the Central Bank of the Bahamas launched the Sand Dollar, a digital version of the Bahamian dollar (Central Bank of The Bahamas (2020)). In March 2021 the Eastern Caribbean Central Bank (ECCB) announced the public roll out of DCash, and in October the Central Bank of Nigeria (CBN) launched the e-Naira. The Bank of Jamaica announced in started rolling out its CBDC, JAM-DEX, in the first quarter of 2022. Beyond these high-profile announcements, central bankers around the world gave a more favourable airing to the potential of retail CBDCs in their speeches (Graph 7, left-hand panel). Research and development work on CBDCs kicked into higher gear, with over 60 publicly announced CBDC projects by March 2021 (right-hand panel). Meanwhile, 90% of 81 responding central banks in a survey noted that they are now researching CBDCs (Kosse and Mattei (2022)).

Work on CBDCs has accelerated during the Covid-19 pandemic

Graph 7



The black vertical lines indicate 11 March 2020, when the World Health Organisation (WHO) declared the Covid-19 outbreak a "public health emergency of international concern".

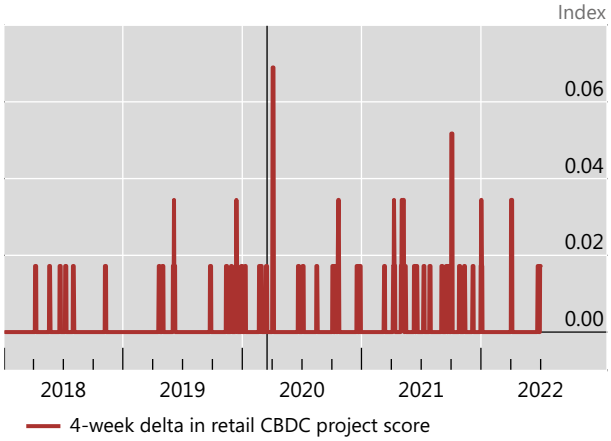
[1] Search on keywords "CBDC", "digital currency" and "digital money". The classification is based on the authors' judgment. The score takes a value of –1 if the speech stance was clearly negative or in case it was explicitly said that there was no specific plan at present to issue digital currencies. It takes a value of +1 if the speech stance was clearly positive or a project/pilot was launched or was in the pipeline. Other speeches (not displayed) have been classified as neutral. [2] Based on publicly communicated reports. Cumulative count of scores in each bucket. The score can take a value of 0 when there is no announced project, 1 in case of research studies, 2 in the case of an ongoing or completed pilot and 3 for a live CBDC. For more information see Auer et al (2020c).

Sources: Auer et al (2020c); central banks' websites.

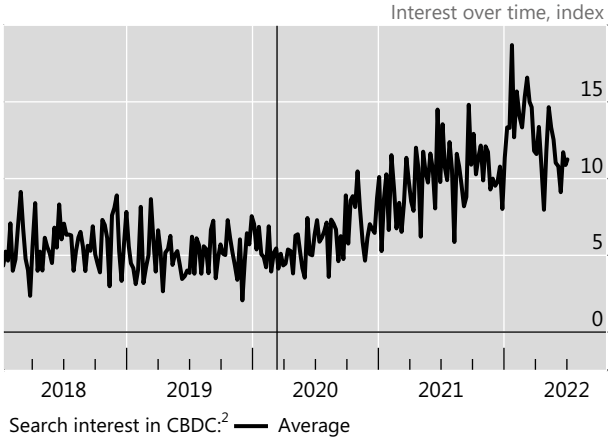
Notably, several central banks' CBDC projects were announced very close to the initial lockdowns in March 2020 (Graph 8, left-hand panel). While in many countries it is still too early to tell whether issuance will be considered, interest in the topic among the general public remains high (right-hand panel).

Central banks advanced their work on CBDCs — Graph 8

Work on retail CBDC accelerated…



…and the topic became more and more popular



The black vertical lines indicate 11 March 2020, when the World Health Organisation (WHO) declared the Covid-19 outbreak a "public health emergency of international concern".

