

The demand for cash: stylized facts and substitution by electronic means of payment¹

Luis Cabezas and Alejandro Jara

Abstract

This article analyses the impact of the increasing use of electronic means of payment on the demand for cash (banknotes and coins). It estimates two models: one with panel data and the other with cross-sectional data. The two methodologies offer complementary views for evaluating the degree to which electronic means of payment act as a determinant of currency in circulation. The study identifies an intense substitution process between cash and electronic means of payment, which is common to most of the economies analysed. However, there are also a number of idiosyncratic factors that explain the high degree of heterogeneity in the demand for cash that exists between countries. In emerging economies, electronic payment is still incipient, so the demand for cash is likely to continue to decline. However, this does not mean that these economies will become “cashless societies” in the near future.

Keywords

Money, supply and demand, money supply, electronic commerce, Internet, information technology, communication technology

JEL classification

E41, E42, E5

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¹ The opinions expressed in this article are the authors' sole responsibility and, therefore, do not represent the opinion of the institutions to which they are affiliated. The authors are grateful for comments made by an anonymous referee, which resulted in substantive improvements being made to the article.

I. Introduction

Households demand cash (banknotes and coins)² mainly for three motives: for transactional purposes; to hold as a store of value; and for precautionary reasons. Data from recent years shows that the amount of cash circulating in the economy, as a percentage of the M1 monetary aggregate,³ has declined in most countries, and that this decline has even been accentuated in emerging economies. The smaller demand for cash as a proportion of M1 is explained mainly by the increasing use of electronic means of payment, as cash transactions compete, for example, with the use of credit cards, debit cards and Internet payments.⁴ This process poses major challenges for monetary policy and financial regulation. Recent research suggests that greater use of electronic means of payment increases the elasticity of the demand for money with respect to interest rate changes (Atanasio, Guiso and Jappelli, 2002), which could potentially affect overall price stability (Carstens, 2018). This makes it important to understand the factors driving the increased use of electronic means of payment and how these have contributed to the evolution of the demand for physical money in a broad range of countries.

Although the global trend shows that electronic payment has increased at the expense of banknotes and coins in virtually all economies, there are still significant differences between countries (Jobst and Stix, 2017; Bech and others, 2018). In particular, most economies use electronic means of payment considerably less than the Nordic countries (Sweden, for example), which have been leaders in the digitalization of the means of payment at the retail level. The increased use of electronic payment has been driven by innovations in both financial markets and information technologies, in a transformation process that has been under way for several decades. Humphrey, Pulley and Vesala (1996) analyse the payment systems of 14 developed countries and identify a substitution effect of around 68% between cash and other means of payment. This means that a 10% reduction in cash holdings is associated with a 6.8% increase in the use of other means of payment. This trend towards electronic payment is also present in less developed countries, where cell phones are increasingly being used to make payments (Bagnall and others, 2016). However, international data show that the substitution between the use of banknotes and coins and electronic means of payment varies over time and, consequently, is not perfect (Jonker and others, 2017). Moreover, in some countries, cultural and institutional factors favour the use of cash (Bagnall and others, 2016). For example, households hold a considerable portion of their assets as cash, particularly for low-value transactions. Stix (2013) further shows that lack of trust in banks, the memory of past financial crises, and the weakness of the tax collection system may hinder the process of cash being replaced by electronic means.

This article presents a series of stylized facts on the demand for physical currency and the role of electronic means of payment as a potential substitute for cash in a group of advanced and emerging economies in 2000–2016. The factors that have contributed to the decline in the demand for cash as a percentage of M1 are analysed through econometric estimations of panel and cross-sectional data. These emphasize the role of factors that could encourage the replacement of cash by electronic means —traditionally associated with greater access to the financial system, greater use of payment

² In this article, the terms “cash”, “banknotes and coins in circulation” and “currency in circulation” are used interchangeably, to refer to banknotes and coins circulating outside the banking system.

³ M1 is a narrow measure of the money supply that includes physical currency, demand deposits, traveler’s checks, and other checkable deposits.

⁴ The above, however, contrasts with the observed trend of cash as a percentage of GDP, which has increased in most countries. This is partly due to the growth of the informal economy, increased precautionary demand for cash, and the demand for banknotes and coins as a store of value (Goodhart and Ashworth, 2017; Jobst and Stix, 2017).

via the Internet, and the desire to make government transfers and wages received by the public more conducive to the use of electronic media.⁵

The results of the panel and cross-sectional estimations reveal the potential impact of different factors on the demand for cash. The estimations performed show that, on average, if all the countries included in the panel sample had similar attitudes towards the use of electronic payment as those of 2014 Sweden (the country with the least demand for currency at the time of the study), the demand for currency as a percentage of the monetary aggregate M1 would fall from 30% to 23%. The main implication of this is that the increased use of electronic means of payment would reduce the use of cash as a proportion of M1; but this does not mean that it would disappear. This result is consistent with what has been documented in the literature, in which data from surveys on means of payment use are applied to estimate causal inference models with a view to analysing means of payment innovations and payment decision models (see Fung, Huynh, and Sabetti, 2014 and Wakamori and Welte, 2017).

Section II of this article makes a detailed analysis of the trends in the demand for circulating currency in emerging and advanced economies in 2000–2016. It also reviews the results of the World Bank's Global Findex means of payment survey. Section III presents the main results of the econometric estimations of the model used in the present study with panel and cross-sectional data. Lastly, section IV presents the conclusions.

II. Data and stylized facts

1. The data

This section presents a set of stylized facts in relation to the demand for banknotes and coins and the use of electronic means of payment in a selected group of economies. The different measures of the use of cash are analysed by combining data published by the Center for Latin American Monetary Studies (CEMLA), the Bank for International Settlements (BIS) and the World Bank, for 2000–2016. This database includes 21 countries, of which 13 are emerging economies (Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay), and eight are advanced economies or groupings of economies (Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the eurozone).

The analysis of the use of electronic means of payment is based on data for 2014 published by the World Bank in the Global Findex database.⁶ This database covers 170 economies from different geographic areas and levels of development, but the data are available only for a small number of years. The stylized facts based on this information presented in the following section consider information on these 170 economies. The cross-sectional estimates presented in the next section, which are based on Global Findex data, are limited by the availability of complementary macrofinancial data used in the regressions and, consequently, are based on a subset of 54 economies.

Table 1 provides a detailed description of the variables considered in the analysis, indicating the sources used in each case.

⁵ This article does not consider the potential implications of the recent development of digital currencies (cryptocurrencies) on the demand for cash, because this is still considered incipient and because digital currencies are not currently widely used as a means of payment by the population (BIS, 2018). However, it is reasonable to assume that in the future their effect on the demand for cash will be significant.

⁶ For further details on the contents of this database see Demircuc-Kunt and Klapper (2012).

Table 1
Description of the variables considered in the analysis

Variable name	Description	Source
Cash	Banknotes and coins (currency) in circulation, amount at year-end expressed as a percentage of the M1 monetary aggregate and as a percentage of GDP.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
GDP per capita	GDP divided by mid-year population.	World Bank, "World Development Indicators," 2021 [online] http://data.worldbank.org/data-catalog/world-development-indicators .
Automatic teller machines	ATM terminals located in the country: number of terminals per million inhabitants, at year-end.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
Credit cards	Cards with a credit function issued in the country: number of cards per inhabitant, at year-end.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
Debit cards	Cards with a debit function issued in the country: number of cards per inhabitant, at year-end.	World Bank/Center for Latin American Monetary Studies (CEMLA), Yellow Book Statistics 2019 and Bank for International Settlements (BIS), Red Book, various years.
Financial depth	Domestic credit granted by the financial sector (as a percentage of GDP).	World Bank, "World Development Indicators," 2021 [online] http://data.worldbank.org/data-catalog/world-development-indicators .
Monetary policy rate	Monetary policy interest rate.	Bank for International Settlements (BIS) monetary policy interest rate statistics.
Inflation	Inflation, consumer prices, annual percentage.	World Bank, "World Development Indicators," 2021 [online] http://data.worldbank.org/data-catalog/world-development-indicators .
Account in a financial institution	Percentage of population over 15 years of age with an account in a financial institution.	Global Findex, database published by the World Bank.
Uses credit card	Percentage of the population over 15 years of age that used a credit card in the past year.	Global Findex, database published by the World Bank.
Uses debit card	Percentage of population over 15 years of age that used a debit card in the past year.	Global Findex, database published by the World Bank.
Transactions through cell phones	Percentage of the population over 15 years of age that made transactions at a financial institution using a cell phone.	Global Findex, database published by the World Bank.
Internet use	Percentage of the population over 15 years of age using the Internet to pay bills and make purchases.	Global Findex, database published by the World Bank.
Government transfers in cash	Percentage of population over 15 years of age that receives government transfers in cash.	Global Findex, database published by the World Bank.
Wages received in cash	Percentage of population over 15 years of age that receives wages in cash.	Global Findex, database published by the World Bank.

Source: Prepared by the authors.

