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Research Report

Foreign demand for euro banknotes

ECB Occasional Paper, No. 253

Provided in Cooperation with:

European Central Bank (ECB)

Suggested Citation: Lalouette, Laure et al. (2021) : Foreign demand for euro banknotes, ECB Occasional Paper, No. 253, ISBN 978-92-899-4510-3, European Central Bank (ECB), Frankfurt a. M., <https://doi.org/10.2866/965881>

This Version is available at:

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EUROPEAN CENTRAL BANK
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Occasional Paper Series

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No 253 / January 2021



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Abstract

In order to understand why there is a continuous increase in euro banknote circulation even though the use of cash for transactions is decreasing in the euro area – a phenomenon known as the paradox of banknotes – the members of the Overseas workstream of the Eurosystem Research Network on Cash (EURECA)¹ have conducted a study on the foreign demand for euro banknotes. The results of this study are based on desk research using data collected in the Eurosystem and from other organisations, and using both proven and innovative techniques.

The objectives of this study are to identify the drivers of foreign demand and to estimate the share of euro banknotes circulating outside the euro area. The results provide an insight into the reasons for the increase in banknote circulation. They also show how significant the international demand for euro banknotes is, providing us with a clue to understanding the paradox of banknotes.

The study shows that there are a multitude of factors behind the demand for euro banknotes, for both store-of-value and transaction purposes. In particular, euro cash flows are mainly driven by local-specific determinants, i.e. factors affecting a country's demand for euro (local inflation, economic activity and foreign tourism) rather than external factors (global uncertainty or short-term interest rates in the euro area). On the back of this research, the share of euro banknotes in circulation estimated to be outside the euro area is between 30% and 50% of the total value of euro banknote circulation.

Keywords: euro, banknotes, foreign demand for money, euroisation, currency substitution, hoarding, remittances

JEL classification: E41, E47, E49, E59, F24

¹ [Eurosystem Research Network on Cash \(EURECA\)](#).

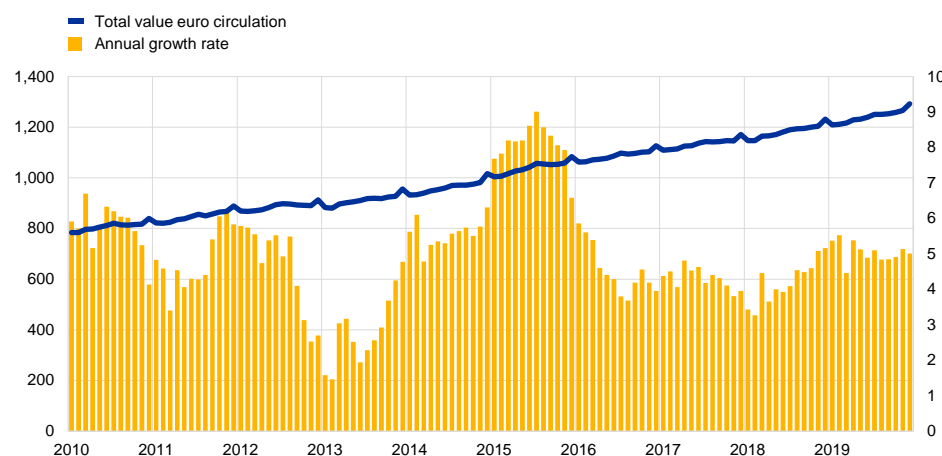
1 Research question and objectives

Prepared by Laure Lalouette, ECB

A currency's international role may, to a certain extent, explain the trends seen in the total value of its circulation. At the end of December 2019, the total value of euro banknotes in circulation was €1,292.7 billion, with an annual growth of 5.0% – the average rate over the past ten years (see Chart 1). Euro banknote circulation is growing continuously, even though it is claimed that cash usage is declining: this phenomenon has been referred to as the “paradox of banknotes” (Bailey, 2009) or the “cash paradox” (Williams, 2012; Jiang and Shao, 2020). However, the euro is not only used for transaction purposes, although other factors underpinning demand have, until now, been insufficiently investigated.