[1] The sample includes 54 countries. [2] Simple average of Google Trends search interest for keyword "CBDC" and topic "Central Bank Digital Currency". The sample includes up to 95 countries.

Sources: Auer et al (2020c) ; trends.google.com; authors' calculations.

4. Empirical analysis

Our empirical approach is the following. We regress a range of indicators of retail payment behaviours (cash in circulation, contactless and card-not-present payments, search interest, payment app usage) against measures of the intensity of the Covid-19 pandemic and a number of controls. To ensure comparability, we restrict our regressions to 18 countries for which we have all indicators, over the period December 2019 to December 2020. Basic estimations take the form of:

$$Y_{i,t-1} = \alpha_i + \alpha_t + \beta X_{i,t-1} + \varepsilon_{i,t} \qquad (1)$$

where dependent variable $Y_{i,t-1}$ is: (i) the 4-week change in year-on-year change in cash in circulation, (ii) the ratio of card-not-present transactions in total card net transactions, or (iii) downloads of the top payment apps relative to population. Independent variables in the vector $X_{i,t-1}$ are the 4-week changes in: Stringencyi,t–1, an index of Covid-19 containment measure stringency (Hale et al (2020)), Mobilityi,t–1, the Google mobility index and new casesi,t–1, the number of new cases per 100,000 of the population.[12] We also estimate interaction estimations of the form:

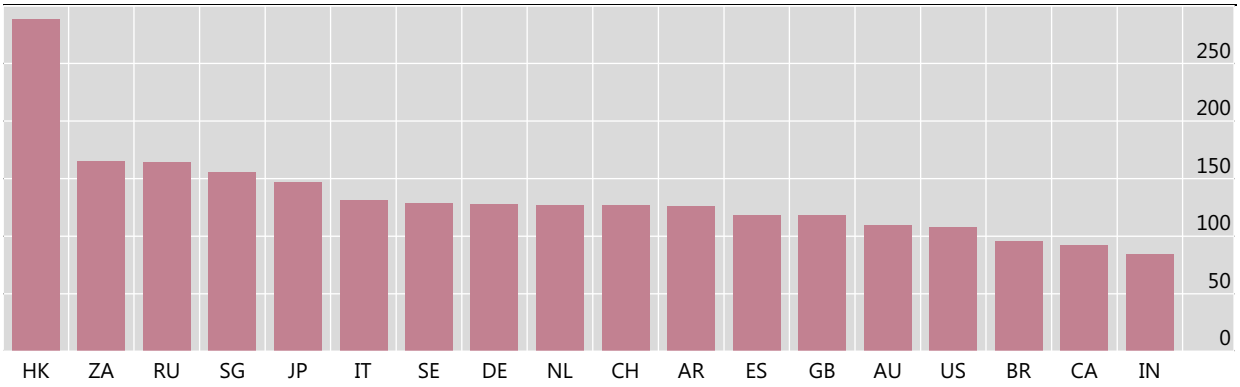
$$Y_{i,t-1} = \alpha_i + \alpha_t + \beta X_{i,t-1} + \gamma Mobiles_{i,0} X_{i,t-1} + \varepsilon_{i,t} \qquad (2)$$

[12] Descriptive statistics and pairwise correlations are given in Tables A1 and A2 in the appendix.

where $Mobiles_{i,0}$ is the pre-pandemic level of the mobile phones per 100 adults, as a measure of digital adoption.[13] Graph 9 shows the cross-country distribution of this variable.

Cross-country distribution of mobiles penetration

Number of mobiles per 100 people — Graph 9



Data for 2019.

Source: World Bank.

Table 2 shows our results for cash in circulation.[14] Column 1 documents that more stringent lockdown measures associated with greater cash in circulation in our sample. A one-standard deviation rise in the stringency index was associated with an increase in cash in circulation by 0.8 percentage points (pp). The interaction term in column 2 shows that there was no significant difference for economies that had higher mobile phone ownership. Similar results hold when using the drop in mobility as a measure of pandemic intensity (columns 3 and 4), though here, the relationship between the drop in mobility and cash in circulation is attenuated when mobile ownership was higher. Similar results are again obtained when looking at new cases as a measure of pandemic intensity (columns 5 and 6), but the interaction term in this case is not statistically significant. A simple "horse race" of measures of the intensity of the pandemic finds that especially stringency and new cases were important (column 7).[15]

[13] Following the ISO definition, the first week of the year 2020 includes the period 30 December 2019 – 5 January 2020. This week itself is always excluded from the analysis.