2. Stylized facts

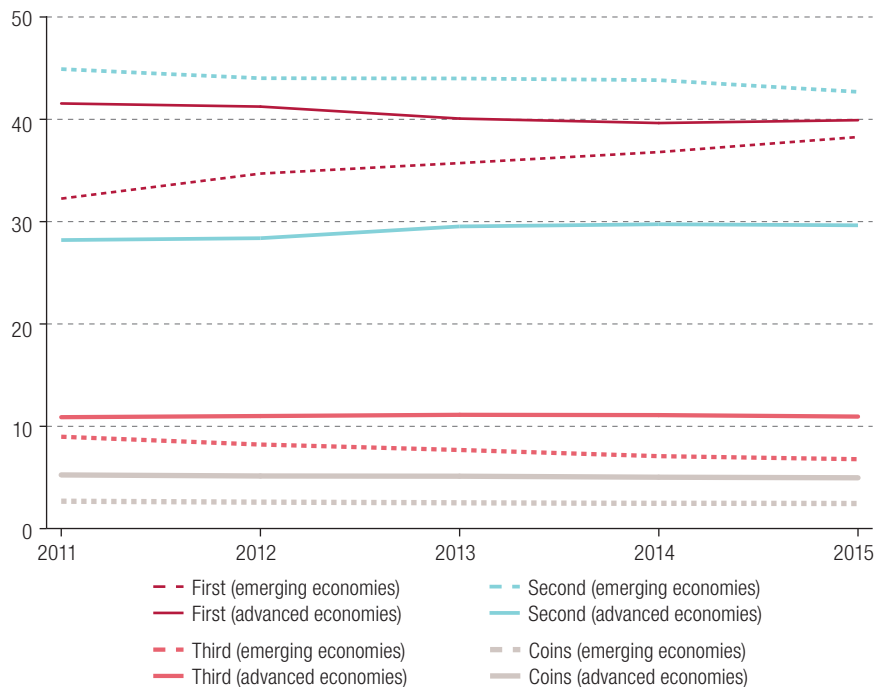
The relative importance of the use of banknotes and coins in circulation in an economy can be measured in several ways. At the aggregate level, currency is traditionally measured in dollars, as a percentage of the population, as a percentage of GDP and as a percentage of one of the monetary aggregates, typically M1. At the micro level, the relative share of cash as a means of payment (in terms either of amount or of the number of transactions) is measured by surveys that track household payment behaviour.⁷

⁷ These surveys also make it possible to evaluate the use of cash as a store of value.

(a) Denomination of banknotes and coins

A first stylized fact that emerges is that higher-denomination banknotes and coins account for a larger share of total cash holdings in advanced and emerging economies alike. Figure 1 shows the average shares of banknotes listed by denomination.⁸ On average, in advanced economies, the highest denomination accounts for over 40% of the stock of banknotes and coins in circulation, while in emerging economies the second highest denomination has the largest share. The relative importance of higher-denomination banknotes in emerging economies has increased in recent years, whereas coins in circulation account for a much smaller proportion of the total.

Figure 1
Composition of currency in circulation in emerging and advanced economies, 2011–2015
(Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

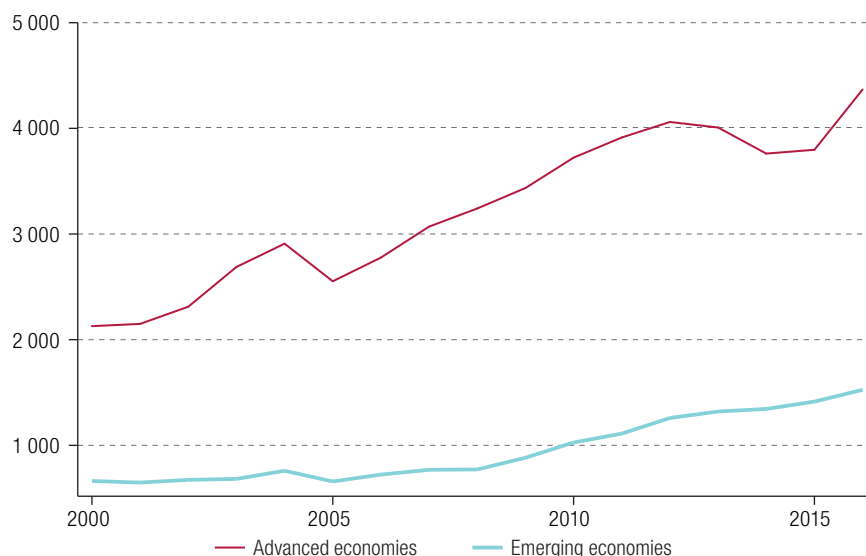
Note: The calculation of the composition of currency in circulation also includes cash balances held by banks. The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United States, the United Kingdom and the euro area. The term “First” corresponds to the highest denomination banknotes; “Second” and “Third” correspond to the second and third highest denomination banknotes, respectively.

(b) Currency in circulation per capita

Secondly, the demand for cash relative to population (currency per capita) has grown significantly in both groups of countries. In advanced countries, although the level of currency per capita is higher than in emerging countries, it is growing at a slower pace (see figure 2).

⁸ The highest-denomination banknotes are grouped in the variable “first” and those with the second highest denomination in “second”.

Figure 2
Currency in circulation per capita in emerging and advanced economies, 2000–2016
(United States dollars)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the euro zone.

(c) Currency in circulation as a percentage of GDP

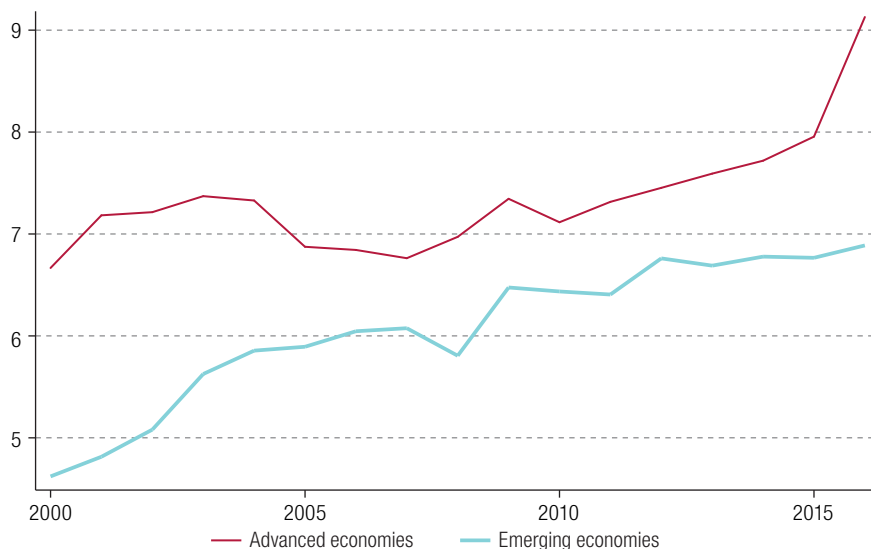
The value of banknotes and coins in circulation as a percentage of GDP increased in both emerging and advanced economies between 2000 and 2016, and most significantly in developed countries in the latter part of that period (see figure 3). The ratio of cash to GDP also increased in most countries in the last decade,⁹ albeit with some exceptions. In Sweden, South Africa, India and China, the cash-to-GDP ratio fell sharply. In India and China, this reflected explicit policies that have reduced the circulation of high denomination banknotes, partly as a way of combating illegal trade.¹⁰ Nonetheless, in both cases, the ratio remains at relatively high levels (around 8% and 10%, respectively).

Another salient point, which can be discerned in figure 4, is that the cash/GDP ratio displays high dispersion across countries. In Japan, for example, cash in circulation represents about 20% of GDP, while the most recent data from Sweden puts the equivalent indicator below 2%.

⁹ One of the main limitations when comparing the demand for cash in economies such as the United States and Europe concerns the role of the United States dollar and the euro as foreign exchange. There is a demand for foreign exchange that goes beyond the volume of the United States or European economies, which is affected by factors such as tourism and international reserve investment.

¹⁰ See the case of India in Dasgupta (2017).

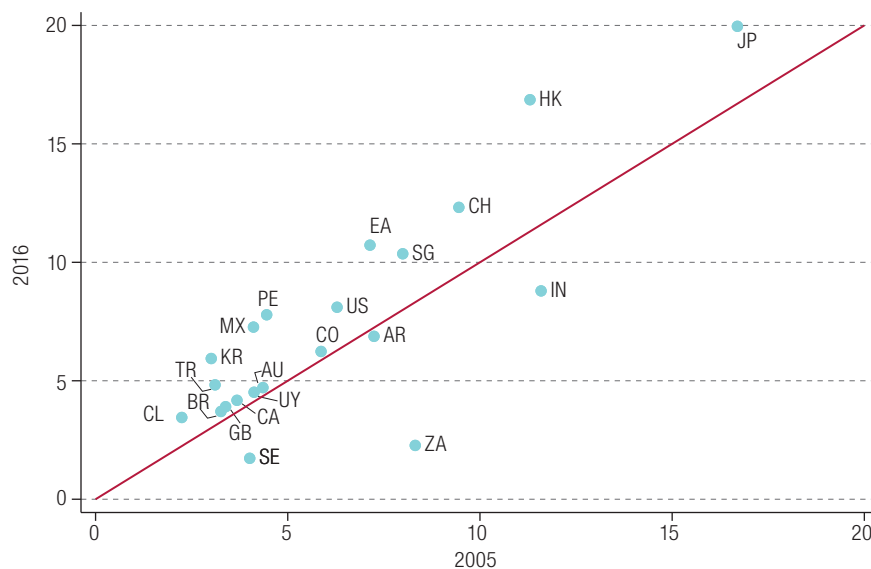
Figure 3
 Currency in circulation in emerging and advanced economies relative to GDP, 2000–2016
 (Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the euro zone.

Figure 4
 International comparison of currency in circulation as a proportion of GDP in 2005 and 2016
 (Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina (AR), Brazil (BR), Chile (CL), Colombia (CO), Hong Kong (China) (HK), India (IN), Mexico (MX), Peru (PE), the Republic of Korea (KR), Singapore (SG), South Africa (ZA), Turkey (TR) and Uruguay (UY). The advanced economies included are: Australia (AU), Canada (CA), Japan (JP), Sweden (SE), Switzerland (CH), the United States (US), the United Kingdom (GB) and the euro area (EA).

