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Cashless Payment Activity: Banking Capacity, Income and Economic Structure in 25 Economies

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Abstract

Payment activity sits between the banks that supply payment services and the economy that uses them, yet most studies centre on one side. The present study asks how much of the cashless payment activity of an economy is associated with its banks, its income and its economic structure, for the 25 jurisdictions with a total cashless payment series in the statistics of the Bank for International Settlements, 2012 to 2024. Three hypotheses are tested and combined. Firstly, payment activity stands higher where banks had more capacity and payment infrastructure in place a year earlier: across economies, credit to the private sector is associated with more payments per adult with income held constant, and within economies payments track the terminals already deployed, though no single measure stands out beyond each economy's own trend. Secondly, a year of faster growth of real gross domestic product (GDP) per adult is a year of faster payment growth (1.10 points per point, $p < 0.001$), significantly so for card payments and more strongly in emerging economies; no association is detected for direct debits. Thirdly, economies with larger finance, real estate, business and public service sectors settle more payments by direct debit, with income held constant ($\rho = 0.72$, $q = 0.010$ over 72 tests). A Shapley decomposition shows that income and domestic sector shares exceed a placebo benchmark in every specification that includes them, while bank measures do so only under some measures. Hence the explained variation in payment activity is shared among banking measures, income and structure.

Keywords: payment systems, bank participation, cashless payments, economic structure, business cycle, Shapley decomposition

JEL Classification: E42 , G21 , O57

1 Introduction

Every economic exchange ends in a payment. A wage, a purchase, a rent and a tax all pass through the payment system of the country in which they are settled. Hence the payment activity of a country can be viewed from two sides. On one side stand the banks, whose deposits are the money that is paid and whose cards, terminals and accounts are the means of paying. On the other side stands the economy, whose income sets how much is spent and whose structure sets what kind of payments are needed.

The literature has mostly studied these sides one at a time. Studies of banks treat payments as a core function of the bank and examine who processes them (Kahn and Roberds, 2009; Parlour et al., 2022). Studies of the macroeconomy relate electronic payments to GDP, consumption and growth (Zhang et al., 2019; Wong et al., 2020; Tee and Ong, 2016). Studies of payment choice explain why people in different countries pay differently through prices, convenience, merchant acceptance and demographics (Humphrey

et al., 1996; Bagnall et al., 2016; Khiaonarong and Humphrey, 2019). Each of these studies centres on one side, and the parts of payment activity associated with each side have not, to the knowledge of the author, been measured together in one model for these economies.

The present study takes up this question for the 25 jurisdictions with a total cashless payment series in the statistics of the Bank for International Settlements (BIS), from 2012 to 2024. The bank side is read through three dimensions, namely the financial capacity of banks, their technological readiness and the payment performance they carry, with each variable studied on its own. The study is intended to test three hypotheses, one for each side, and then to bring them into one model. The first is that payment performance stands higher where banks had more capacity and readiness in place beforehand. The second is that payment activity moves with the economy, differently for each instrument. The third is that the structure of the economy is associated with which payment instrument matters.

The study makes four contributions. Firstly, it shows that the capacity and payment infrastructure banks have in place are associated with how many payments an economy makes, across economies and within each economy over time. Secondly, it places banks, income and economic structure in one model and measures the part of payment activity associated with each, across economies and from year to year, by the Shapley decomposition of explained variation, with a placebo benchmark for each part. Thirdly, it shows for which instruments an association with the economy is detectable, namely card payments and not direct debits, and that the response of card payments is stronger in emerging than in advanced economies. Fourthly, it reports an association between the structure of the domestic economy and the payment mix, between the size of the finance, real estate, business and public service sector and the use of direct debits, which holds with income held constant. Every result is reported with inference suited to few economies, and the two exploratory families of 72 tests of the third hypothesis are corrected for multiple testing. The remainder of the paper is organised as follows. Section 2 reviews the literature, Section 3 sets out the data and method, Section 4 presents the analysis, Section 5 discusses the findings, Section 6 states the limitations and Section 7 concludes.

2 Review of Literature

The literature relevant to the present study falls into eight strands, namely the place of payments in banking, payments and the real economy, the choice of payment instruments across countries, the costs and networks of payment instruments, instant payments, finance and economic structure, financial inclusion, and payment data as a record of behaviour. Each strand speaks to one of the three sides from which payment activity can be explained, namely the banks that supply payment services, the economic cycle and the structure of the economy. The studies of each strand are reviewed below in turn.

2.1 Payments as a function of banks

Kahn and Roberds (2009) surveyed the economics of payments and presented a simple model of the essential function of payments. According to the authors, payments link monetary theory, corporate finance and industrial organisation. Hence payments are a subject of economics in their own right.

The information value of payment flows was modelled by Parlour et al. (2022). In their model a bank uses the payment data of its customers to learn about their credit quality. It was concluded that competition from FinTech firms in payments disrupts this information

spillover, changes the pricing and lending of banks and can promote financial inclusion. Thus who processes a payment matters for who lends.

2.2 Payments and the real economy

The macroeconomic association of retail payments was examined by Zhang et al. (2019) for 27 countries of the European Union. The results showed that a higher penetration of electronic payment methods is associated with greater GDP, trade, consumption and tax revenue. It is observed that paper and electronic instruments substitute for each other, while electronic instruments complement one another.

For Austria, Belgium, France, Germany and Portugal over 2000 to 2012, Tee and Ong (2016) applied panel cointegration and a vector error correction model. The results showed that the adoption of cashless payments affects the economy only in the long run. In the short run, causality runs among cheques, transfers and cards themselves.

Selected countries of the Organisation for Economic Co-operation and Development over 2007 to 2016 were studied by Wong et al. (2020). It was concluded that cashless payment stimulates economic growth, and that the effect is found in debit card payments, while credit cards, electronic money and cheques show no growth effect.

A natural experiment in India was used by Chodorow-Reich et al. (2020). The demonetisation of 2016 withdrew 86 percent of cash, and districts with more severe cash shortages experienced lower economic activity, faster adoption of alternative payment technologies and lower bank credit growth. Thus a payment shock is also an output shock and a credit shock.

The same episode was studied from the side of technology adoption by Crouzet et al. (2023). The results showed that the adoption of an electronic wallet rose persistently after the temporary cash shock, consistent with complementarities in adoption, and that adoption would have been about 45 percent lower without them. Hence payment habits, once changed, need not revert.

2.3 Choice of payment instruments across countries

Cash and five non-cash instruments in 14 developed countries over 1987 to 1993 were examined by Humphrey et al. (1996). The differences in instrument use across countries were explained by prices, incomes, institutions and availability, and cheques were found to decline as electronic payments grew.

A later survey by Humphrey (2010) showed how institutional differences produced different national payment arrangements historically. According to the author, changes in bank costs driven by technology have made payment arrangements across countries more homogeneous. Hence national payment arrangements are shaped both by their history and by common technology.

The demand for currency in 13 advanced economies over 1988 to 2003 was estimated by Amromin and Chakravorti (2009). The results showed that demand for small denominations falls with greater use of debit cards and with retail consolidation, while demand for large denominations responds to interest rates and not to card use. Hence cash for payment and cash as a store of value behave differently.

Harmonised payment diaries from seven countries were compared by Bagnall et al. (2016). It was observed that cash use differs across countries, has not disappeared, particularly for low-value transactions, and is strongly correlated with transaction size,

demographics and merchant acceptance of cards. Thus national payment mixes reflect both the people and the merchants.

Bech et al. (2018) noted that, despite the growth of electronic payments, there is scant evidence of a shift away from cash. Cash demand has risen in most advanced economies since the Great Financial Crisis, apparently driven by store-of-value motives rather than by payment needs. Hence a rise in cashless payments does not by itself establish a fall in cash.

The level and trend of cash use in 11 countries were estimated with four measures by Khiaonarong and Humphrey (2019). The decline in cash use was found to be largely associated with demographic change, and the level of cash use was linked to the likely demand for central bank digital currency.

A broad survey of research on holding and using cash was provided by Shy (2023). It covers transactional demand, hoarding, cash management, merchant acceptance, denominations, cash substitutes and the cost of cash. This survey sets out the questions that any cross-country reading of cashless payments has to keep in view.