Chart 1
Euro banknotes in circulation

(left-hand scale: EUR billions; right-hand scale: percentages)



Source: ECB Currency Information System (CIS2) data.
Note: Last observation December 2019.

The steady upward trend for euro banknotes in circulation is not the homogeneous stylised pattern seen for other European currencies. As Chart 2 shows, the value of banknotes in circulation in developed countries may increase, remain stable or decline. Various factors may explain these trends, e.g. the international role of a currency. The Swedish krona, which is mainly used for domestic transaction purposes, shows circulation growth declining over time (Engert et al., 2019). The Danish krone, which is mainly used for domestic transactions and as a domestic store of value, shows stable growth. The euro, which is used for domestic and foreign² transactions and for domestic and foreign³ store-of-value purposes, shows strong circulation growth. There may be evidence that foreign demand for euro banknotes, both for transaction and for store-of-value purposes, is supporting its circulation growth. The

² E.g. euroisation, cross-border shopping, travel for leisure or for business.

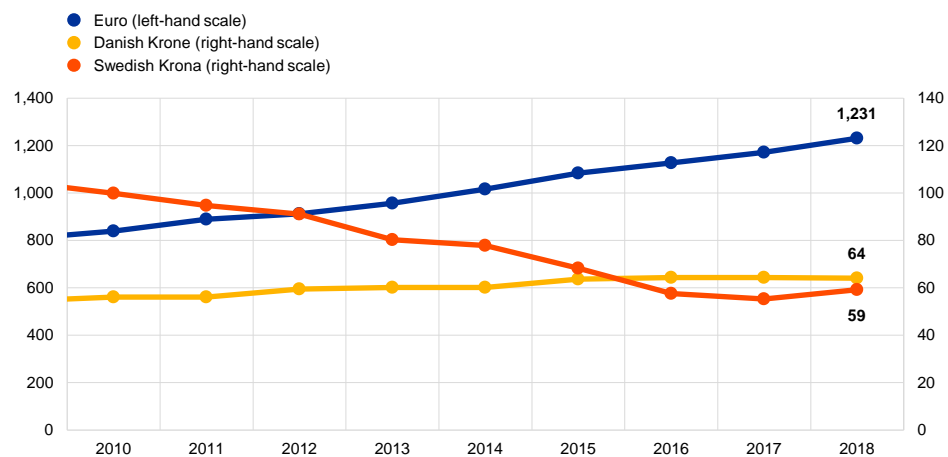
³ E.g. savings, currency reserves and asset portfolio management.

next step is to establish what factors trigger international demand (see Section 2) and in what proportion (see Section 3).

Chart 2

Banknotes in circulation

(left-hand scale: value, EUR billions, annual end-year figures; right-hand scale: SEK and DKK billions, annual end-year figures)



Source: Central banks' websites.
Note: Latest observation year 2018.

2 The drivers of foreign demand

There are a multitude of drivers of demand for euro banknotes. Various sources are interrogated in this section in order to establish the drivers of foreign demand. Section 2.1 reviews the research literature dealing directly or indirectly with foreign demand. Section 2.2 estimates a currency demand function analysing the long and short-run effects of foreign demand on demand for euro banknote denominations. Section 2.3 provides an initial analysis of wholesale data and the factors explaining shipments of euro banknotes. Finally, Section 2.4 introduces the latest results of the OeNB Euro Survey, shedding light on the influence of the euro in neighbouring European countries.

2.1 Literature review of the drivers of demand for cash abroad

Prepared by Alejandro Zamora-Pérez, ECB

Several strands of the economic literature have followed different approaches to addressing the issue of why people hold and use domestic and foreign currencies outside developed countries. This section reviews the literature.