The growth of cash relative to GDP in most economies can be explained partly by its use as a store of value — particularly in the case of high denomination banknotes. In a context of low interest rates and fewer investment alternatives, as has prevailed globally in recent years, people choose to hold a higher proportion of their wealth in the form of banknotes (Jobst and Stix, 2017). Compounding this, mistrust of banks, the memory of past banking crises and the diminished capacity to collect taxes all increase the demand for precautionary cash holdings (Stix, 2013; Esselink and Hernandez, 2017).

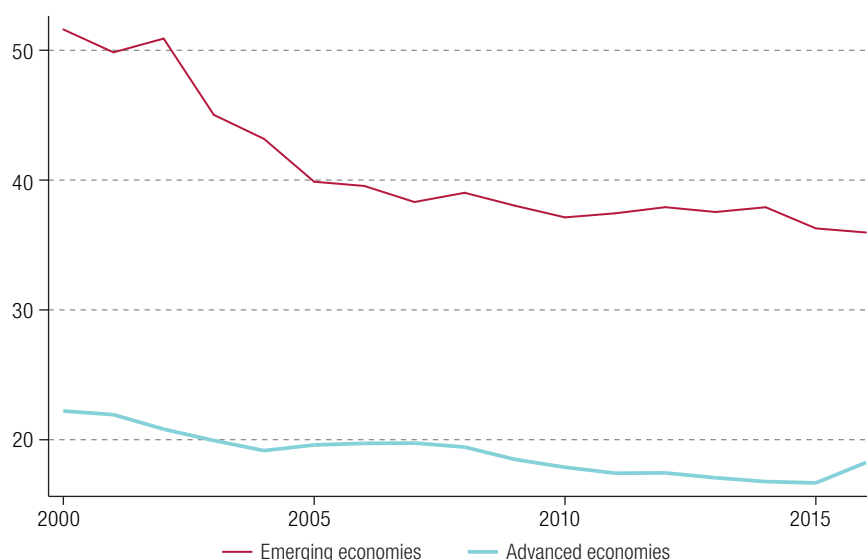
The second reason is the role of the shadow economy. The anonymity of cash transactions encourages the use of banknotes and coins as a way to evade taxes and thus be able to engage in illicit activities (Goodhart and Ashworth, 2017). In particular, Goodhart and Ashworth (2014) emphasize this role in the case of the United Kingdom, where they estimate that the shadow economy has expanded by about 3% since the global financial crisis.

(d) Currency in circulation as a percentage of M1

Currency in circulation as a percentage of the M1 monetary aggregate in emerging and advanced economies shows a diametrically opposite picture to that presented by cash relative to GDP, since in the first case the ratio falls in both groups of countries between 2000 and 2016. This indicator displays a sustained decline over time, although less pronounced in the most recent period, when there was even a slight increase in the average of advanced economies in recent years (see figure 5).

Figure 5

Currency in circulation in emerging and advanced economies as a proportion of M1, 2000–2016
(Percentages)

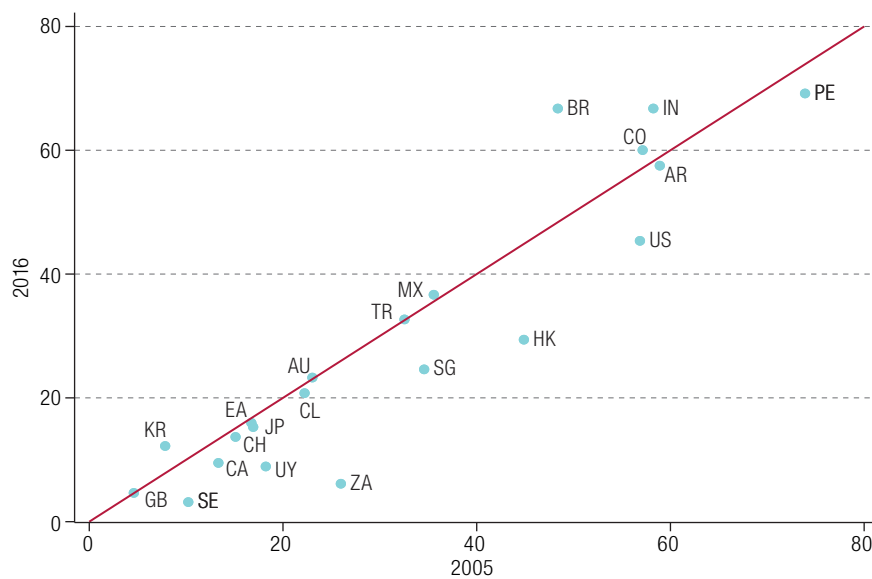


Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, Japan, Sweden, Switzerland, the United Kingdom, the United States and the euro zone.

The observed reduction is common to the vast majority of economies, although the level of currency in circulation as a proportion of M1 varies greatly from one country to another (see figure 6). Whereas in Sweden currency in circulation represented less than 4% of M1 in late 2016, in Peru the figure was 70%.

Figure 6
International comparison of currency in circulation as a proportion of M1, 2005 and 2016
(Percentages)



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

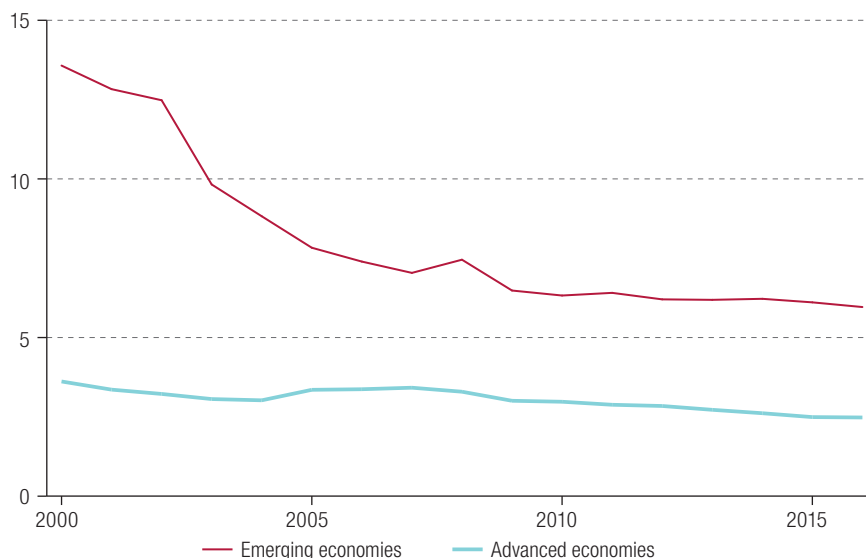
Note: The emerging economies included are: Argentina (AR), Brazil (BR), Chile (CL), Colombia (CO), Hong Kong (China) (HK), India (IN), Mexico (MX), Peru (PE), the Republic of Korea (KR), Singapore (SG), South Africa (ZA), Turkey (TR) and Uruguay (UY). The advanced economies are: Australia (AU), Canada (CA), Japan (JP), Sweden (SE), Switzerland (CH), the United Kingdom (GB), the United States (US) and the euro area (EA).

The reduction in circulating currency as a proportion of M1 is compatible with its increase relative to GDP, if the velocity of circulation (V), postulated by the classical quantity theory of money, is not constant.¹¹ While there is conclusive evidence that the relationship between the demand for money and the interest rate is stable in the long run (Benati and others, 2017), significant deviations can occur over shorter timespans. Empirically, it has been shown that the velocity of circulation is not constant over time. Figure 7 shows that the velocity of circulation of money has fallen in both emerging and advanced economies since 2000; and it is considerably lower in advanced economies than in emerging ones.

Figure 8 illustrates this differentiation at a disaggregated level. The advanced economies are grouped in the lower portion of the graph, while the emerging economies are distributed in the upper part.

¹¹ From the quantity theory of money, the velocity of circulation can be reformulated as follows: $V = (C/M1)/(C/GDP)$, where C is cash in circulation, V the velocity of circulation, and GDP is nominal gross domestic product.

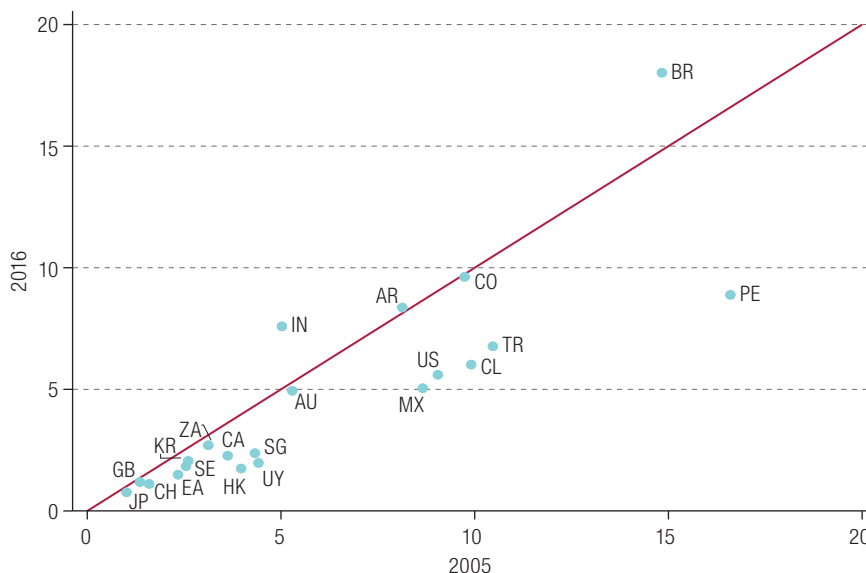
Figure 7
Velocity of circulation of money in emerging and advanced economies, 2000–2016



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina, Brazil, Chile, Colombia, Hong Kong (China), India, Mexico, Peru, the Republic of Korea, Singapore, South Africa, Turkey and Uruguay. The advanced economies included are: Australia, Canada, the United States, Japan, Sweden, Switzerland, the United Kingdom, the United States and the eurozone.