Consumer data for the United States were used by Schuh and Stavins (2010). The results showed that characteristics of instruments, namely relative convenience and cost, are the most important determinants of their adoption and use, and they explain much of the decline in cheque use between 2003 and 2006.

Canadian shopping diaries were analysed by Arango et al. (2015). It was concluded that the lack of merchant acceptance of cards plays a large role in cash use, particularly for low-value transactions, and that credit card rewards shift payments towards credit cards.

For Germany, transaction and survey data were examined by von Kalckreuth et al. (2014a). Cash accounted for 82 percent of direct payment transactions by number in 2008, and its use reflected systematic decisions on card adoption, transaction characteristics, relative costs and demographics. In a related study, von Kalckreuth et al. (2014b) showed that consumers who need to monitor their remaining liquidity use cash for a larger share of payments and hold larger cash balances. Hence the German preference for cash has an explanation in household budgeting.

Sweden and Canada were compared by Engert et al. (2019). The two countries show a similar decline in small-denomination notes relative to GDP after similar payment innovations, but differing demand for large-denomination notes explains why cash relative to GDP fell rapidly in Sweden and not in Canada. The Swedish path towards a cashless society, its history and its outlook were described in detail by Arvidsson (2019).

2.4 Costs, networks and two-sided markets

The social cost of retail payment services in 13 countries of the European Union was measured by Schmiedel et al. (2013). The cost averages almost 1 percent of GDP, cash accounts for nearly half of it, and a cluster analysis divides the European market into five groups. This study is one such example in which clustering was used to compare national payment systems.

Scale economies in European card and payment networks were estimated by Bolt and Humphrey (2007). The results indicated substantial gains in cost efficiency from consolidating processing across borders, with cost reductions likely to induce further replacement of small cash transactions. On the other hand, Dutch survey data analysed by Bolt et al. (2010) showed that surcharging debit card payments steers consumers from debit cards to cash, explaining about half of the difference in debit card shares across retailers.

The benefits to European banks from the shift of payment technology from paper to electronic means were studied by Humphrey et al. (2006).

Payment cards are a standard example of a two-sided market. Rochet and Tirole (2003) modelled competition between platforms that serve two sides, including payment systems, and showed how the allocation of prices between the sides depends on platform governance. Rochet and Tirole (2006) defined two-sided markets as those in which the structure of prices, and not only their level, matters. Rysman (2007) showed with United States data that consumers concentrate their spending on one network while holding several cards, and that consumer usage and merchant acceptance are correlated across regions. Rysman (2009) explained the strategy and policy implications of such markets, and Bounie et al. (2017) found with French data that the probability that a merchant accepts cards rises with the card preferences of consumers in the same sector and region. Hence the spread of terminals and the spread of card use feed each other.

2.5 Instant payments

Instant payment systems in 12 advanced and emerging economies were studied by Khiaonarong and Humphrey (2022). It was concluded that instant payments, promoted by regulators, have significantly substituted for cash, cards, cheques and direct debits. Duarte et al. (2022) drew lessons from Pix in Brazil and reported that it signed up 67 percent of adults within little more than a year of its launch in November 2020, helped by the mandatory participation of large banks. Thus a public infrastructure can change the payment mix of a whole economy within a few years.

2.6 Finance, economic structure and development

The link between finance and growth was established for 80 countries over 1960 to 1989 by King and Levine (1993). Measures of financial development were strongly associated with growth per person, capital accumulation and efficiency. Levine (1997) reviewed the theory and evidence and argued for a positive, first-order relation between financial development and growth. Rajan and Zingales (1998) showed that industries that rely more on external finance grow faster in countries with more developed financial markets, and Beck et al. (2000) found that banking development has a large effect on productivity growth.

Arcand et al. (2015) qualified this relation. Financial depth begins to have a negative effect on output growth when credit to the private sector exceeds about 100 percent of GDP. Hence the depth of a banking system is not a measure of its contribution without limit.

The structure of the economy enters this literature through exports. Hausmann et al. (2007) constructed an index of the income level of the exports of a country and showed that what a country exports predicts its subsequent growth. Hidalgo and Hausmann (2009) treated trade data as a network of countries and products and derived measures of economic complexity that correlate with income. Rodrik (2016) documented premature deindustrialisation, in which countries reach their peak share of manufacturing at lower incomes than early industrialisers, with Latin America especially hard hit.

The relation between natural resources and banks was examined for 128 countries by Kurronen (2015). The banking sector tends to be smaller in resource-dependent economies, with the effect starting at a low level of dependence. Beck et al. (2007) constructed indicators of banking outreach for 99 countries and found that branch and ATM penetration predict the use of banking services by households and firms.

2.7 Financial inclusion

Account ownership and digital payments across more than 120 economies are documented in the Global Findex Database of Demirgüç-Kunt et al. (2022), and its 2025 edition extends the record to connectivity and the digital economy (Klapper et al., 2025). In Kenya, Jack and Suri (2014) found that households using mobile money smoothed consumption after shocks while others reduced it by 7 percent, and Suri and Jack (2016) found that access to mobile money increased long-term consumption and reduced extreme poverty. Hence access to payment services changes how households respond to the economy around them.

2.8 Payment data as a record of behaviour

Canadian debit card and cheque clearing data were shown by Galbraith and Tkacz (2018) to reduce nowcast errors for GDP and retail sales. Aprigliano et al. (2019) found that monthly data from the Italian retail settlement system contribute to nowcasting GDP and its components, and Duarte et al. (2017) found that ATM and POS data forecast Portuguese private consumption better than typical indicators. Chapman and Desai (2023) reported that Canadian payments data improve predictions of GDP and sales by up to 25 percent, with the largest gains during crises.

The pandemic of 2020 made this use of payment data visible. Carvalho et al. (2021) used billions of card transactions to track consumption in Spain under business closures. Andersen et al. (2022) found with Danish bank data that spending fell by almost 30 percent early in the pandemic and recovered after the first wave. Auer et al. (2020) argued that the pandemic could speed the shift to digital payments, and Kotkowski and Polasik (2021) found in 22 European countries that the divide between users of cash and of cashless payments widened during the pandemic.

2.9 Research gap

The above studies have laid a foundation to understand payments from three separate sides. The first side is the bank, whose payment flows carry information and whose balance sheet and devices are the means of payment (Kahn and Roberds, 2009; Parlour et al., 2022). The second side is the economic cycle, with which electronic payments are associated (Zhang et al., 2019; Wong et al., 2020) and which payment data can track in real time (Galbraith and Tkacz, 2018; Aprigliano et al., 2019). The third side is the structure of the economy and of the population, through which the choice of instruments has been explained (Humphrey et al., 1996; Bagnall et al., 2016). The studies reviewed here each centre on one side. None of them, to the knowledge of the author, measures the parts of payment activity associated with banks, income and economic structure in one model, across economies and from year to year, for the economies of the BIS payment statistics. It is this gap that the present study addresses.

3 Data and Methodology

3.1 The bank side of payments

The bank side of payment activity is read through three dimensions of bank participation in payment systems (Battula, 2026). Financial capacity (FC) is the balance sheet through

which banks hold the money used for payment and lend it, and it is measured here by deposits and by credit to the private sector, both relative to GDP. Technological readiness (TR) is the infrastructure through which payments are delivered, and it is measured by POS terminals and cards with a debit function per adult, with ATMs as an alternative. Payment performance (PI) is the use of cashless instruments, and it is measured by the number of cashless payments per adult, in total and for each instrument. Capacity and infrastructure are measured in year $t-1$ and payment performance in year t. This is a timing rule, so that the capacity and infrastructure set against a year's payments are those already in place before that year, and not figures of the same year that could not yet have been put to use. It is not a claim that the deployment of one year produces the payments of the next, since payment activity in any year can rise for many other reasons. The dimensions serve only as a frame for the analysis; no composite index is formed, since an index across economies would need weights and proxies that the data do not support.

3.2 Sample

The Committee on Payments and Market Infrastructures (CPMI) of the Bank for International Settlements (BIS) publishes annual payment statistics in its bulk files. The sample comprises the 25 jurisdictions with observations for the selected aggregate, the total number of cashless payments of all speeds (series key A.Z.A.A with all terminal and card locations), in the bulk files downloaded for the present study. Hong Kong SAR appears in the files but does not report this aggregate and is therefore not included. Each test uses every jurisdiction that reports the variables the test needs, as Table 1 records, so that the number of economies in each test is set by the data and not by choice. An economy with a single usable year is excluded from every fixed-effects model, since it does not help to identify a within-economy slope. Ten economies are treated as emerging, namely Argentina, Brazil, China, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa and Turkiye, and the remaining fifteen as advanced, following the classification of the World Economic Outlook of the International Monetary Fund (IMF). The period is 2012 to 2024, since the BIS bulk files begin in 2012 and 2024 is the latest year they report. Some values for 2024 are provisional.