[14] The amount of currency in circulation may be affected by both cash hoarding and retail payment habits. One can examine the dynamics of large and small denominations because larger notes are typically hoarded while smaller notes and coins are typically used for payment transactions. Indeed, Kosse and Szemere (2021) demonstrate that large-denomination notes witnessed higher growth during 2020, suggesting that the hoarding incentive may possibly be at play in several of the findings in this section. Unfortunately, the high-frequency data we analyse does not allow splitting up currency by denominations.

[15] Cash in circulation shows holdings of cash. Looking at searches for "ATM near me" as a proxy of *use* of cash, we see a drop when stringency index or new cases were higher (see Table A3 in the appendix). Results using four-week change in cash in circulation (rather than four-week change in year-on-year change) are also broadly consistent (see table A4 in the appendix).

Estimations of cash in circulation[1] Table 2

	Measure of in cash in circulation[2]						
Four-week change in:	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Stringency index	0.043***	0.051***					0.040***
	(0.007)	(0.013)					(0.008)
stringency*mobiles$_{2020week0}$		–0.006					
		(0.008)					
Google mobility			–0.033***	–0.095***			–0.004
			(0.008)	(0.017)			(0.007)
mobility*mobiles$_{2020week0}$				0.047***			
				(0.013)			
New cases per 100k people					0.005***	–0.012	0.003*
					(0.001)	(0.018)	(0.002)
new cases*mobiles$_{2020week0}$						0.014	
						(0.014)	
No of observations	846	846	738	738	918	918	738
R-squared	0.334	0.334	0.314	0.323	0.312	0.313	0.338

Standard errors clustered on week in parentheses; ***/**/* indicates statistical significance at the 1/5/10% level.

[1] All the independent variables are lagged of one week. The regressions include time and country fixed effects. The interaction terms correspond to the product of the respective independent variable and the pre-pandemic level (ie first week of 2020) of the number of mobiles per adults. [2] To address seasonality, the indicator is the four-week change in the year-on-year change in cash in circulation.

Source: Authors' calculations.

Table 3 shows the estimations for CNP transactions. As lockdowns were instituted and physical mobility dropped, e-commerce and the need for remote payment methods surged. In general, a one-standard deviation increase in stringency was associated with a 2.7 pp increase in the CNP transaction share (column 1). In countries with an initially higher mobile ownership rate, this was less pronounced (column 2). Similar results again hold when considering the drop in mobility (columns 3), and here too the interaction term is significant (column 4). CNP transactions were also higher when new cases were higher (column 5), but the interaction is not significant (column 6). All three measures of pandemic intensity are significant when included together (column 7).

Estimations of card-not-present transactions[1] Table 3

	Card-not-present transaction share based on transaction count[2]						
Four-week change in:	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Stringency index	0.137***	0.253***					0.035*
	(0.014)	(0.033)					(0.020)
stringency*mobiles$_{2020week0}$		–0.084***					
		(0.023)					
Google mobility			–0.234***	–0.364***			–0.202***
			(0.017)	(0.045)			(0.022)
mobility*mobiles$_{2020week0}$				0.099***			
				(0.029)			
New cases per 100k people					0.017***	–0.011	0.007***
					(0.003)	(0.025)	(0.002)
new cases*mobiles$_{2020week0}$						0.023	
						(0.020)	
No of observations	846	846	738	738	918	918	738
R-squared	0.560	0.576	0.691	0.703	0.501	0.501	0.703

Standard errors clustered on week in parentheses; ***/**/* indicates statistical significance at the 1/5/10% level.