Figure 8
International comparison of the velocity of circulation in 2005 and 2016



Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Note: The emerging economies included are: Argentina (AR), Brazil (BR), Chile (CL), Colombia (CO), Hong Kong (China) (HK), India (IN), Mexico (MX), Peru (PE), the Republic of Korea (KR), Singapore (SG), South Africa (ZA), Turkey (TR) and Uruguay (UY). The advanced economies included are: Australia (AU), Canada (CA), Japan (JP), Sweden (SE), Switzerland (CH), United Kingdom (GB), the United States (US) and the euro area (EA).

(e) Stylized facts gleaned from surveys

The following are some of the most relevant stylized facts gleaned from various surveys about the use of cash as a means of payment:¹²

(i) Frequency and use of cash for transactional motives

Although there is a trend towards greater use of electronic payment for transactions, the demand for cash remains strong. The available data show that the main motive for households to demand cash is for transactions, and that cash is also the most frequently used means of payment.

(ii) Share of cash in the amount and number of transactions

In Europe, 79% of the number of transactions and 54% of their value involve cash payments. However, the situation varies greatly between economies. While in Germany cash is used in over 80% of transactions, in the Netherlands and Finland the figure is less than 50%. Similarly, in Australia 46% of transactions are cash-based, while in Denmark cash accounts for 20% of total retail transactions.

(iii) Reasons why households use cash

The two main characteristics of cash that contribute to its use as the principal means of payment in transactions are its ability to provide liquidity and the fact that cash is a highly acceptable means of payment.

(iv) Effect of transaction size

Although there is no linear relationship, the use of electronic means of payment increases with transaction size. International data are unequivocal in this respect: small transactions are mostly carried out with cash. However, this trend is not absolute, since the development of technologies such as payment through cell phones, or the use of contactless cards, has shown that electronic payment can also compete with cash in smaller transactions.

(v) Effect of demographic factors on the use of electronic means of payment

Although there are differences in the cross-sectional comparison, the use of electronic means of payment has increased in all cohorts. It is not a phenomenon that is confined to the younger age brackets, or higher education or income groups.

(vi) The role of cash as a store of value

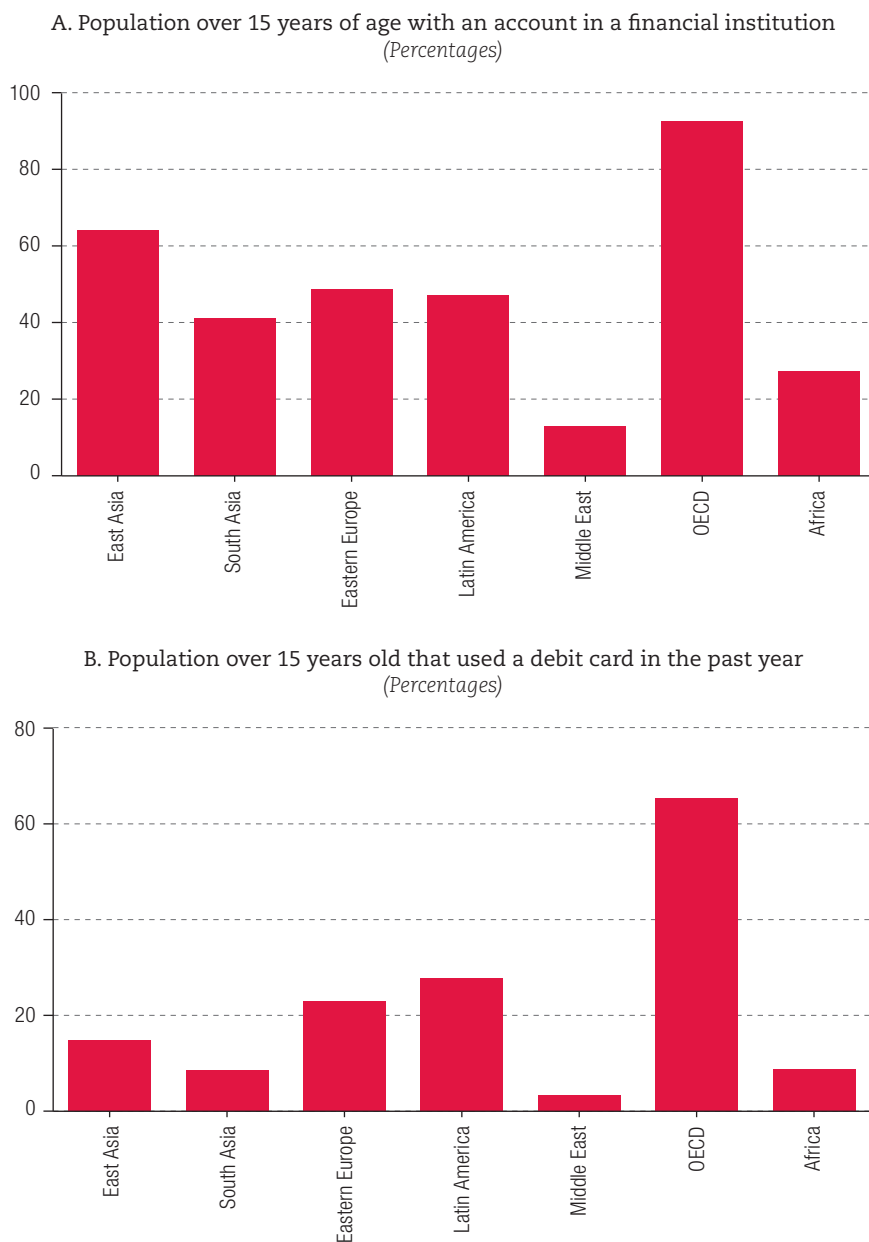
The demand for high-denomination banknotes has increased in advanced economies, probably associated with the increase in the demand for cash as a store of value, given the low interest rates prevailing in these economies in recent years.

(vii) Other factors

Other factors that contribute to a higher demand for cash are associated with the anonymity of the parties in cash transactions, particularly the growth of the informal economy and activities associated with organized crime.

The Global Findex survey, which the World Bank applied to a broad set of economies and was published in 2011, 2014 and 2017, makes it possible to compare the use of electronic means of payment in a variety of countries (see figures 9, 10 and 11). First, the data show that the economies that are members of the Organisation for Economic Co-operation and Development (OECD) have substantially higher levels of use and access to electronic means of payment than other economies. This can be seen both in the percentage of the population that has an account in a financial institution and in the percentage that has used a debit card in the past year (see figures 9A and 9B, respectively).

¹² For further information, see Esselink and Hernández (2017).

Figure 9Availability and use of electronic means of payment, average of 2011, 2014 and 2017^a

Source: World Bank, Global Findex Database [online] https://globalfindex.worldbank.org/#data_sec_focus.

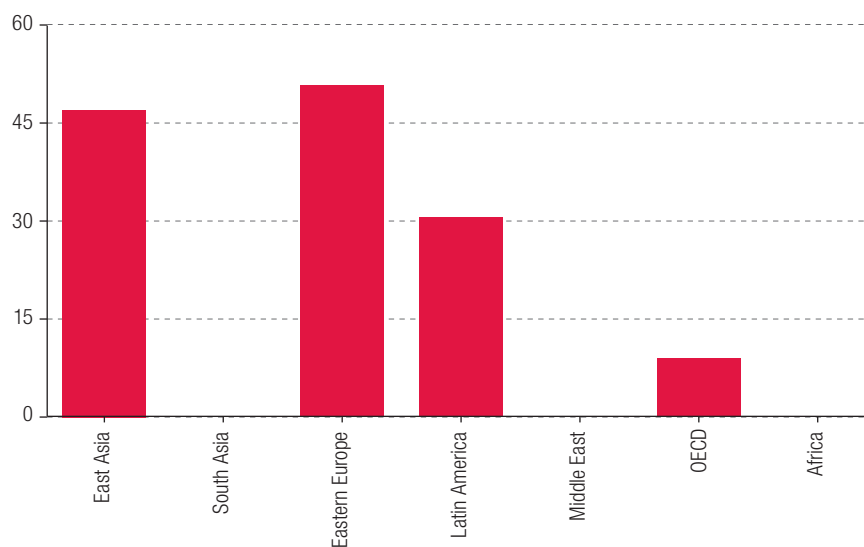
Note: Country classifications correspond to those reported by the World Bank.

^a Averages include the years indicated depending on the availability of information in each case.

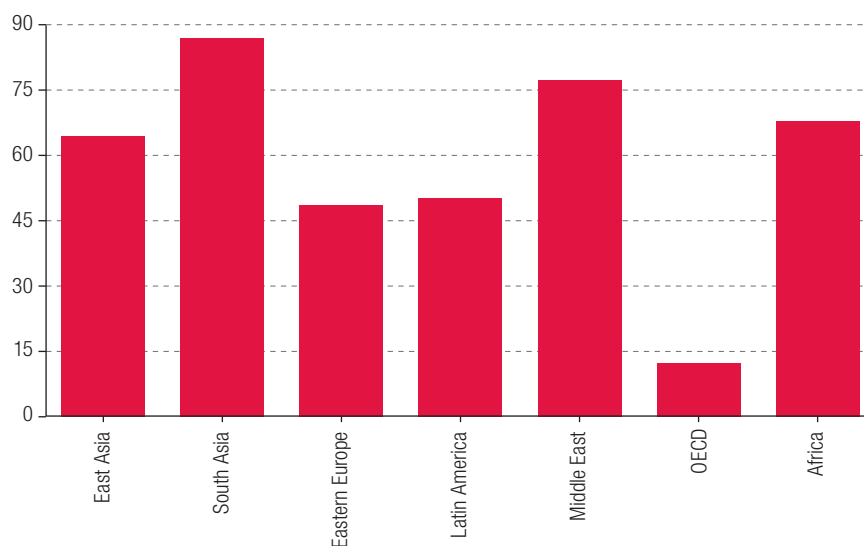
In the emerging economies, in contrast, the proportion of the population receiving government transfers wages in cash form is substantially higher than in OECD countries (see Figures 10A and 10B, respectively). In the latter case, while around 10% of wage-earners in OECD economies receive their pay in the form of banknotes and coins, the figure averages 90% in the South Asian economies.