Table 1 The 25 jurisdictions and the tests each enters

Economy	Group	BIS payment data	H1 main (within)	H1 (across)	H2	H3	Between (main)	Within decomposition
Argentina	Emerging	2012 to 2024	yes	yes	yes	yes	yes	yes
Australia	Advanced	2012 to 2024	yes	yes	yes	yes	yes	yes
Belgium	Advanced	2012 to 2024	yes	yes	yes	yes	yes	yes
Brazil	Emerging	2012 to 2024	yes	yes	yes	yes	yes	yes
Canada	Advanced	2012 to 2024	no	no	yes	yes	no	no
China	Emerging	2012 to 2024	no	no	yes	yes	no	no

France	Advanced	2012 to 2024	yes	yes	yes	yes	yes	yes
Germany	Advanced	2012 to 2024	yes	yes	yes	yes	yes	yes
India	Emerging	2012 to 2024	yes	yes	yes	yes	yes	yes
Indonesia	Emerging	2012 to 2024	yes	yes	yes	yes	yes	yes
Italy	Advanced	2012 to 2024	yes	yes	yes	yes	yes	yes
Japan	Advanced	2012 to 2024	no	yes	yes	yes	no	no
Korea	Advanced	2012 to 2024	no	no	yes	yes	no	no
Mexico	Emerging	2012 to 2024	yes	yes	yes	yes	yes	yes
Netherlands	Advanced	2012 to 2021	yes	yes	yes	yes	yes	yes
Russia	Emerging	2012 to 2020	yes	yes	yes	yes	yes	yes
Saudi Arabia	Emerging	2012 to 2024	yes	yes	yes	yes	yes	no
Singapore	Advanced	2012 to 2024	no	no	yes	yes	no	no
South Africa	Emerging	2012 to 2024	no	no	yes	yes	yes	no
Spain	Advanced	2014 to 2024	yes	yes	yes	yes	yes	yes
Sweden	Advanced	2012 to 2024	yes	yes	yes	yes	yes	yes
Switzerland	Advanced	2012 to 2024	yes	yes	yes	yes	yes	yes
Turkiye	Emerging	2012 to 2024	yes	yes	yes	yes	yes	yes
United Kingdom	Advanced	2014 to 2024	no	no	yes	yes	no	no
United States	Advanced	2012 to 2024	no	no	yes	yes	no	no
Economies		25	17	18	25	25	18	16

Note: H1 is the main payments model; it needs IMF deposits and credit and BIS POS terminals and debit cards in the year before payments. Within economies, an economy with a single usable year in a break regime is excluded, since it does not help to identify a within-economy slope; the within decomposition needs at least three years in a regime so that a trend can be removed. The secondary technology models of H1 use 18 and 20 economies (workbook). The main between model needs IMF credit, BIS POS terminals and UN sector shares. The alternative between models add or drop economies as listed in the workbook (sheet Decomposition); with World Bank credit and ATMs they add China, Japan, Korea, Singapore and the United Kingdom and drop Saudi Arabia (for 2015 to 2019 Saudi Arabia is kept), and the model with deposits and debit cards adds Japan, Korea and the United States and drops South Africa.

Source: compiled from the coverage of BIS CPMI statistics, IMF Monetary and Financial Statistics, World Bank WDI and UN National Accounts Main Aggregates.

3.3 Data

Table 2 lists the sources. Payment numbers and values, devices and cards are taken from the BIS. Deposits and credit are taken from the Other Depository Corporations Survey of the

IMF, which covers depository corporations other than the central bank. For the six euro-area members, credit is the claim on the private sector resident anywhere in the euro area, as published in the national surveys, while for the other economies it is the claim on the domestic private sector; dividing by national GDP does not remove this difference, and World Bank domestic credit to the private sector is used as an alternative measure. GDP in constant and current prices, national income, population and the composition of exports are taken from the World Development Indicators (WDI) of the World Bank, which also provide domestic credit to the private sector and ATMs per 100,000 adults as alternative bank measures. Value added by sector is taken from the National Accounts Main Aggregates Database (AMA) of the United Nations.

Table 2 Sources and variables

Source	Variables
BIS CPMI statistics	Number and value of cashless payments: all, credit transfers, direct debits, cheques, card and e-money payments with cards issued in the country; ATMs; POS terminals; cards with a debit function
IMF MFS, Other Depository Corporations Survey	Deposits (transferable and other deposits included in broad money, plus deposits excluded from broad money); claims on the private sector (euro-area residents for the six euro members)
World Bank WDI	GDP in constant 2015 US dollars and in national currency; GNI per person in constant 2015 US dollars; population aged 15 to 64 and 65 and above; food, fuel, ores and metals, agricultural raw materials and manufactures in merchandise exports; travel in service exports; domestic credit to the private sector; ATMs per 100,000 adults
UN National Accounts Main Aggregates	Value added in current US dollars, 2024: agriculture; mining, manufacturing and utilities; manufacturing; construction; trade, restaurants and hotels; transport, storage and communication; other activities (finance, real estate, business services, public administration, education, health)

Source: compiled by the author; the download link of every series is given in the companion source document.

3.4 Payment terms

The BIS uses terms that differ from those of national regulators, and Table 3 defines them with their nearest equivalents in India. A credit transfer is pushed by the payer and a direct debit is pulled by the payee under a mandate, so that the share of direct debits indicates how far recurring bills are settled automatically from bank accounts.

Table 3 Payment instruments in the BIS statistics

Instrument	Meaning, with an example	Nearest Indian equivalent
Credit transfer	The payer instructs his bank to move funds to the payee; a salary credit, an online bill payment, an instant transfer	NEFT, RTGS, IMPS, UPI
Direct debit	The payee collects from the payer's account under a standing mandate; a monthly electricity or insurance bill	NACH debit, UPI AutoPay
Card payment	Payment with a debit, credit or prepaid card at a terminal or online	Debit and credit card payments
Cheque	A paper order to the bank to pay a named payee	Cheques cleared through CTS
E-money	Payment from stored value held with an issuer	Prepaid payment instruments (PPI)

Source: BIS CPMI methodology for the payment statistics; Indian equivalents compiled by the author from Reserve Bank of India payment system categories.

3.5 Hypotheses

Payment activity sits between the banks that supply payment services and the economy that uses them. Hence three hypotheses are tested, one for each side.

H1. Payment performance in year t is higher where, and when, banks had greater financial capacity and technological readiness in place in year $t-1$.

H2. Payment activity is associated with the economy, so that the growth of payments moves with the growth of real GDP and national income, and the strength of this association differs by instrument.

H3. The structure of the economy is associated with which payment instrument matters, namely the shares of agriculture, mining, manufacturing, trade and services in value added and the composition of exports are related to the payment mix.

The three hypotheses are then brought into one model, which asks how much of the differences in payment activity, across economies and from year to year, is associated with banks, with income and the cycle, and with economic structure.

3.6 Measures and estimation

Counts are expressed per adult, where adults are persons aged 15 and above. For economy i in year t, payments per adult are $p_{it} = N_{it}/A_{it}$, where N_{it} is the number of cashless payments and A_{it} the adult population, and annual growth is $g_{it} = 100\ln(p_{it}/p_{i,t-1})$.