2.1.1 Reasons for the use of domestic cash outside developed economies

In order to explain the demand for euro cash abroad it is first necessary to understand what determines the use of domestic currencies in developing and transition economies. The consensus view in the development economics literature is that the high demand for cash in developing countries is due to a lack of credible saving and payment alternatives, as well as deeply entrenched habits. Efforts should be made to achieve widespread access to formal intermediaries, adequate saving options and digital forms of payments. This would gradually reduce transactional and store-of-value demand for cash in favour of other saving alternatives and cashless methods of payment. Evidence-based policy recommendations seek to increase digital financial inclusion in developing countries (Klapper and Singer, 2014) in order to improve supply-side deficiencies (such as poor physical infrastructure for digital payments, i.e. scarce cash-out points, an absence of safe electronic payment systems, a lack of digital ecosystems offering store-of-value and bill payment functionalities, etc.)⁴. They also tackle demand-side challenges (such as user

⁴ The fact that cash is by far the most reliable payment and store-of-value option in most developing countries is supported by rich and growing evidence. Some of the specific topics addressed by the literature are the conditions explaining the use of cash for domestic remittances, wages, and government payments (CGAP, 2012; Demircuc-Kunt et al., 2018; Alhassan et al., 2019), access to basic accounts (Dupas et al., 2018), access to mobile payments and related cash-in/cash-out services (Jack and Suri, 2014; Evans and Pirchio, 2015); the development of digital government transfer schemes (Zimmerman et al., 2014), adequate regulatory frameworks (Classens and Rojas-Suárez, 2016), and the persistent effects of former legal and institutional systems (Beck et al. 2003; Grosjean 2011).

education and trust in electronic payments, as well as the need for consumers to perceive that digital products are (at least) as attractive and accessible as cash)⁵.

The absence of safe and return-yielding savings channels leads the poorer members of society to save predominantly in cash. Only a relatively small proportion of these people manage to develop informal and semiformal strategies for saving (Banerjee and Duflo, 2007; Dupas and Robinson, 2013; Newman et al., 2014). In this regard, factors such as belonging to a social network and social learning also play an important role in households' decisions to save in cash (Newman et al. 2014).

As countries develop and solve some of the main problems of financial inclusion, the emphasis placed on explanations for the store-of-value use of cash seems to shift from supply restrictions to institutional and demand-driven considerations. The evidence from transition economies suggests that a high preference for cash cannot be fully explained by low access to bank products. Instead, other factors dominate, such as a lack of trust in the banking system, memories of past crises, weak institutions (e.g. tax enforcement), and memories of restricted access to deposits, as well as demographic aspects such as financial literacy, education and income (Knell and Stix, 2009; Coupé, 2011; Preat and Stix, 2011; Stix, 2013⁶; Beckman et al., 2013; Beckman, 2013).

2.1.2 Determinants of the use of the US dollar as a foreign currency

The wide-ranging problems relating to the supply of/demand for alternative payments, as well as access to saving mechanisms in developing and transition economies, partly explain why strong currencies like the US dollar and the euro are used abroad. Indeed, the absence of reliable saving and payment alternatives from formal intermediaries may well induce people to use foreign cash options if domestic money serves that purpose poorly. However, none of the obstacles covered above are, usually, the main determinants discussed in the literature on the use of strong foreign cash. Porter and Judson (1996) explain how US dollar banknotes provide similar monetary services to those that were offered by gold and silver coins in the past, which circulated outside the countries in which they were minted. These services have been used not only by countries to guarantee monetary and financial stability, but also by individuals (e.g. paying wages of foreign workers, using US dollars when travelling to optimise exchange costs, or insuring against current or future political or economic turmoil).

The wider literature on dollarisation and currency substitution identifies high inflation exhibited by a domestic currency as the main catalyst of the use of foreign currencies. Calvo and Vegh (1992) describe the process of currency and asset substitution. In high-inflation environments, a foreign currency might be used first as a store of value

⁵ On the impact of demographic characteristics (e.g. education, income, gender and financial literacy) on financial inclusion see Zinsa and Weill (2016) and Grohmann et al. (2018).

⁶ Stix (2013) presents a more detailed account of the causes of cash saving in transition economies, which is partially corroborated by Beckman et al. (2013) and Beckman (2013). It is worth noting that, among the factors studied, the level of social capital does not significantly influence the decision to save in cash in economies in transition, contrary to what was observed in a euro area country (Italy) in Guiso et al. (2014).

(dollarisation) and only at later stages of the process as a means of exchange (currency substitution). This shows that the store-of-value function is probably the most vulnerable of all the functions of domestic currency. The later process of currency substitution starts with large-ticket items being quoted in foreign currency (e.g. real estate or cars) – only afterwards are large transfers of funds performed in foreign currency. Non-durables, however, are normally exchanged in the domestic currency.