Figure 10
Use of cash to receive income, average 2014 and 2017

A. Population over 15 years of age receiving government transfers in cash
(Percentages)



B. Population over 15 years of age receiving wages in cash
(Percentages)



Source: World Bank, Global Findex Database [online] https://globalfindex.worldbank.org/#data_sec_focus.

Note: Country classifications are those reported by the World Bank. No information is available for South Asia, Middle East and Africa for panel A.

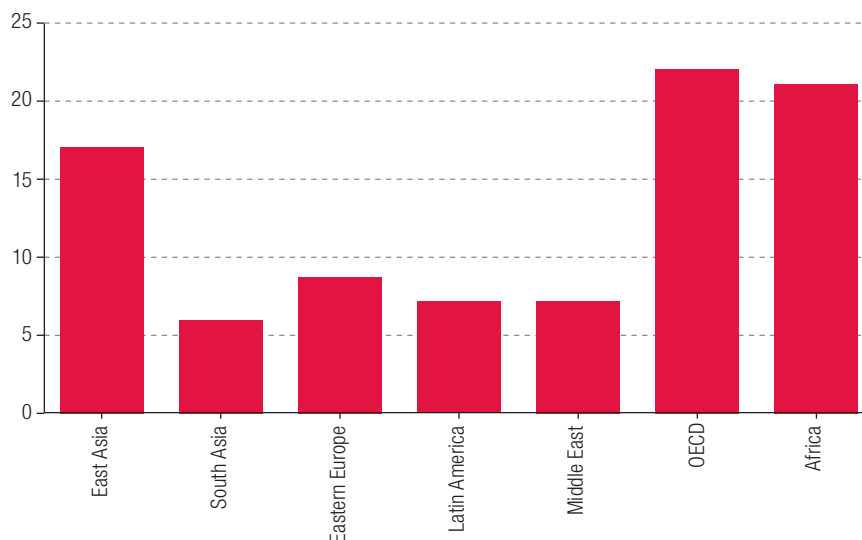
Payment via cell phone is widespread in the economies of Africa and East Asia, with rates that are close to those of the more advanced economies. In contrast, the use of the Internet to pay bills and make purchases still lags far behind in the emerging economies (see figures 11A and 11B, respectively).

Figure 11

Role of technological advances in payment methods, 2014 and 2017 average

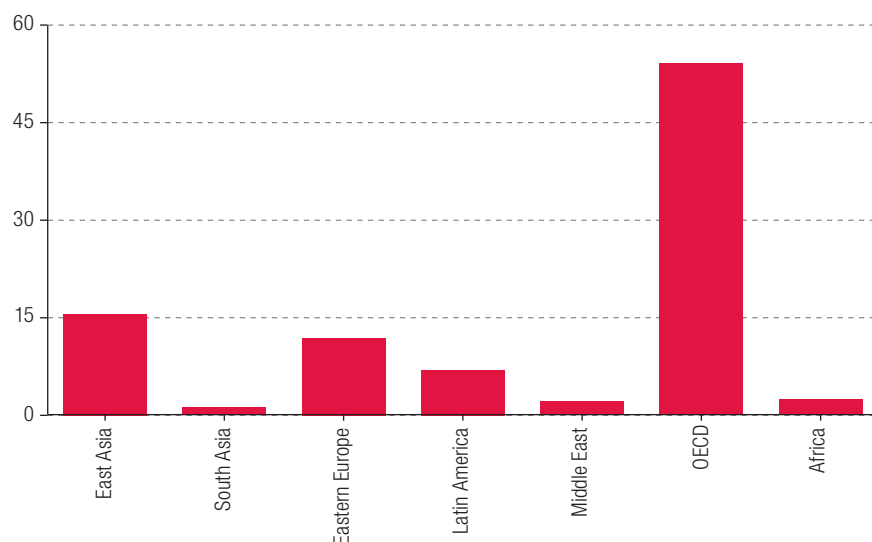
A. Population over 15 years of age that made transactions from an account in a financial institution using a cell phone

(Percentages)



B. Population over 15 years old that used the Internet to pay bills and make purchases

(Percentages)

**Source:** World Bank, Global Findex Database [online] https://globalfindex.worldbank.org/#data_sec_focus.**Note:** Country classifications correspond to those reported by the World Bank.

III. Demand for cash and substitution by electronic means of payment

This section analyses the degree of substitution that could exist between circulating currency and the use of electronic means of payment, based on a series of panel and cross-sectional estimations of cash in circulation as a percentage of M1.

1. Panel estimations

This subsection reports a series of panel estimations, with country and time fixed effects, for the level of circulating currency as a percentage of M1 in 2000–2015. The following equation is estimated:

$$\ln\left(\frac{C}{M1}\right)_{it} = \alpha_i + \beta Z_{it} + \gamma_t + \varepsilon_{it} \quad (1)$$

where $(C/M1)_{it}$ represents banknotes and coins in circulation as a percentage of M1 of country i in year t ; α_i corresponds to the country- i fixed effect; and Z_{it} corresponds to the set of determinants of cash in circulation, including the following: (i) financial depth, (ii) income per capita, (iii) the number of ATMs, (iv) the number of credit cards per capita, and (v) the number of debit cards per capita. Lastly, γ_t and ε_{it} represent the time fixed effect and the error term, respectively.¹³

These estimations were based on data from 21 economies. The panel is unbalanced and contains a total of 229 observations. Table 2 reports the main descriptive statistics of the variables used in the panel regressions. The lower level of cash as a percentage of M1 and the greater financial depth in advanced economies are clearly visible.

Table 2
Descriptive statistics of the variables used in panel estimation, 2000–2015

	Cash (% M1)	Cash (% GDP)	Number of ATMs	Number of credit cards per capita	Number of debit cards per capita	Financial depth	GDP per capita (US\$)
Total sample							
No. of observations	229	229	229	229	229	229	229
Mean	28.9	6.4	713.4	1.0	1.1	123.9	28 697
Median	21.8	4.9	484.3	0.7	0.9	117.1	27 770
Standard deviation	19.8	3.8	551.3	1.0	0.8	72.7	20 694
Emerging economies							
No. of observations	123	123	123	123	123	123	123
Mean	38.7	5.8	517.4	0.7	0.9	73.4	13 539
Median	36.9	5.1	332.8	0.6	0.7	71.0	10 243
Standard deviation	18.9	2.7	564.6	0.6	0.7	35.4	12 241
Advanced economies							
No. of observations	106	106	106	106	106	106	106
Mean	17.5	7.2	940.9	1.4	1.3	182.6	46 286
Median	15.5	4.6	1 015.6	1.0	1.1	166.9	42 593
Standard deviation	13.7	4.7	438.5	1.1	0.8	59.7	13 202

Source: Prepared by the authors, on the basis of Bank for International Settlements (BIS), Centre for Latin American Monetary Studies (CEMLA) and World Bank.

Before the estimation results are presented, it is necessary to consider whether the dependent variable (currency in circulation as percentage of M1) has a unit root.¹⁴ Since the panel is unbalanced, the Im, Pesaran and Shin (2003) and Fisher tests are applied, as proposed by Choi (2001).¹⁵ The results of these unit root tests are reported in the tables in annex A1. In particular, column (1) of table A1.1

¹³ To measure the robustness of the estimations, alternatives were considered that included inflation and the monetary policy interest rate as determinants of cash in circulation. The results of these estimates are consistent with those presented in table 3 and can be obtained from the authors by email.

¹⁴ The intuition of the test relates to the extent to which lagging the variable of interest provides information for understanding its dynamics. If the lag is important for understanding the dynamics, the series is said to be mean-reverting and, consequently, stationary. In this case, the null hypothesis that the series has a unit root is rejected. Otherwise, when the lag does not provide information and, consequently, the coefficient that accompanies the lag in the autoregressive process is not different from zero, the series is said to be non-stationary. Consequently, the null hypothesis of a unit root cannot be rejected.

¹⁵ The alternative unit root tests proposed by Levin-Lin-Chu (2002) and Hadri (2000), among others, are only applicable to balanced panels.

shows that the null hypothesis that all panels contain unit roots is rejected at 1% when the average fixed effect per panel (*demean*) and the time trend (*trend*) are included, and it is assumed that the errors are not serially correlated. Column (2) of table A1.1 shows similar results when the assumptions on the inclusion of *demean* and *trend* are maintained, but this time considering the possibility of lags in the order of the autoregressive process in the augmented Dickey-Fuller (ADF) specification of the errors.¹⁶ The estimations shown in table A1.2 of annex A1 report a set of statistics associated with the Fisher-type panel unit root test. The statistics presented differ in terms of the distribution used to calculate the confidence values, while the specifications in columns (1) to (4) differ in terms of the inclusion or otherwise of *demean* and *trend* and whether or not the variable displays drift.^{17 18} The results are consistent in most of the statistics, in the sense that the null hypothesis that all panels have unit roots is rejected at a high level of confidence.

Consequently, the results of the estimation of equation (1) are presented in table 3. Seven different specifications are shown, which differ in terms of the inclusion or otherwise of the time fixed effect, and the inclusion or otherwise of variables that are not statistically significant. The standard errors are clustered by country.