H1 is estimated in levels with

$$100\ln p_{it} = \alpha_i + \tau_t + \beta\, x_{i,t-1} + \gamma\, z_{i,t-1} + \varepsilon_{it}, \tag{1}$$

where $x_{i,t-1}$ is one of the four bank measures in year $t-1$, namely deposits and credit to GDP in percent and 100 times the log of POS terminals and of debit cards per adult, and $z_{i,t-1}$ holds the other three. Within economies, α_i is an economy effect that absorbs the average level of each economy, and it is allowed to change at each recorded break in a series used, so that a change of definition is not read as a change of level; τ_t is a year effect that removes the movement common to all economies. Since payments and bank infrastructure both rise over time, the within estimate is repeated with a linear trend for each economy, which asks whether payments stand above their own trend in years when more capacity and readiness

were in place. Across economies, α_i is replaced by a common constant, and the estimate is repeated with log real GDP per adult in year t held constant. The capacity of banks to issue terminals and cards is examined in the same way, with POS terminals or debit cards per adult in year t on deposits and credit in year $t-1$, as a descriptive check. H2 is estimated within economies with annual log growth $g_{it} = 100\ln(p_{it}/p_{i,t-1})$ of each instrument on the growth of real GDP per adult or of real GNI per person in year t, with economy and year effects; the economy effect absorbs the average growth of each economy. With 8 to 25 economies per regression, conventional clustered standard errors are unreliable, and hence each p value comes from the wild cluster bootstrap with the null hypothesis imposed (Cameron et al., 2008; Roodman et al., 2019), using 9,999 draws over economies, with Rademacher weights and, when fewer than 12 economies enter, the six-point weights recommended for few clusters (Roodman et al., 2019). Every Monte Carlo p value in the study is computed as $(b + 1)/(B + 1)$, where b is the number of simulated statistics at least as extreme as the observed one and B the number of draws, so that no p value is reported as zero (Phipson and Smyth, 2010); the draws, the exceedance counts and the seeds are given in the workbook. Whether the response to growth differs between emerging and advanced economies is tested by an interaction of real growth with an emerging-economy indicator, and whether two instruments respond differently is tested by regressing the gap between their growth rates, in the same country-years, on real growth. Since payments and real GDP are both divided by the adult population, the main relation is also estimated for totals, which shows whether it is driven solely by the shared denominator.

H3 is tested across economies with Spearman rank correlations (Spearman, 1904) between the sector shares of 2024, the export shares and the payment mix over 2020 to 2024. The share of an instrument is the sum of its payments over the sum of all cashless payments, both taken over the years in which both are reported, so that numerator and denominator cover the same years. Each p value is obtained from 100,000 random permutations (Ernst, 2004). Since structure and income move together, each correlation is also computed with the rank of log real GDP per adult removed from both variables, and the residuals are permuted. Since 72 associations are tested, the false discovery rate is controlled by the method of Benjamini and Hochberg (1995) within each of the two families of 72 tests, the unadjusted and the income-adjusted. Multiplicity adjustment is applied to these two exploratory H3 families; the p values of H1 and H2 are unadjusted and are interpreted test by test.

The unifying model divides the explained variation of payment activity among groups of variables by the Shapley value of R^2 (Shorrocks, 2013; Grömping, 2006). The Shapley value averages the gain in R^2 from adding a group over every order in which the groups can be added, so that the contributions sum to the total R^2 and do not depend on an arbitrary order. Across economies, the log of payments per adult averaged over 2020 to 2024 is explained by three groups, namely banks (credit to GDP and log POS terminals per adult, averaged over 2019 to 2023 in keeping with the timing rule), income (log real GDP per adult) and structure (the shares of finance, real estate, public and other services and of manufacturing in value added). Within economies, the log of payments per adult, with the effect of each economy and break regime removed, is explained by banks (the four measures of H1 in year $t-1$), income (log real GDP per adult) and common shocks (year effects), first in levels and then with the trend of each economy removed as well; regimes with fewer than three years are dropped so that a trend can be removed. Intervals are obtained by resampling economies 1,999 times across economies and 999 times within them. Since a group with more variables gains R^2 by chance, each contribution is also compared with a placebo benchmark: across

economies, that group alone is randomly reassigned across economies 1,999 times; within economies, the years of that group alone are reordered within each economy 999 times, which keeps each economy's values but breaks their timing. The benchmark p value is $(b + 1)/(B + 1)$. Reassignment also breaks the correlation of the group with the other groups and, within economies, serial dependence, so that the benchmark is descriptive and is not an exact test of incremental association (Winkler et al., 2014); it does not fully remove the effect of the number of variables in a group. Adjusted R^2 is reported with R^2.

3.7 Series breaks

The BIS publishes notes on definitional changes both for whole series (COMMENT_TS) and for single observations (COMMENT_OBS). Both fields were reviewed for every selected payment, device and card series of the 25 economies, and Table 4 lists the resulting breaks with the series they affect. A growth rate is dropped from a test when its own series breaks in that year, and a lagged growth rate when its series breaks in the year before. In the level models of H1, the same breaks start a new economy regime, so that a level is compared only with levels measured on the same definition. Notes that record revisions, interpolation or estimates without a change of definition are not treated as breaks, except for the first revised year of the United States, as Table 4 explains. In addition, any annual log change larger than 50 points in a series used by a test is treated as a likely reporting break and dropped. Hence growth is not measured across a recorded change of definition.

Table 4 Series breaks dropped from the annual growth tests

Economy	Year	Series affected	Note	Reason published by the BIS
Australia	2018	all series	TS	break in all series: new reporting forms, methodology and reporting sample
Belgium	2022	debit cards	OBS	cards reclassified from debit to e-money function
Brazil	2017	cards, total	TS	new set of institutions incorporated from September 2017
Brazil	2018	cards, total	TS	first full year with the institutions added in September 2017
Canada	2023	debit cards	OBS	Visa Debit and Debit Mastercard moved from credit to debit cards
Germany	2014	direct debits, total, POS	TS	simple book entries included only until 2013; POS terminals abroad operated by domestic banks included only before 2014
Germany	2022	direct debits, total	TS	break due to data quality improvements
Germany	2023	POS	TS	POS terminals cover only the girocard scheme up to 2022
Italy	2022	cards, total, POS, ATMs	TS	reporting instructions revised: card, ATM and POS definitions
Japan	2013	cards, total, debit cards	TS	credit card payments excluded from 2013; debit card networks changed in FY2013
Japan	2014	POS	TS	POS terminals double counted up to 2013
Japan	2022	cheques, total	TS	cheque clearing consolidated in the Electronic Clearing House, November 2022
South Africa	2017	POS	OBS	only bank-owned POS terminals included (note on 2017 and 2018)
South Africa	2019	POS	OBS	first year after the bank-owned-only note

South Africa	2023	direct debits, total	OBS	direct debits corrected from 2023 after change in collection
Spain	2014	transfers, direct debits, cheques, total	TS	non-card instruments estimated from a sample before 2014; 2014 from second half-year
Spain	2015	transfers, direct debits, cheques, total	TS	first growth from the estimated 2014 base
Spain	2018	debit cards	TS	card data estimated until Q1 2018, reported by PSPs thereafter
Spain	2022	all payments, POS, debit cards	TS	Banco de España data excluded; devices reported directly by PSPs
Switzerland	2014	POS	OBS	reporting population and survey approach for POS terminals adjusted in December 2014
Switzerland	2015	cards, total	OBS	reporting population and survey approach for card payments adjusted at end-2014
Switzerland	2022	transfers, direct debits, total	OBS	credit transfer and direct debit survey revised; foreign-currency payments added
Turkiye	2013	transfers, total	TS	credit transfers in 2012 cover December only
Turkiye	2015	POS	TS	POS terminals estimated from 2015 as cash registers replace terminals
Turkiye	2020	transfers, total	OBS	credit transfers include a non-bank (PTT) for November and December 2020
Turkiye	2021	transfers, total	OBS	credit transfers include fast payments from January 2021
United States	2015	transfers, direct debits, cheques, total	TS/OBS	start of block revised to the Federal Reserve Payments Study; 2014 not revised
United States	2019	cards, total	TS/OBS	start of block revised to the Federal Reserve Payments Study; 2018 not revised

Note: A growth rate is dropped from a test when its own series breaks in that year; a lagged growth rate is dropped when its series breaks in the year before. In the level models of H1 each break starts a new economy regime. TS: series note; OBS: observation note. For the United States the BIS records revisions of 2015 to 2023 and of 2019 to 2023 to the Federal Reserve Payments Study; the first revised year is treated as a possible break because the year before it was not revised, which is a precaution rather than a documented discontinuity. Any annual log change larger than 50 points in a series used by a test is also dropped as a likely reporting break.

Source: BIS CPMI statistics, series notes (COMMENT_TS) and observation notes (COMMENT_OBS) in the bulk files for the selected series.

4 Data Analysis and Interpretation

4.1 Payment activity in the 25 economies

The objective of the present section is to set out where the economies stand before the hypotheses are tested. Figure 1 shows the number of cashless payments per adult in the first and the last year of each economy's data.