[1] All the independent variables are lagged of one week. The regressions include time and country fixed effects. The interaction terms correspond to the product of the respective independent variable and the pre-pandemic level (ie first week of 2020) of the number of mobiles per adults. [2] Four-week change in the card-not-present transaction share based on transaction count .

Source: Authors' calculations.

How did the pandemic influence the adoption of payment apps? Using payment app downloads as our dependent variable (Table 4), we find a clear and statistically significant relationship between lockdown stringency and new downloads by users (column 1).[16] A one-standard deviation shock in lockdown stringency is associated with 12 more downloads per 100,000 of the population in the following week (about 0.14 standard deviations of the dependent variable). This was attenuated in countries with an initially high level of mobile ownership (column 2). Downloads also rose when mobility dropped (column 3), but again by less in countries where mobile adoption was high (column 4). Payment app downloads were also higher when new cases were high (column 5), but again less so for jurisdictions with higher mobile ownership (column 6). When including indicators together, none is statistically significant in explaining overall changes in payment app downloads (column 7).[17]

[16] This is broadly consistent with evidence for 74 countries from Fu and Mishra (2020).

[17] Similar findings hold when looking at downloads of broader finance apps (Table A5).

Estimations of payments app downloads per 100k people[1] Table 4

	Payments app downloads per 100k people[2]						
Four-week change in:	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Stringency index	0.431*	3.128***					0.360
	(0.228)	(0.615)					(0.267)
stringency*mobiles$_{2020week0}$		–1.955***					
		(0.391)					
Google mobility			–0.756**	–3.364***			–0.479
			(0.318)	(0.598)			(0.359)
mobility*mobiles$_{2020week0}$				1.967***			
				(0.429)			
New cases per 100k people					0.083***	1.275**	0.041
					(0.024)	(0.477)	(0.026)
new cases*mobiles$_{2020week0}$						–0.942**	
						(0.377)	
No of observations	846	846	738	738	918	918	738
R-squared	0.111	0.150	0.120	0.143	0.111	0.118	0.123

Standard errors clustered on week in parentheses; ***/**/* indicates statistical significance at the 1/5/10% level.

[1] All the independent variables are lagged of one week. The regressions include time and country fixed effects. The interaction terms correspond to the product of the respective independent variable and the pre-pandemic level (ie first week of 2020) of the number of mobiles per adults. [2] Four-week change in the number of payments app downloads (among the country specific top 25 finance apps as classified by Sensor Tower) per 100,000 people. Winsorised at the 2.5th and 97.5th percentiles.

Source: Authors' calculations.

5. Acceleration and heterogeneity in digital payments

Around the globe, the Covid-19 pandemic has thrown retail payment behaviour for a loop. We assemble and make available for research a novel "Future of Payments" database and use it to document a number of salient patterns of retail payment behaviours during and after the pandemic.

We show that the pandemic has been associated with several pronounced changes in payment behaviours, only some of which were lasting. Cash in circulation, use of card-not-present transactions and downloads of payment apps all spiked during the early phase of the pandemic. We show that during times when the pandemic was more intense (ie during stringent lockdowns, times of reduced mobility and with higher new cases), the volume of cash in circulation, remote (ie CNP) payments and downloads of payment apps rose. Second, we document that the changes we analyse have been quite heterogeneous across countries. Countries with greater pre-pandemic mobile adoption (as measured by mobile phone subscriptions per inhabitant) saw less pronounced changes during the acute phase of the pandemic. Notably, recent data show that some of the effects have not lasted beyond the acute phase of the pandemic. For example, CNP transactions fell again as lockdowns ended, even below pre-pandemic levels in some jurisdictions, while the contactless ratio generally stayed above pre-pandemic levels.

Our findings are notable considering several concurrent trends in the global policy debate. Within countries, a key issue is disparity in access to payment instruments, with gaps in access to digital payments for unbanked and elderly customers. Any shift away from cash might have distributional ramifications. If cash is not widely accepted as a form of payment, it may create a "payments divide" between those who have access to digital payments and those who do not. This, in turn, might have a particularly negative impact on unbanked and elderly clients. Access to such alternatives is far from ubiquitous in many emerging market and developing nations where authorities have recently asked for more usage of digital payments. This might be a major argument in the future, calling for a stronger role for physical currency, and potentially calling for a digital complement for online transactions, ie a retail CBDC. Still, a key finding is that the impact of lockdowns and the pandemic has partly reversed – suggesting that retail behaviours may change slower than some have anticipated, and that cash may continue to play a vital role going forward.