Table 3
Determinants of the demand for currency in circulation as a percentage of M1

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables							
Financial depth (ln)		-0.2620*		-0.3006***	-0.1625*	-0.2966***	-0.1963**
GDP per capita (ln)		-0.1353*		-0.0542	0.1889		
ATMs (ln)			0.0517	0.1446*	0.1348	0.1182**	0.2031*
Credit cards			-0.4011***	-0.3608***	-0.3276***	-0.3839***	-0.2587***
Debit cards			-0.0452	0.0254	0.1956		
year = 2001							-0.0552
year = 2002							-0.0518
year = 2003							-0.0884
year = 2004							-0.1368**
year = 2005							-0.2215***
year = 2006							-0.2174***
year = 2007							-0.2042***
year = 2008							-0.1870***
year = 2009							-0.2205***
year = 2010							-0.2475***
year = 2011							-0.2525***
year = 2012							-0.2419***
year = 2013							-0.2647***
year = 2014							-0.2744***
year = 2015							-0.2904***
R ²	0.959	0.967	0.971	0.974	0.980	0.974	0.978
Adjusted R ²	0.956	0.964	0.969	0.971	0.976	0.972	0.974
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	No	No	No	No	Yes	No	Yes
Standard errors	Country cluster	Country cluster	Country cluster	Country cluster	Country cluster	Country cluster	Country cluster

Source: Prepared by the authors.

Note: *** p<0.01; ** p<0.05; * p<0.1.

¹⁶ The optimal number of lags for each panel is obtained from the Akaike information criterion (AIC).

¹⁷ Maddala and Wu (1999) find that Fisher tests with critical values based on the bootstrap method perform better. Consequently, they are the preferred choice when testing for unit roots in panel estimations.

¹⁸ The presence of drift seems a reasonable assumption, since the variable to be tested (cash in circulation as a percentage of M1) has a non-zero mean.

The results presented in table 3 give rise to the following conclusions:

- *Role of financial depth.* Greater financial depth (measured by bank credit as a percentage of GDP) is associated with smaller demand for cash relative to M1, in a stable and consistent manner across all estimations.
- *Role of per capita income.* The relation between this variable and the demand for cash is negative, but not significant. This partly reflects the dominance of variables that capture the level of financial development more effectively. Also, certain more developed economies have a higher demand for banknotes and coins, either because their currency is used as foreign exchange or because the precautionary demand for cash is relatively higher in these countries.
- *Role of the number of ATMs.* In the estimations made in this study, this variable is always positive, but its statistical significance is not stable. This is reasonable because, although a larger number of ATMs is associated with the possibility of obtaining cash, its effect also depends on geographical factors that determine the distance people have to travel to reach an ATM to withdraw cash. It is also noted that in an initial stage of the expansion of banking services the number of ATMs increases, but in more advanced stages of financial development the number declines.
- *Role of credit cards.* The number of credit cards per capita is negatively associated with the demand for cash. The estimated coefficient is stable and statistically significant at 1% in all specifications.
- *Role of debit cards.* The number of debit cards shows no statistically significant relation with the demand for cash as a percentage of M1. This is partly because debit cards can be considered as either a substitute or a complement for cash as a means of payment. The latter is exemplified when people receive their income electronically, but owing to their payment habits they withdraw a large proportion of their income to make their payments in cash.
- *Role of fixed effects.* Column (1) of table 3 shows that much of the inter-country variation observed in demand for cash as a percentage of M1 is due to idiosyncratic factors that are not captured in the estimation. This can be attributed to both cultural factors and specific policies that affect the demand for cash as a means of payment.¹⁹ There are also many relevant structural variables that cannot be measured over time. This point is discussed further below in the context of cross-sectional estimations.²⁰ Column (7) of table 3 reports the details of the coefficients and the statistical significance of the time fixed effects on the demand for cash as a percentage of M1. The sign and statistical significance of the variables highlighted in columns (1) to (6) of table 3 (financial depth, credit cards and ATMs) are robust to the inclusion of time fixed effects in the estimation. The time fixed effects are negative and particularly significant from 2004 onwards — a period in which the size of the coefficient, and consequently the significance of the unobservable time factor, have been increasing over time.

The exercises included in table 3 show a high degree of model fit (adjusted $R^2 > 0.95$), which is largely explained by the relevance of the idiosyncratic effects of each country. This is an expression of the high degree of heterogeneity existing in the demand for cash across countries, which is also

¹⁹ In Sweden, for example, businesses are not required to receive cash, even though banknotes and coins issued by the central bank are the only legal tender, as in most countries. Some countries also impose restrictions on the use of cash in certain government activities, which can have a significant impact on the demand for cash in these economies.

²⁰ See, for example, the discussion on the effect of payment through cell phones or the Internet and on the role of cash in wage payments and government transfers, in the comments on the cross-sectional estimations below (in subsection 3 of this section III).

observed within both emerging and advanced economies. It is important to note that, in addition to the variables included in the model, the prediction error reflects the relevance of country-specific factors over time.²¹ In other words, the dynamics of the demand for cash in the countries considered reflect other factors in addition to the dynamics of financial depth, the number of credit cards, the number of ATMs and the fixed effect estimated in table 3.

Lastly, an exercise is performed to evaluate what the economic impact would be if all of the countries considered in the estimation reported in table 3 (column 7) had the characteristics of 2014 Sweden, the country with the lowest demand for cash in the sample. The results indicate that, in this hypothetical scenario, currency in circulation as a percentage of M1 would fall from an average of 30% to 23%. One implication of this result is that consumers have a preference for using cash.²² This finding corroborates information obtained from causal inference models used to analyse innovations in means of payment, and from payment-decision models that use information obtained through surveys on the use of different means of payment. Fung, Huynh and Sabetti (2014) show that the use of contactless credit cards and prepaid cards reduces cash use. Moreover, Wakamori and Welte (2017) find that if all commercial outlets had to accept card payments, the use of cash would drop by about 8%. Huynh, Schmidt-Dengler and Stix (2014), using an inventory model, also find that the demand for cash would fall if cards were more widely accepted at points of sale.

2. Cross-sectional estimation

The following section uses data from the World Bank's Global Findex 2014,²³ covering a set of 54 emerging and advanced economies to assess the determinants of the demand for cash as a percentage of M1 in a cross-sectional estimation.²⁴

The control variables used are grouped into three categories:

- (i) Use of and access to electronic means of payment —specifically the percentage of the population over 15 years of age that: (i) has an account in a financial institution; (ii) used a credit card in the past year; and (iii) used a debit card in the past year.
- (ii) Variables that determine how wages and government transfers are received. This includes the percentage of the population over 15 years of age that: (i) receives transfers from the government in cash; and (ii) receive their wage payment in cash.
- (iii) Variables that capture the intensity of the use of technology-based means of payment (cell phones and Internet). This measures the percentage of the population over 15 years of age that: (i) carries out transactions paid through cell phones; and (ii) uses the Internet to pay bills and make purchases.

²¹ Figure A1.1 in annex A1 reports the observed level of cash as a percentage of M1 (right scale), the prediction of the panel estimation in table 3 (column (7)) (right scale) and the prediction error (left scale) for all economies considered in the estimation (column 7).

²² Wakamori and Welte (2017) state that this preference for cash applies mainly to small-value transactions. On the other hand, Huynh, Schmidt-Dengler and Stix (2014) report that precautionary motives or occasional large purchases also boost the demand for cash.

²³ This information is compiled in partnership with Gallup World Poll (GWP). The indicators are based on interviews held with a nationally representative sample of over 150,000 adults in more than 140 economies.

²⁴ The economies considered are: Afghanistan, Algeria, Argentina, Australia, Belize, Brazil, Bulgaria, Canada, Czech Republic, Chile, China, Colombia, Costa Rica, Denmark, the Dominican Republic, Egypt, Guatemala, Honduras, Hong Kong (China), Hungary, India, Indonesia, Iraq, Israel, Japan, Kazakhstan, Kenya, Latvia, Malaysia, Mexico, Morocco, New Zealand, Nicaragua, Nigeria, Norway, Pakistan, Paraguay, Peru, the Plurinational State of Bolivia, Poland, the Republic of Korea, the Republic of Moldova, the Russian Federation, Saudi Arabia, Singapore, South Africa, Sweden, Switzerland, Thailand, Turkey, Ukraine, the United Kingdom, the United States and Uruguay.

Table 4 reports the descriptive statistics of these variables for a maximum of 54 economies for which the analysis described below was performed.

Table 4
Descriptive statistics of the variables used in the cross-sectional estimations

	Number	Average	Standard deviation	Minimum	Maximum
Cash in circulation (<i>% of M1</i>)	54	36	24	4	93
Account in financial institutions (<i>% of the population over 15 years of age</i>)	54	60	29	10	100
Use of credit card in the past year (<i>% of the population over 15 years of age</i>)	52	22	21	0	75
Debit card use in the past year (<i>% of the population over 15 years of age</i>)	52	35	30	1	96
Transactions from cell phones (<i>% of the population over 15 years of age</i>)	49	15	11	0	40
Use of the Internet to pay bills and make purchases (<i>% of the population over 15 years of age</i>)	52	24	25	1	79
Government transfers received in cash (<i>% of the population over 15 years of age</i>)	37	28	26	0	93
Wages received in cash (<i>% of the population over 15 years of age</i>)	51	43	27	3	92

Source: Prepared by the authors.

Tables 5, 6 and 7 report a series of cross-sectional estimations to measure the relationship between the variables considered and the demand for cash as a percentage of M1.

Table 5 presents the analysis of the role of the variables measuring access to and use of electronic means of payment. The results can be summarized as follows:

- Role of access to the financial system: economies in which a higher percentage of the population has access to an account in the financial system have, on average, less demand for cash as a percentage of M1.
- Role of credit and debit cards: economies in which a higher percentage of the population uses these cards have on average less demand for cash as a percentage of M1.
- There is a high degree of collinearity between the variables of use and access to electronic means of payment, which is reflected in the loss of statistical significance when more than one of these variables is considered in the regression.