The empirical findings of the currency substitution literature do not provide a detailed understanding of the determinants of foreign cash usage, as they deal mostly with asset substitution rather than currency substitution in the strictest sense. This is because the use of cash abroad has been viewed as unobservable (Calvo and Vegh, 1992). For the US dollar, this observability problem has only been solved by using cross-border currency flow data from US Customs and confidential Federal Reserve System data. In a first attempt to systematically investigate the determinants of the foreign demand for dollar cash, Hellerstein and Ryan (2011) find that a high level of historical, rather than current, inflation (i.e. the inflation rate recorded over the last 30 years) increases the probability of using the US dollar as a secondary currency. Moreover, transaction costs and the size of the domestic market also affect the use of dollars. Interestingly, the authors found that large national informal economies do not lead, in themselves, to the adoption of the US dollar as a secondary currency. On condition that the dollar is already widely used, a 1% higher level of informal activity is associated with a 1% higher level of banknote flow. This finding seems to be in line with the above discussion of the research on financial inclusion: a lack of reliable alternatives and institutional deficiencies ensure the economy does not become more formal and this, in turn, drives the demand for cash. It is reasonable to infer that if domestic cash is no longer a reliable alternative, foreign currencies could serve this function if they are already widely adopted.

Judson (2012, 2017) notes that when a country starts using US dollars, subsequent crises bring about additional inflows, which are only reversed following economic stabilisation and modernisation. In a more recent study, Banegas et al. (2015) assessed the global and local factors determining the net shipments of US dollars. Measures of global financial and economic uncertainty have had a considerable impact on net shipments (especially since 2008), although demand seems to be more sensitive to economic uncertainty than to financial stress. Also, using several country groupings, the results provide evidence that foreign currency is used as a safe haven in emerging markets. Country-specific factors (e.g. domestic inflation, past dollar use, local economic uncertainty and local economic conditions) also play a role in explaining currency flows.

2.1.3 Determinants of the use of euro cash abroad

As explained in Section 3.1, data for euro cash net shipments have been used to estimate the share of cash abroad (ECB, 2017), although rather less to explore the

reasons for euro banknote demand⁷. However, recent research on euroisation provides valuable findings with regard to some of the determinants surrounding the use of euro cash in foreign countries, although the literature is mainly limited to central, eastern and south-eastern European countries⁸. Since 2002, it has been observed that the euro quickly replaced the function of the dollar in these countries (Hellerstein and Ryan, 2011; Stix, 2011; Judson, 2017)⁹.

Stix (2011) used survey data to analyse the choice between foreign currency cash and foreign currency deposits. He concludes that both trust in the banking system and access to banking services influence individuals' choice between euro deposits and euro cash. Stix (2013) demonstrates that larger foreign euro cash holdings are associated with a stronger preference for cash, an effect which is higher in countries in which there is a high level of savings deposits denominated in foreign currency (especially in south-eastern European countries). Also, he finds that foreign currency is used as a safe asset, as well as the presence of stronger network effects in these countries. Additionally, Ritzberger-Günwald and Scheiber (2012) show that, in addition to its store-of-value function, euro cash is also used partly as a medium of exchange in south-eastern European countries. In this regard, Scheiber and Stern (2016) note that in the Czech Republic, Hungary and Poland residents use euro cash for foreign and domestic transactions. Brown and Stix (2015) find that the euroisation of bank deposits is mainly driven by demand. They also find that households with and without euro-denominated deposits have similar preferences with regard to foreign currency. These two findings suggest that policies aimed at the de-euroisation of bank deposits may, instead, unintentionally encourage a greater use of euro cash. Scheiber (2019) shows that expectations in respect of euro adoption also have a positive influence on the likelihood of euro banknotes being held, although not on the actual amount of euro cash held. Other factors found to increase the likelihood of an individual holding euro cash are high income, income in euro, high wealth or the receipt of remittances.

2.2 Evidence from banknote demand functions

Prepared by António Rua, Banco de Portugal

A macro-econometric model of the demand for euro banknotes has recently been developed (see Rua (2020)). The model, known as D€notes (demand for euro notes), corresponds to a system of seven equations, with one equation per banknote denomination¹⁰.