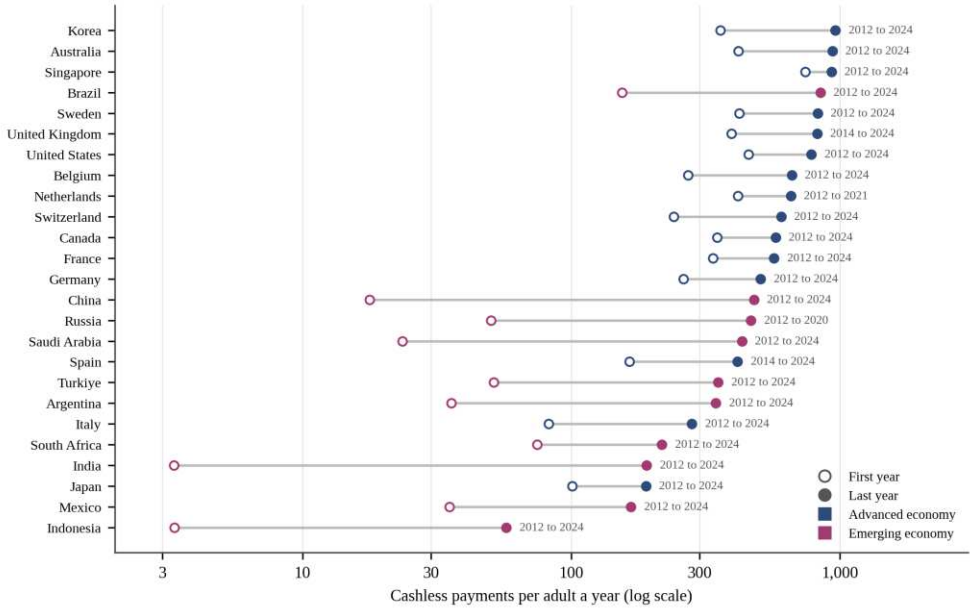


Fig. 1 Cashless payments per adult a year, first and last year reported, 25 economies
Source: computed from BIS CPMI statistics and World Bank WDI (population aged 15 and above).

Payments per adult rose in every economy. Some of the largest proportionate increases occurred in economies with low initial levels: India moved from 3 to 190 payments per adult between 2012 and 2024, Indonesia from 3 to 57 and China from 18 to 478, while Singapore moved from 744 to 929 and the United States from 456 to 782. The last year is 2021 for the Netherlands and 2020 for Russia, whose total series end earlier. In 2024 the highest levels were in Korea (961), Australia (937) and Singapore (929), and the lowest in Indonesia (57), Mexico (167) and Japan (189). It is observed that emerging and advanced economies overlap: Brazil (845) made more payments per adult than Germany (507) or France (567). Hence income alone does not order the economies, and the hypotheses below ask what else does.

4.2 H1: capacity and readiness in place and payment performance

Table 5 reports the test of H1, with each bank measure taken in the year before the payments it is set against.

Table 5 Hypothesis 1: payments per adult at t and the capacity and readiness of banks in place at $t-1$

Bank measure at $t-1$	Within economies		Within, own trends removed		Across economies		Across, income held constant	
	Coef.	p	Coef.	p	Coef.	p	Coef.	p
Deposits to GDP	−0.429	0.576	0.144	0.612	−0.299	0.665	−0.429	0.535
Credit to GDP	−0.081	0.863	−0.279	0.442	1.827	0.087	1.260	0.042
POS terminals per adult	0.592	< 0.001	0.066	0.544	0.256	0.089	0.140	0.406
Debit cards per adult	0.343	0.272	−0.199	0.059	0.859	0.059	0.716	0.052
Country-years (economies)	167 (17)		167 (17)		180 (18)		180 (18)	
Excluding 2020 and 2021								
Deposits to GDP	−0.304	0.736	0.280	0.247	−0.302	0.692	−0.455	0.566
Credit to GDP	−0.252	0.693	−0.522	0.309	1.823	0.123	1.253	0.060
POS terminals per adult	0.635	< 0.001	0.097	0.672	0.278	0.090	0.153	0.389
Debit cards per adult	0.275	0.284	−0.106	0.360	0.843	0.059	0.708	0.072
Country-years (economies)	136 (17)		136 (17)		149 (18)		149 (18)	
Within economies by stage, all years								
Emerging (74 country-years, 8 economies): deposits to GDP 1.447 (p 0.672); credit to GDP −0.376 (p 0.749); POS terminals per adult 0.145 (p 0.802); debit cards per adult 0.140 (p 0.895)								
Advanced (93 country-years, 9 economies): deposits to GDP 0.429 (p 0.112); credit to GDP −0.410 (p 0.204); POS terminals per adult 0.056 (p 0.599); debit cards per adult 0.178 (p 0.004)								
Descriptive check, devices at t on deposits and credit at $t-1$, within economies: POS terminals per adult on deposits to GDP −0.588 (p 0.607); POS terminals per adult on credit to GDP 0.646 (p 0.354); debit cards per adult on deposits to GDP −0.624 (p 0.107); debit cards per adult on credit to GDP 0.105 (p 0.650)								

Note: Dependent variable: 100 times the log of cashless payments per adult in year t. The four bank measures of year $t-1$ enter one regression jointly: deposits and credit to GDP in percent, and 100 times the log of POS terminals and of debit cards per adult, so that the coefficients on these two are elasticities. All models include year effects. Within economies, the economy effect changes at each recorded break in a series used (Table 4) and at any jump above 50 log points; own trends add a linear trend for each economy and regime. Across economies, a common constant replaces the economy effects, and income is log real GDP per adult in year t. p values are from the wild cluster restricted bootstrap over economies (9,999 draws; Rademacher weights, or Webb six-point weights when fewer than 12 economies), computed as $(b + 1)/(B + 1)$; seeds are in the workbook. Emerging: Argentina, Brazil, China, India, Indonesia, Mexico, Russia, Saudi Arabia, South Africa, Turkiye.

Source: computed from BIS CPMI statistics, IMF MFS and World Bank WDI.

Within economies, payments per adult stand higher in years when more POS terminals per adult were already in place: one percent more terminals goes with 0.59 percent more payments ($p < 0.001$), and the same holds without the pandemic years (0.64, $p < 0.001$). Deposits, credit and debit cards show no detectable association with the other measures held constant. Once the trend of each economy is removed, no single measure is significant at the 5 percent level (the smallest p is 0.059, for debit cards), since payments and terminals rise together over the period and the four measures move together; the decomposition in Section 4.5 shows that the four measures taken together still carry a part of the movement around each economy's trend. Across economies, an economy whose credit to the private sector was one point of GDP higher in the year before makes 1.83 percent more payments per adult ($p = 0.087$), and 1.26 percent more with income held constant ($p = 0.042$); debit cards are close to the 5 percent level with income held constant (0.72, $p = 0.052$). By stage of

development, only debit cards are significant, in advanced economies (0.18, $p = 0.004$). As a descriptive check, deposits and credit show no detectable association with the terminals and cards in place in the next year. Hence H1 is supported in part: payment performance stands higher where credit was deeper across economies and where terminals had already been deployed within economies, but no single measure is associated with payments beyond the upward trend of each economy.

4.3 H2: payment activity and the economy

Table 6 and Figure 2 report how the growth of each instrument moves with the growth of the economy.