This underscores both progress and challenges of the past decades in the global retail payment system (BIS (2020)) and the need for global initiatives to foster the growth of digital payments in all countries alike. The sudden shift to card payments made it painfully clear that not all consumers have access to payment cards, bank accounts and digital wallets.[18] And the pandemic itself is a case in point of how the availability of digital payment methods can mitigate the impact of crisis. As many governments enacted direct payments to households or informal workers, these gaps in access hindered the effectiveness of the public policy response (Auer et al (2020b)). In the United States, for instance, the government relied on cheques and prepaid cards to reach unbanked recipients. In China and many other emerging jurisdictions, the government could make instant transfers to digital wallets.

Uniform access to payment services is crucial in promoting equitable and sustainable development, and a precondition for international convergence of living standards. Despite significant progress on the financial inclusion objective, large portions of the population continue to be excluded from digital payments. Financially excluded individuals and firms have to rely on the informal economy, hampering development across the board. At the current juncture, global development efforts are focused on cross-border payments, and a global roadmap that is addressing existing challenges of high cost, low speed, limited transparency, and far from universal access faced by cross-border payments.[19] They could be complemented by similar initiatives aimed at improving payments domestically (CPMI 2020b).

[18] Another trend of concern is entrenched market power and resultant high fees in payments. Despite decreases in the cost of price of communication equipment and bandwidth, the cost of conventional digital payment options, such as credit and debit cards, remains high in many economies. While card payments provide additional services (such as fraud protection or insurance), these high costs can also reflect economic rents. The costs are levied on the merchant, and this not directly visible to consumers, even though they are ultimately passed on to them. Going forward, one new concern is that when big tech and fintech firms enter the payments market, their access to user data from associated digital business lines may allow them to achieve a dominant position, leading to fees that are even higher than those charged by credit and debit card companies currently. Merchant fees as high as 4% have been reported for some big techs and fintechs (see eg Reuters, 2021).

[19] See CPMI (2020a), CPMI et al (2021), and Auer, Boar, Cornelli, Frost, Holden and Wehrli (2021).

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Appendix: additional tables and estimation results

Descriptive statistics, extended dataset — Table A1

Four-week change in:	Observations	Mean	Std Dev	Min	Max
Cash in circulation[1]	11,167	11.77	9.47	–2.86	36.06
Google trends search intensity for "ATM near me"	12,090	18.14	23.91	0	100
Retail CBDC project score	7,436	0.86	0.66	0	3
Wholesale CBDC project score	7,436	0.52	0.81	0	2
Central bankers' speech stance on CBDCs	126	0.54	0.58	–1	1
Cumulative number of central bankers' speeches on retail CBDCs	3,250	2.08	2.39	0	16
Cumulative number of central bankers' speeches on wholesale CBDCs	1,820	2.33	3.52	0	24
Stringency index	12,090	49.74	23.19	0	93.52
Google mobility[2]	10,463	–13.14	20.95	–68.68	50.78
New cases per 100k people[3]	11,960	150.80	389.72	0	6486.16

[1] To address seasonal patterns, indicator refers to the four-week change in the year-on-year change in cash in circulation. [2] Simple average of categories retail and recreation, transit and stations and workplaces. [3] Winsorised at the 2.5th and 97.5th percentiles.

Sources: Auer et al (2020b); Hale et al (2020); Google, *COVID-19 community mobility reports*; Our World In Data; Authors' elaboration.

Pairwise correlations — Table A2

Four-week change in:	Stringency index	Google mobility[1]	New cases per 100k people[2]
Stringency index	1		
Google mobility[1]	–0.80***	1	
New cases per 100k people[2]	0.15***	–0.21***	1

*** indicates statistical significance at the 1% level.

[1] Simple average of categories retail and recreation, transit and stations and workplaces. [2] Winsorised at the 2.5th and 97.5th percentiles.