Table 5
Determinants of demand for cash: role of access to electronic means of payment

Variables	(1)	(2)	(3)	(4)	(5)
Account in financial institutions (<i>logarithms</i>)	-0.5940***			-0.1878	
Credit card used in the past year (<i>logarithms</i>)		-0.2242***		0.1579	0.1422
Debit card used in the past year (<i>logarithms</i>)			-0.3660***	-0.4400*	-0.5205***
No. of observations	52	52	52	52	52
R ²	0.225	0.149	0.258	0.276	0.272
Adjusted R ²	0.21	0.132	0.243	0.231	0.242

Source: Prepared by the authors.

Note: *** p<0.01; ** p<0.05; * p<0.1.

Table 6 analyses the effect of receiving wages and government transfers in cash. Economies in which a larger proportion of the population receive such payments in cash display a higher demand for cash.

Table 6
Determinants of demand for cash: role of the form in which income is received

Variables	(1)	(2)	(3)
Government transfers received in cash (<i>in logarithms</i>)	0.3225***		0.068
Wages received in cash (<i>in logarithms</i>)		0.5259***	0.4447**
No. of observations	37	37	37
R ²	0.284	0.361	0.365
Adjusted R ²	0.263	0.343	0.328

Source: Prepared by the authors.

Note: *** p<0.01, ** p<0.05, * p<0.1.

Lastly, table 7 analyses the role of technological advances in the demand for cash. Countries where a higher percentage of the population makes payments through cell phones or the Internet tend to have a smaller demand for cash. However, in contrast to the previous variables, the collinearity between these variables is less, since they continue to be statistically significant when considered together in the regression. This is explained by the fact that in certain less economically developed economies (for example, those located in Africa), cell phones have become widely used as a means of payment. However, both greater use of cell phones and greater use of the Internet are associated with a lower demand for cash.²⁵

Table 7
Determinants of demand for cash: the role of technological advances

Variables	(1)	(2)	(3)	(4)
Transactions from financial institutions via cell phone (<i>logarithms</i>)	-0.5696***		-0.3516**	-0.3931**
Use of Internet for bill payment and purchases (<i>logarithms</i>)		-0.3855***	-0.2588***	
Account in financial institutions (<i>logarithms</i>)				-0.4523*
No. of observations	49	49	49	49
R ²	0.306	0.328	0.409	0.357
Adjusted R ²	0.291	0.313	0.383	0.329

Source: Prepared by the authors.

Note: *** p<0.01; ** p<0.05; * p<0.1.

3. Analysis of idiosyncratic factors

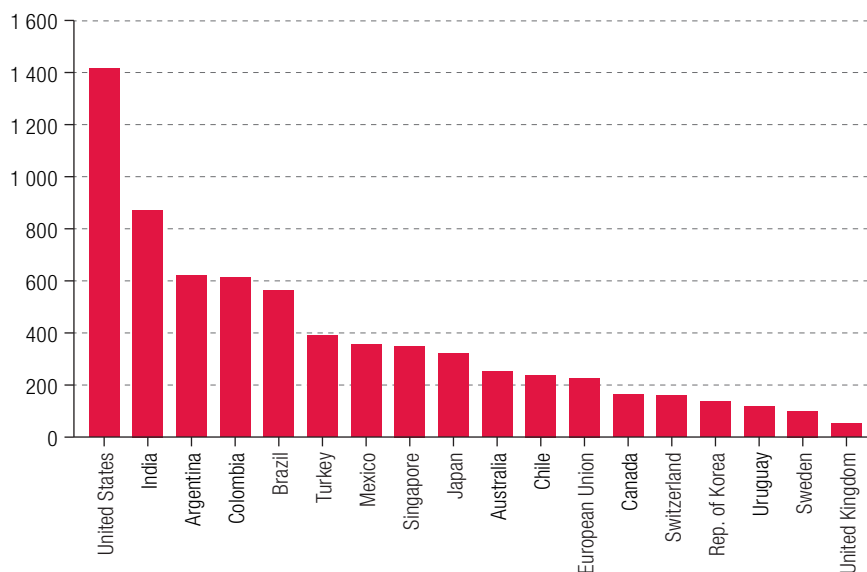
As noted above, the model in equation (1) generates a series of country-level fixed effects, which express an important idiosyncratic component that is not captured by financial depth, ATM availability or credit card ownership (see column (7) of table 3). In fact, the model incorporating only country-level fixed effects generates a goodness-of-fit of 95.9% (see column (1) of table 3), as opposed to time fixed effects, whose marginal contribution to the adjusted R² is less.

An important factor to take into consideration is the high degree of heterogeneity among the idiosyncratic factors of each country. Firstly, this heterogeneity is determined by the variance in the cash-to-GDP ratio discussed above. In this sense, the fixed effect is related directly to the value of this ratio (see figure 12). Secondly, heterogeneity is dominated by factors beyond the “fundamental” variables that were evaluated in the panel data model. Thus, the ranking of countries according to the ratio of each country’s fixed effect to the observed value of cash relative to M1 is completely different from that observed when comparing only the fixed effects of each country. The ratio is much higher in countries that have institutional or cultural components that are very different from those of the average

²⁵ China’s experience with the use of smartphones also shows how alternatives that facilitate money transfer can lead to a reduction in the use of physical money. This phenomenon has been characterized by the massive use of smartphones as a transactions medium, which, combined with applications such as WeChat and Alipay (the equivalents of Whatsapp and Amazon in the Western hemisphere) and QR code (Quick Response) technology enables electronic transfers to be made instantaneously. Survey-based estimates indicate that WeChat and Alipay accounted for about 55% of the value of transactions in 2017 (Korella, 2017).

country, for example, Sweden, Japan or the United States, among others (see figure 13). In view of this, the possibility that the idiosyncratic variables reported by the World Bank survey could explain this heterogeneity was analysed.

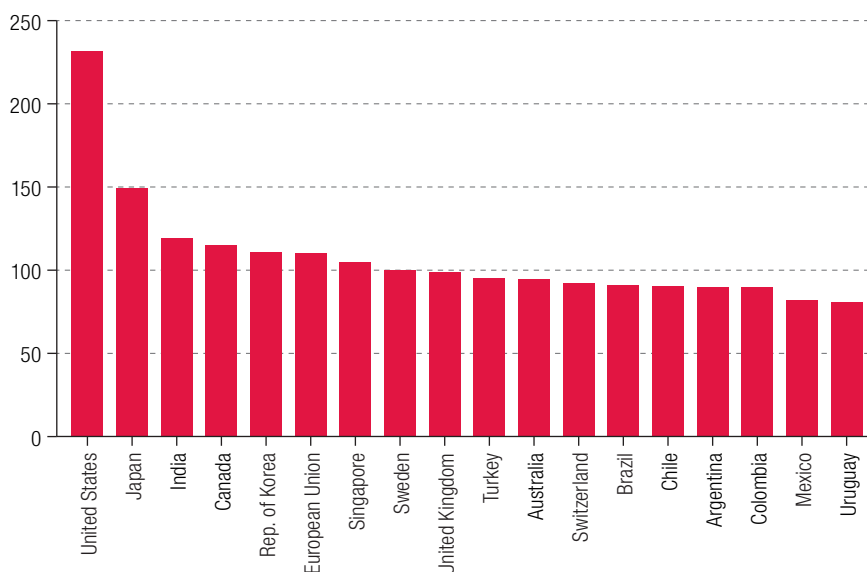
Figure 12
Country fixed effects relative to Sweden, 2000–2015
(Percentages)



Source: Prepared by the authors on the basis of estimates of panel data of banknotes and coins in circulation.

Note: Statistically significant values at the 10% confidence level. The estimates are given as a percentage of the monetary aggregate M1, having as determinants the fixed effect of the country and time, the level of financial depth, the number of ATMs and the number of credit cards per capita.

Figure 13
Fixed effects of each country with respect to its ratio between currency
in circulation and M1, 2000–2015
(Percentages)



Source: Prepared by the authors on the basis of estimates of panel data of banknotes and coins in circulation.

Note: Statistically significant values at the 10% confidence level. The estimates are given as a percentage of the monetary aggregate M1, having as determinants the fixed effect of the country and time, the level of financial depth, the number of ATMs and the number of credit cards per capita.

The previous sections used two models, one with panel data and the other with cross-sectional data. The advantage of the first model is the existence of a time trend in the structural variables that explain the demand for cash as a percentage of M1. The second case, in contrast, draws on a recent survey of payment behaviour in a large number of countries, but without a time span that would enable it to be complemented with the first approach.

The results presented in table 8 are quite striking. They show that each of the variables affects the idiosyncratic component in the same way as observed in the cross-sectional estimates. This can be understood as contributing to the explanatory power of cash as a percentage of M1. Thus, part of this fixed effect can be associated with the use of credit and debit cards, the receipt of wages in cash and the use of the Internet to pay bills, which are the variables of highest statistical significance. This finding poses a major challenge for further progress in understanding trends in cash usage, in which the generation of more precise information on economic agents' payment behaviour will be particularly important.

Table 8
Determinants of the idiosyncratic factor

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Account in financial institutions (<i>in logarithms</i>)	-0.6974						
	(0.4030)						
Credit card used in the past year (<i>percentages of the population over 15 years of age</i>)		-0.5481***					
		(0.1783)					
Debit card used in the past year (<i>% of the population over 15 years of age</i>)			-0.5968**				
			(0.2115)				
Transactions from cell phones (<i>% of the population over 15 years of age</i>)				0.1104			
				(0.1376)			
Use of the Internet to pay bills and make purchases (<i>% of the population over 15 years of age</i>)					0.3972**		
					(0.1350)		
Government transfers received in cash (<i>% of the population over 15 years of age</i>)						-0.5657**	
						(0.2171)	
Wages received in cash (<i>% of the population over 15 years of age</i>)							-0.4220***
							(0.1064)
No. of observations	14	14	14	11	14	14	14
R ²	0.200	0.441	0.399	0.067	0.419	0.361	0.567
Adjusted R ²	0.133	0.394	0.349	-0.0369	0.371	0.308	0.531

Source: Prepared by the authors.