Table 6 Hypothesis 2: annual growth of payments and growth of the economy

Instrument per adult	GDP per adult, all years			GDP per adult, without 2020, 2021		GNI per person, all years	
	Coef.	*p*	*n* (econ.)	Coef.	*p*	Coef.	*p*
All cashless payments	1.102	< 0.001	268 (25)	1.741	0.003	0.464	< 0.001
Card payments	1.151	0.002	269 (24)	1.209	0.052	0.601	0.019
Credit transfers	0.891	0.089	269 (25)	1.604	0.148	0.358	0.219
Direct debits	0.041	0.934	250 (23)	−0.067	0.934	−0.393	0.863
Cheques	0.941	< 0.001	243 (23)	0.578	0.307	0.417	0.005
By stage, real GDP per adult, all years							
Emerging: all cashless payments 1.55 (*p* 0.018); card payments 1.80 (*p* 0.005); credit transfers 1.21 (*p* 0.182)							
Advanced: all cashless payments 0.60 (*p* 0.003); card payments 0.54 (*p* 0.106); credit transfers 0.47 (*p* 0.114)							
Difference, emerging minus advanced (interaction): all cashless 0.54 (*p* 0.230); card payments 1.11 (*p* < 0.001)							
Difference, cards minus direct debits on a common sample: 1.13 (*p* 0.136, 241 country-years); cards minus credit transfers 0.26 (*p* 0.588)							
Totals without the adult denominator, on growth of real GDP: all cashless 0.98 (*p* < 0.001); card payments 1.01 (*p* 0.002)							

Note: Annual log growth in percent; economy and year fixed effects; *p* values from the wild cluster restricted bootstrap (9,999 draws over economies; Webb weights below 12 economies), computed as $(b + 1)/(B + 1)$. Growth rates that cross a break in their own series (Table 4) are dropped. The differences are the slopes of the gap between two growth rates in the same country-years and test whether the two instruments respond differently. Values for 2024 are partly provisional. A coefficient of 1 means that a year in which real GDP per adult grows one point faster than usual is a year in which the instrument grows one point faster than usual.

Source: computed from BIS CPMI statistics and World Bank WDI.

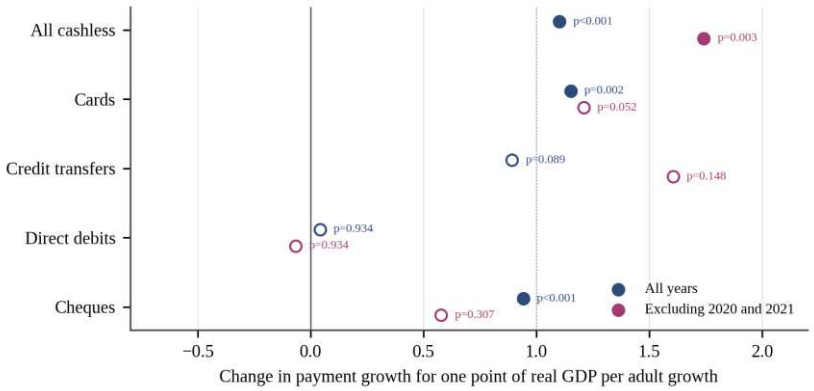


Fig. 2 Response of each payment instrument to growth of real GDP per adult, within economies
Source: computed from BIS CPMI statistics and World Bank WDI. Filled markers: $p < 0.05$ (wild cluster restricted bootstrap).

Payment growth moves with the growth of the economy. Across all 25 economies, a year in which real GDP per adult grows one point faster than usual is a year in which cashless payments per adult grow 1.10 points faster than usual ($p < 0.001$). The relation is larger, not smaller, without the pandemic years (1.74, $p = 0.003$), so that it does not rest on 2020. It holds for the totals without the shared adult denominator (0.98, $p < 0.001$), so that it is not produced by dividing both sides by the same population. The relation is significant for card payments (1.15, $p = 0.002$), and close to the 5 percent level without the pandemic years (1.21, $p = 0.052$). For credit transfers it is not significant at the 5 percent level (0.89, $p = 0.089$), and for direct debits no association is detected (0.04, $p = 0.934$). Cheques move with the economy only when the pandemic years are included. Against real national income per person the relation is weaker but present (0.46, $p < 0.001$). On a common sample, the response of card payments is larger than that of direct debits by 1.13 points, but this difference is not statistically significant ($p = 0.136$), and the difference from credit transfers is small (0.26, $p = 0.588$). Hence the instruments differ in whether their own response is detectable, but the data do not establish that they respond differently from one another.

The relation differs by stage. In emerging economies, payment growth moves 1.55 points for each point of real growth ($p = 0.018$), and card payments 1.80 points ($p = 0.005$). In advanced economies the response is 0.60 ($p = 0.003$). The difference between the two groups is significant for card payments (1.11, $p < 0.001$) but not for all cashless payments (0.54, $p = 0.230$). One possible interpretation, which the present data do not identify, is that recurring and contractual payments weigh more in advanced economies, while in emerging economies a larger part of card payments is new everyday spending. Hence H2 is supported for all cashless payments and for card payments, and for cards the association is stronger in emerging economies.

4.4 H3: economic structure and the payment instrument

Table 7 reports the eight of the 72 associations with the smallest income-adjusted p values between economic structure and the payment mix, and Figure 3 shows the strongest one.

Table 7 Hypothesis 3: economic structure and the payment instrument, the eight associations with the smallest income-adjusted *p* values of 72

Structure	Payment measure	*n*	*ρ*	*p*	*q*	*ρ* holding income constant	*p*	*q*
Finance, real estate, public and other services, % of value added	Direct debits, % of number	23	0.71	< 0.001	0.012	0.72	< 0.001	0.010
Manufacturing, % of value added	Direct debits, % of value	23	−0.60	0.003	0.047	−0.54	0.009	0.335
Finance, real estate, public and other services, % of value added	Cheques, % of value	24	−0.25	0.241	0.591	−0.44	0.031	0.545
Travel, % of service exports	Cards, % of number	24	0.40	0.056	0.329	0.44	0.031	0.545
Finance, real estate, public and other services, % of value added	Direct debits, % of value	23	0.58	0.004	0.056	0.42	0.046	0.545
Finance, real estate, public and other services, % of value added	Cards, % of number	24	−0.23	0.284	0.591	−0.39	0.059	0.545
Trade, restaurants, hotels, % of value added	Payments per adult	25	−0.33	0.104	0.446	−0.38	0.059	0.545
Manufactures, % of goods exports	Cards, % of value	25	−0.38	0.059	0.329	−0.38	0.061	0.545

Note: Spearman rank correlations across economies; sector shares for 2024, payment measures and export shares averaged over 2020 to 2024. Payment shares are computed as the sum of the instrument over the sum of all cashless payments, using only years in which both are reported. *p* values from 100,000 random permutations, computed as $(b + 1)/(B + 1)$; *q* values control the false discovery rate within each family of 72 associations, the unadjusted and the income-adjusted (Benjamini and Hochberg). Rows are the eight smallest income-adjusted *p* values. Holding income constant removes the rank of log real GDP per adult from both variables. All 72 results are in the workbook.

Source: computed from BIS CPMI statistics, UN National Accounts Main Aggregates and World Bank WDI.

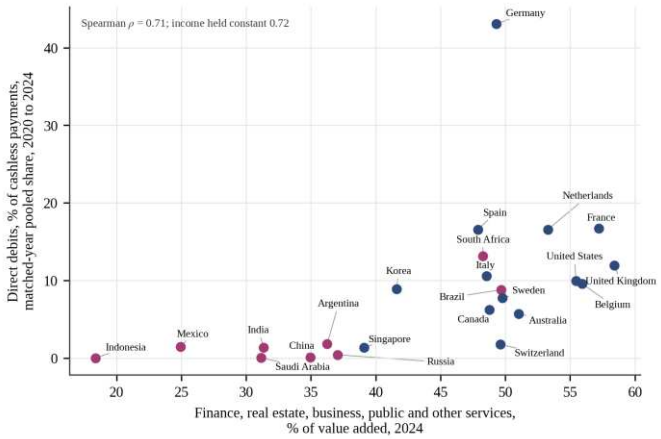


Fig. 3 Share of finance, real estate, public and other services in value added and share of direct debits in cashless payments

Source: computed from UN National Accounts Main Aggregates (2024) and BIS CPMI statistics (matched-year pooled share, 2020 to 2024, where available).

One association stands out. Economies in which finance, real estate, business services, public administration, education and health (ISIC J to P) form a larger share of value added settle a larger share of their payments by direct debit ($\rho = 0.71$, $p < 0.001$, $q = 0.012$). The association remains when income is held constant ($\rho = 0.72$, $p < 0.001$, $q = 0.010$), so that it does not reflect income alone. Germany, France, the Netherlands (2020 and 2021, the years with a reported total), Spain and the United Kingdom combine large service sectors with direct debit shares between 12 and 43 percent, while Indonesia, Saudi Arabia, Mexico and India have small service sectors and direct debit shares below 2 percent. A possible interpretation, not identified by the present test, is that a services economy runs on recurring contracts, namely rents, insurance, utilities, subscriptions and loan instalments, which are commonly settled automatically from bank accounts.