Sources: Hale et al (2020); Google, *COVID-19 community mobility reports*; Our World In Data; Authors' elaboration.

Estimations of internet searches for "ATM near me"[1] Table A3

	Google trends search intensity for "ATM near me"[2]						
Four-week change in:	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Stringency index	–0.384***	–0.244					–0.298***
	(0.055)	(0.158)					(0.077)
stringency*mobiles$_{2020week0}$		–0.101					
		(0.124)					
Google mobility			0.203***	0.068			0.015
			(0.058)	(0.230)			(0.075)
mobility*mobiles$_{2020week0}$				0.102			
				(0.175)			
New cases per 100k people					–0.019	0.063	–0.006
					(0.015)	(0.118)	(0.014)
new cases*mobiles$_{2020week0}$						–0.065	
						(0.093)	
No of observations	846	846	738	738	918	918	738
R-squared	0.224	0.225	0.207	0.207	0.173	0.173	0.226

Standard errors clustered on week in parentheses; ***/**/* indicates statistical significance at the 1/5/10% level.

[1] All the independent variables are lagged of one week. The regressions include time and country fixed effects. The interaction terms correspond to the product of the respective independent variable and the pre-pandemic level (ie first week of 2020) of the number of mobiles per adults. [2] Four-week change in the Google trends search intensity for "ATM near me".

Source: Authors' calculations.

Estimations of alternative measure of cash in circulation[1] Table A4

	Alternative measure of in cash in circulation[2]						
Four-week change in:	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Stringency index	0.023***	0.035***					0.030***
	(0.004)	(0.008)					(0.005)
stringency*mobiles$_{2020week0}$		–0.009					
		(0.007)					
Google mobility			–0.008	–0.047**			0.007
			(0.006)	(0.018)			(0.005)
mobility*mobiles$_{2020week0}$				0.030**			
				(0.014)			
New cases per 100k people					–0.002	–0.006	–0.003
					(0.001)	(0.015)	(0.002)
new cases*mobiles$_{2020week0}$						0.003	
						(0.012)	
No of observations	846	846	738	738	918	918	738
R-squared	0.540	0.541	0.527	0.533	0.474	0.475	0.545

Standard errors clustered on week in parentheses; ***/**/* indicates statistical significance at the 1/5/10% level.

[1] All the independent variables are lagged of one week. The regressions include time and country fixed effects. The interaction terms correspond to the product of the respective independent variable and the pre-pandemic level (ie first week of 2020) of the number of mobiles per adults. [2] The indicator is the four-week change in cash in circulation, rather than the four-week change in year-on-year change in cash in circulation (which addresses seasonality, as in table 2).

Source: Authors' calculations.

Estimations of finance app downloads per 100k people[1] Table A5

	Top 25 finance app downloads per 100k people[2]						
Four-week change in:	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
Stringency index	0.059	20.636*					–4.531
	(3.293)	(11.443)					(4.605)
stringency*mobiles$_{2020week0}$		–14.917**					
		(6.801)					
Google mobility			–6.361*	–51.204***			–9.497*
			(3.330)	(14.254)			(4.728)
mobility*mobiles$_{2020week0}$				33.816***			
				(9.282)			
New cases per 100k people					–0.081	–5.193	–0.279
					(0.312)	(5.103)	(0.452)
new cases*mobiles$_{2020week0}$						4.042	
						(3.814)	
No of observations	846	846	738	738	918	918	738
R-squared	0.068	0.078	0.071	0.101	0.068	0.068	0.073

Standard errors clustered on week in parentheses; ***/**/* indicates statistical significance at the 1/5/10% level.

[1] All the independent variables are lagged of one week. The regressions include time and country fixed effects. The interaction terms correspond to the product of the respective independent variable and the pre-pandemic (ie first week of 2020) level of the number of mobiles per adults. [2] Four-week change in the country specific top 25 finance apps (as classified by Sensor Tower) weekly active users (proxied with the figure for each Monday) per 100,000 people.

Source: Authors' calculations.

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