Note: *** p<0.01; ** p<0.05; * p<0.1.

IV. Conclusions

During the last decade, the demand for cash has decreased considerably as a percentage of M1, while increasing relative to GDP. This article analyses factors that could explain the behaviour of currency in circulation as a percentage of M1. The results show that the growing use of electronic means of payment reduces the demand for cash. Nonetheless, there are hard-to-measure idiosyncratic factors, aside from the observable variables, which explain the differences across economies. One implication of the estimations is that the demand for cash is very far from approaching zero, largely because there are consumer preference factors that prevent it from doing so in the medium term.

In the case of the emerging economies, it is possible to identify several disparities in the use of electronic means of payment, and reducing them will contribute to a further decline in the demand for cash as a percentage of M1. In practice, there are several factors that could hasten this transition, such

as the increasing use of banking services that has occurred in some of these countries, as well as the increased use of smartphones to make payments. All of these factors could contribute to greater use of electronic means of payment in emerging economies and, consequently, to less use of cash. However, there are idiosyncratic and cultural factors that condition consumers' preferences for cash; and these are also present in more advanced economies. This is consistent with the fact that the use of banknotes and coins as a means of payment persists in advanced economies and is likely to continue to do so.

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Anexo A1

Table A1.1

Im, Pesaran and Shin unit root test on currency in circulation as a percentage of M1
(Logarithms)

	(1)		(2)	
	Statistic	p-value	Statistic	p-value
t-bar	-2.6721			
t-tilde-bar	-2.0093			
Z-t-tilde-bar	-4.0539	0.0000		
W-t-bar			-2.4685	0.0068
Panel average	Yes		Yes	
Time trend	Yes		Yes	
Lagged regressions in augmented Dickey-Fuller specification	No		Average 0.62 according to the Akaike Information Criterion (AIC)	

Source: Prepared by the authors, on the basis of figures obtained from the Bank for International Settlements (BIS), the Center for Latin American Monetary Studies (CEMLA) and the World Bank.

Note: The null hypothesis is that all panels contain unit roots, while the alternative hypothesis is that some panels are stationary. The total number of panels is 21, while the average number of periods is 15.19. In the Im, Pesaran and Shin test it is assumed that the autoregressive coefficient parameter is specific to each panel.

Table A1.2

Fisher's unit root test on currency in circulation as a percentage of M1
(Logarithms)

		(1)		(2)		(3)		(4)	
		Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Inverse Chi-Squared (42)	P	83.1011	0.0002	70.5694	0.0038	93.1937	0.0000	127.7282	0.0000
Inverse normal	Z	-1.2141	0.1124	-1.7425	0.0407	-2.8197	0.0024	-6.444	0.0000
Inverse logit t(104)	L*	-2.7154	0.0039	-2.4814	0.0073	-3.7323	0.0002	-6.6919	0.0000
Modified inverse Chi-squared	Pm	4.4845	0.0000	3.1172	0.0009	5.5857	0.0000	9.3537	0.0000
Panel mean		No		Yes		Yes		Yes	
Time trend		No		No		Yes		No	
Drift		No		No		No		Yes	
Lagged regressions in the augmented Dickey-Fuller specification		No		No		No		No	

Source: Prepared by the authors, on the basis of figures obtained from the Bank for International Settlements (BIS), the Center for Latin American Monetary Studies (CEMLA) and the World Bank.

Note: Estimates based on the augmented Dickey-Fuller test. The null hypothesis is that all panels contain unit roots, while the alternative hypothesis is that at least one panel is stationary. The total number of panels is 21, while the average number of periods is 15.19.

Figure A1.1
 Estimated and observed currency in circulation as a proportion of M1, 2000–2015
 (Percentages)

A. Advanced economies

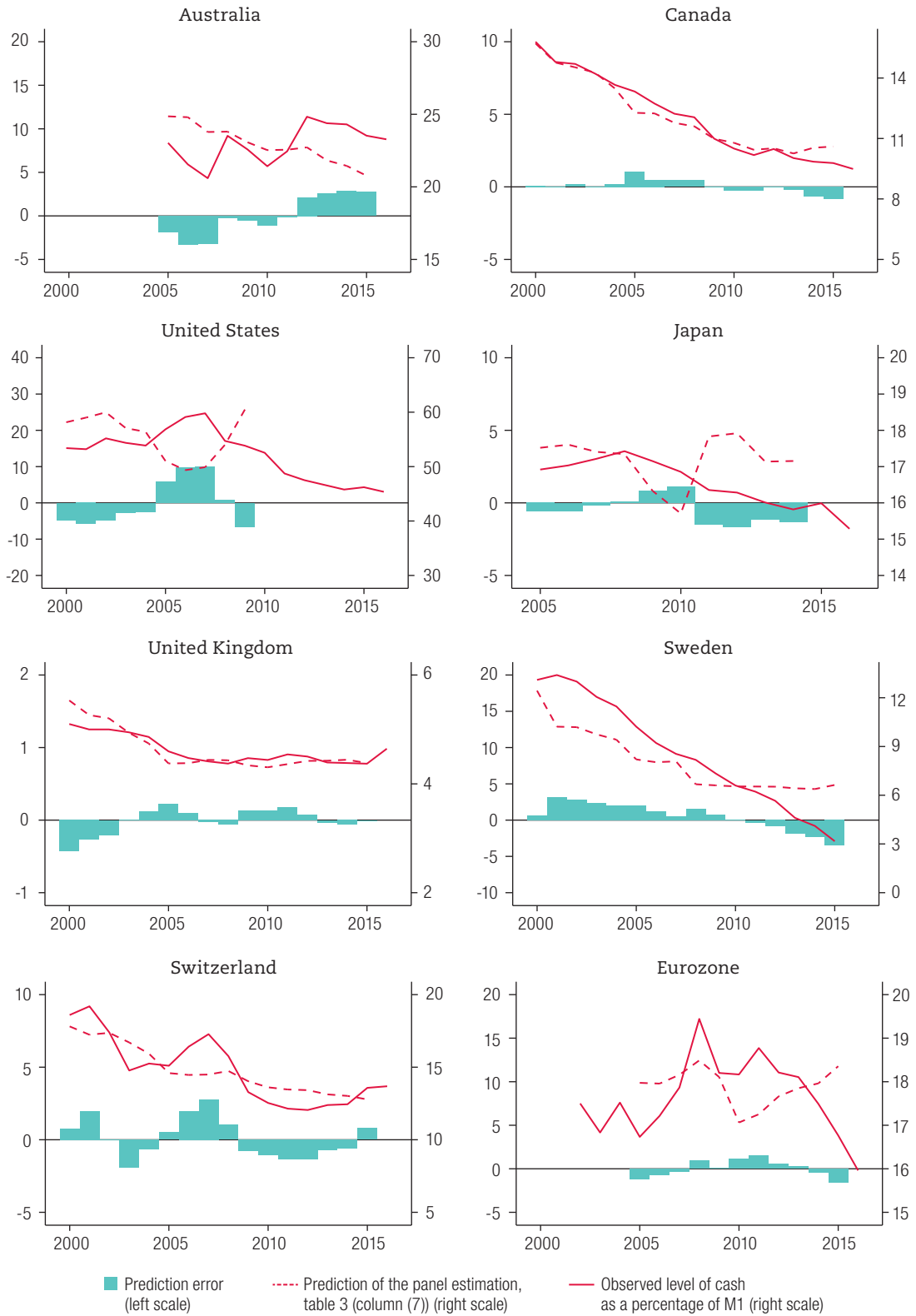
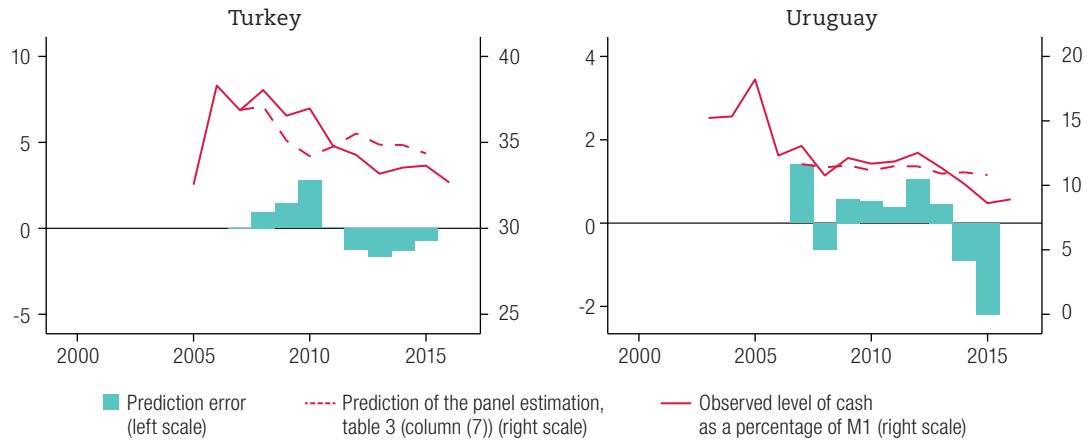


Figure A1.1 (continued)

B. Emerging economies



Figure A1.1 (concluded)



Source: Prepared by the authors, on the basis of figures obtained from the Bank for International Settlements (BIS), the Center for Latin American Monetary Studies (CEMLA) and the World Bank.