The other associations are weaker. Manufacturing economies settle a smaller share of payment value by direct debit ($\rho = -0.60$, $p = 0.003$, $q = 0.047$, close to the threshold), and economies with more travel in their service exports make more card payments once income is held constant ($\rho = 0.44$, $p = 0.031$), but neither survives correction for 72 tests with income held constant. Eight associations have $p < 0.05$, and five have $p < 0.05$ with income held constant, three of them among the eight; four have $q < 0.05$ without and one with income held constant. Hence H3 is supported for one association, between services and direct debits, and remains indicative for the others.

4.5 Banks, income and structure in one model

The three hypotheses are now brought together. Table 8 and Figure 4 divide the differences in payments per adult across economies among structure, income and banks.

Table 8 Between economies: contributions of structure, income and banks to differences in payments per adult

Specification	Economies	R^2 (adjusted)	Structure (90% interval)	Income (90% interval)	Banks (90% interval)
Main: IMF credit and POS terminals; sector shares	18	0.80 (0.72)	0.31 [0.20, 0.41]	0.23 [0.12, 0.36]	0.26 [0.21, 0.37]
			p 0.002	*p* 0.002	*p* 0.003
World Bank private credit and ATMs; sector shares	22	0.63 (0.51)	0.25 [0.10, 0.43]	0.26 [0.14, 0.43]	0.11 [0.05, 0.31]
			p 0.009	*p* 0.001	*p* 0.135
World Bank private credit and ATMs; export composition	22	0.62 (0.51)	0.05 [0.04, 0.21]	0.42 [0.26, 0.55]	0.15 [0.06, 0.38]
			p 0.576	*p* 0.001	*p* 0.096
IMF deposits and debit cards; sector shares	20	0.76 (0.67)	0.39 [0.24, 0.54]	0.27 [0.13, 0.38]	0.10 [0.08, 0.33]
			p 0.001	*p* 0.001	*p* 0.226
World Bank private credit and ATMs; sector shares; 2015 to 2019	23	0.72 (0.64)	0.26 [0.14, 0.43]	0.30 [0.16, 0.42]	0.16 [0.07, 0.33]
			p 0.002	*p* 0.001	*p* 0.022

Note: Dependent variable: log cashless payments per adult, average 2020 to 2024 unless stated. Contributions are Shapley values of R^2 for three groups: structure (share of finance, real estate, public and other services and share of manufacturing in value added, or the shares of manufactures and commodities in goods exports), income (log real GDP per adult) and banks (credit to GDP and log POS terminals or ATMs per adult, or deposits to GDP and log debit cards per adult), with the bank measures averaged over the year before the payment period (2019 to 2023, or 2014 to 2018). Intervals from 1,999 bootstrap resamples of economies; they are not centred on the estimates, since resampling few economies inflates R^2. The *p* under each contribution is a descriptive placebo benchmark: $(b + 1)/(B + 1)$, where b of $B = 1{,}999$ runs, in which that group alone is randomly reassigned across economies, give a contribution at least as large. It is not a test of incremental association given the other groups. Leave-one-economy-out ranges are in the workbook.

Source: computed from BIS CPMI statistics, IMF MFS, World Bank WDI and UN National Accounts Main Aggregates.

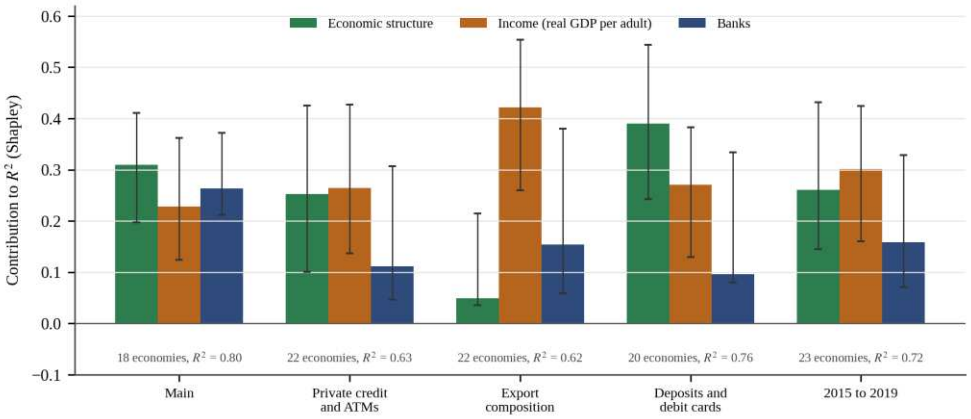


Fig. 4 Contributions of economic structure, income and banks to differences in payments per adult across economies, five specifications

Source: computed from BIS CPMI statistics, IMF MFS, World Bank WDI and UN National Accounts Main Aggregates. Bars show Shapley contributions to R^2; lines show 90 percent bootstrap intervals.

In the main specification, the three groups explain 80 percent of the differences across 18 economies (adjusted R^2 0.72), and they share it almost equally: structure contributes 0.31, banks 0.26 and income 0.23 to R^2. In each case, at most 4 of 1,999 placebo runs give a contribution as large (placebo $p \leq 0.003$). The placebo runs are descriptive benchmarks, since reassigning one group across economies also breaks its correlation with the other groups and is not a test of incremental association (Winkler et al., 2014). Dropping any one economy keeps the contribution of structure between 0.25 and 0.34 and that of banks between 0.25 and 0.29. The contribution of banks depends on how banks are measured: it falls to 0.11 with World Bank credit and ATMs (22 economies) and to 0.10 with deposits and debit cards (20 economies), and in both cases it does not exceed the placebo benchmark at the 5 percent level (placebo $p = 0.135$ and 0.226). The contributions of structure (0.25 and 0.39) and income (0.26 and 0.27) exceed the benchmark in both (placebo $p \leq 0.009$). For 2015 to 2019, structure contributes 0.26, income 0.30 and banks 0.16, all above the benchmark (placebo $p \leq 0.022$). When structure is measured by the composition of exports instead of domestic value added, its contribution is 0.05, which does not exceed the placebo benchmark in the specification tested (placebo $p = 0.576$), and income takes most of the explained variation (0.42); this is not evidence that export composition has no association with payment activity. Thus, in the specifications that include domestic sector shares, domestic structure is associated with how an economy pays, and the two structure measures come from separate models that are not compared by a direct test.

Table 9 and Figure 5 divide the movement of payment activity within economies over time.

Table 9 Within economies: contributions of banks, income and common shocks to payments per adult

Specification	Country-years (economies)	R^2	Banks at $t-1$ (90% interval)	Income (90% interval)	Common shocks (90% interval)
Levels	155 (16)	0.83	0.42 [0.34, 0.52]	0.09 [0.01, 0.27]	0.32 [0.26, 0.44]
			p 0.001	p 0.001	p 0.001
Own trends removed	155 (16)	0.43	0.08 [0.03, 0.22]	0.10 [0.03, 0.21]	0.24 [0.17, 0.48]
			p 0.003	p 0.002	p 0.001

Note: Dependent variable: log of cashless payments per adult, with the effect of each economy and break regime removed, and in the second row the linear trend of each regime as well. Groups: banks (deposits and credit to GDP and log POS terminals and debit cards per adult, all in year $t-1$), income (log real GDP per adult) and common shocks (year effects). Regimes with fewer than three years are dropped. Contributions are Shapley values of R^2; intervals from 999 bootstrap resamples of economies. The p under each contribution is a descriptive placebo benchmark: $(b + 1)/(B + 1)$, where b of $B = 999$ runs, in which the years of that group alone are randomly reordered within each economy, give a contribution at least as large. The reordering keeps each economy's values but breaks their timing, including serial dependence, so the benchmark is not an exact test.

Source: computed from BIS CPMI statistics, IMF MFS and World Bank WDI.

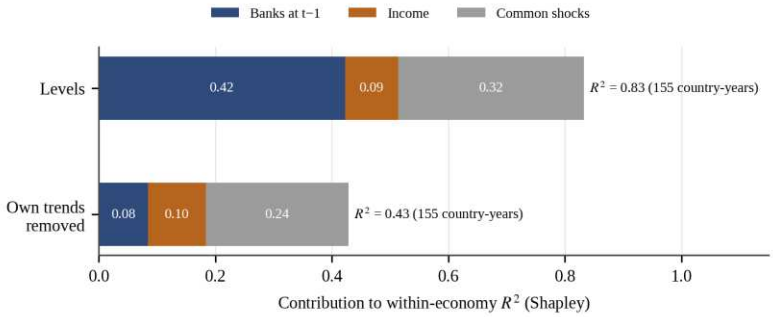


Fig. 5 Contributions of banks, income and common shocks to payments per adult within economies

Source: computed from BIS CPMI statistics, IMF MFS and World Bank WDI.

Within economies, with the effect of each economy and break regime removed, the model explains 83 percent of the movement of payments per adult in 155 country-years from 16 economies. The bank measures in place a year earlier contribute 0.42, common shocks 0.32 and income 0.09, and each exceeds the placebo benchmark. Much of this reflects the joint rise of payments and bank infrastructure over the period, and hence the decomposition is repeated with the trend of each economy removed. The explained share then falls to 43 percent, with common shocks at 0.24, income at 0.10 and the bank measures at 0.08, and the bank measures still exceed the placebo benchmark (2 of 999 runs as large, $p = 0.003$). Hence, once the shared rise over time is set aside, the capacity and readiness banks had in place carry a part of the movement of payments around each economy's trend about as large as that of income, while the largest part is the movement common to all economies.

5 Discussion

5.1 Banks, income and structure

The central finding of the present study is that the explained variation in cashless payment activity is shared among banking measures, income and economic structure, with the banking share sensitive to how banks are measured and to trends. Across economies, income and the structure of domestic value added exceed the placebo benchmark in every specification that includes domestic sector shares, and the bank measures do so in the main specification and for 2015 to 2019, but not with World Bank credit and ATMs or with deposits and debit cards. Across economies with income held constant, deeper credit to the private sector in the year before goes with more payments per adult. Within economies, payments stand higher when more terminals had been deployed, and once the shared rise of payments and infrastructure over time is set aside, the bank measures taken together still carry a part of payment activity about as large as that of income. Hence the bank side matters for where an economy stands in payments, while no single bank measure accounts for the movement of payments around an economy's own trend.

The bank side was read through the capacity and readiness that banks have in place before payments are made (Battula, 2026). The results show why this reading is useful: the capacity and infrastructure in place are associated with the level of payment activity, both across economies and within them, even though payment activity in any year also rises for reasons that have nothing to do with banks, such as income, the cycle and shocks common to all economies. Thus tracking what banks have prepared and deployed adds information about payment activity that income and structure alone do not give.

5.2 Payments and the economy

The within-economy relation between payments and real growth is in line with the associations between electronic payments and economic activity reported for European and OECD panels (Zhang et al., 2019; Wong et al., 2020), which were estimated in different forms. The present study adds two points. Firstly, the relation is significant for card payments and not detectable for direct debits, which is consistent with card data being informative for nowcasting (Galbraith and Tkacz, 2018; Duarte et al., 2017; Chapman and Desai, 2023); the difference between the two responses is, however, not significant on a common sample, so that the data do not establish that direct debits respond less. Secondly, the response of card payments is significantly larger in emerging economies than in advanced ones, while for all cashless payments the difference is not significant. A possible reason is that in emerging economies a larger part of card payments is new everyday spending; the rapid spread of instant payments in such economies (Khiaonarong and Humphrey, 2022; Duarte et al., 2022) is one sign of change in how they pay, although the response of credit transfers in emerging economies is not significant in the present data.

5.3 Structure and the means of payment

The literature explains national payment mixes by prices, institutions, transaction size, merchant acceptance and demographics (Humphrey et al., 1996; Bagnall et al., 2016). The present study adds the structure of the domestic economy. The share of finance, real estate, business and public services in value added is associated with the share of direct debits, and this association holds with income held constant and after correction for 72 tests. It is

consistent with the large share of direct debits in Germany, France and the Netherlands, and with their near absence in economies where this sector is smaller, such as Indonesia, Mexico and India. On the other hand, the contribution of export composition does not exceed the descriptive placebo benchmark in the specification tested, which is not evidence that export composition has no association with payment activity. Thus, in the present sample, the means of payment of an economy are associated with the composition of its domestic value added; since the two structure measures come from separate models, the study does not test whether their contributions differ.

5.4 Implications

The findings carry implications for three groups. Firstly, for statistical agencies and central banks, card payments are an instrument whose association with output within economies is detectable in annual data, which supports their use as an indicator of the economy, subject to tests at higher frequency; whether they are more informative than other instruments needs a direct comparison. Secondly, for banks, the capacity and terminals in place are associated with how many payments an economy makes, so that what banks have deployed is a useful measure to track alongside payment activity; these associations do not establish the returns to infrastructure investment or the horizon over which they arise. Thirdly, for policy, the structure of the economy and its income are associated with much of the payment mix, so that targets for the use of particular instruments may need to take that structure into account rather than be set uniformly across economies.

6 Limitations

The findings are subject to the following limitations. Firstly, 25 jurisdictions report the selected payment aggregate, and only 16 to 18 report every variable needed for the bank tests and the main between model, so that estimates across economies rest on few observations and their intervals overlap. Secondly, the contribution of banks across economies depends on the bank measure, and it is reported as a range rather than as one number. Thirdly, the present specification takes the bank measures one year before payments; longer annual lags and higher-frequency timing remain unexamined. Fourthly, payments and bank infrastructure both rise over the period, so that associations in levels within economies partly reflect shared trends; the estimates with each economy's own trend removed are the stricter reading. Fifthly, the BIS statistics cover the whole payment system and the IMF survey the depository corporations other than the central bank, and neither separates banks from other providers. Sixthly, the breaks are taken from the series and observation notes of the BIS and very large jumps are treated as breaks, but unrecorded changes of definition may remain, and the revisions of the United States are treated as breaks as a precaution. Seventhly, the UN sector data combine finance, real estate, business services and the public sector in one group, so that the financial sector cannot be separated. Eighthly, cash is not measured, so that the growth of cashless payments cannot be read as an equal fall in cash. Ninthly, the relations are associations and do not establish that bank capacity, output or structure drives payments, or the reverse. Tenthly, sector shares are measured for 2024 and are applied to payment averages for 2020 to 2024 and, in one check, 2015 to 2019, and to Russia and the Netherlands, whose total payment data end in 2020 and 2021. Eleventhly, POS terminals and debit cards partly reflect the use of cards as well as bank supply, so that the bank group is not a pure measure of supply. Twelfthly, for the six

euro-area members the IMF credit series covers claims on private residents of the whole euro area, while for the other economies it covers domestic residents, so that the main credit ratio is not fully comparable across economies; the World Bank measure is used as an alternative. Thirteenthly, payment growth and real GDP growth per adult share the adult population as denominator; the test on totals shows that the relation is not solely driven by this, but it is a check rather than a full correction. Fourteenthly, the bootstrap intervals of the Shapley contributions are not centred on the estimates, since resampling few economies inflates R^2, and the placebo benchmarks reassign a group without conditioning on the others or preserving serial dependence, so that both are descriptive guides rather than exact tests. Fifteenthly, some values for 2024 are provisional, and the providers revise past values, so that later downloads may differ slightly.

7 Conclusion

The present study asked how much of the cashless payment activity of an economy is associated with its banks, its income and its economic structure, for the 25 jurisdictions with a total cashless payment series in the BIS statistics, 2012 to 2024. Three hypotheses were tested and then brought into one model. Payment activity stood higher where banks had more capacity and infrastructure in place a year earlier: across economies, deeper credit to the private sector went with more payments per adult with income held constant, and within economies payments tracked the terminals already deployed, although no single bank measure stood out once each economy's own trend was removed. Payment growth moved with the growth of real GDP within economies, significantly for card payments and, for cards, more strongly in emerging economies, while no such association was detected for direct debits. Economies with larger finance, real estate, business and public service sectors settled more of their payments by direct debit, with income held constant. Across economies, income and the structure of domestic value added exceeded the placebo benchmark in every specification that includes domestic sector shares, and the bank measures did so only in some. Hence the explained variation in payment activity is shared among banking measures, income and structure, with the banking share depending on measurement and trends, and payment policy and payment statistics may need to be read against the capacity of the banks and the structure of the economy that uses them. This can be extended further to monthly data, which would allow the timing of capacity, deployment and use to be examined more finely, and to more economies as the BIS statistics grow.

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