⁷ The ECB (2018) has conjectured that some of the factors influencing foreign demand for euro banknotes include financial innovation, geopolitical uncertainty, and tax and financial crime. However, no empirical work contradicting this hypothesis has yet been published.

⁸ The research cited comes mainly from data from the euro survey conducted by the OeNB (see Section 2.4).

⁹ As one would expect, the euro substituted euro legacy currencies (especially the Deutsche Mark) even more quickly in these countries (see Fischer et al. (2004)).

¹⁰ The estimation of a banknote demand function is described, for example, in Assenmacher et al. (2019), Bartzsch et al. (2011) and Judson (2017). The D€notes model has already been used in the context of the ABCD-2 work on forecasting euro banknote demand (see Bartzsch et al. (2019)).

The underlying idea of the approach is that the specific drivers of each euro banknote denomination should be taken into account, as the forces which influence demand may differ across denominations. At the same time, one should also consider the interconnections that exist between the demand for different denominations and, therefore, produce an estimation of the system. Furthermore, in line with the literature on the estimation of money demand functions, one should distinguish between the long-run relationship and short-run dynamics¹¹.

Thus, the estimation of the D€notes model entails two steps. The first step estimates a system of long-run relationships¹². Table A presents the variables by entering the long-run relationship for each euro banknote denomination, along with the sign for the estimated coefficients¹³.

Table 1
Long-run relationships

	€500	€200	€100	€50	€20	€10	€5
Short-term interest rate	-	-	-	-	-	-	-
Real GDP	+		+	+	+	+	+
Foreign demand		+	+				
Real effective exchange rate	+	+	+				
ATM				+	+		

As expected, the transactions motive, captured by euro area real GDP, has a positive effect on demand for all denominations, with the exception of the €200 banknote. This is because demand for €200 banknotes has essentially been from abroad (at least until the end of 2017 when the analysis was conducted¹⁴). The opportunity cost, as measured by the short-term interest rate, negatively affects demand for all denominations. With regard to financial technological developments, the number of ATMs has a positive impact on the long-run net issuance of €50 and €20 banknotes, as these denominations correspond to the majority of the euro banknotes loaded into ATMs in the euro area.¹⁵

A novel indicator is used to capture demand from outside the euro area. In the spirit of the foreign demand indicator used to model exports of goods and services¹⁶, this indicator is constructed as a weighted average of the real GDP of the main destination countries for euro banknotes, where the weights are the relative importance of each country in terms of shipments. It has been found that this variable is relevant for the long-run demand of €200 and €100 banknotes. In addition, the real effective exchange rate is also considered, as the relative strength of the currency affects its

¹¹ Such a framework was initially applied to model the demand for euro banknotes issued in Portugal (see Rua (2018)).

¹² See Mark et al. (2005).

¹³ The full estimation results can be found in Rua (2020).

¹⁴ In the case of the €200 banknote, cumulated net shipments accounted for 85% of net issuance at the end of 2017.

¹⁵ It should be noted that, in theory, although the availability of ATMs eases access to cash it also enhances the efficiency of cash holdings, which could lead to a decrease in cash balances.

¹⁶ See, for example, Hubrich and Karlsson (2010) in the context of the Eurosystem projection exercises.

attractiveness and may influence demand from abroad.¹⁷ In particular, it has been found that an appreciation of the euro leads to an increase in demand for the highest banknote denominations, i.e. the €500, €200 and €100 denominations (see Table A).

Once the system of long-run relationships has been estimated, the short-run dynamics are estimated as a second step. The results are summarised in Table B, which reports the variables by entering each equation, along with the sign of the estimated impact.

Table 2
Short-run dynamics

	€500	€200	€100	€50	€20	€10	€5
Auto regressive term	+	+	+	+	-	-	-
Short-term interest rate		-			-	-	
Real GDP		+	+			+	
Real effective exchange rate		+	+	+			
Foreign demand	+						
Unemployment rate				-	-	-	
Economic policy uncertainty				-			
VSTOXX				+			
Error correction term	-	-	-	-	-	-	-
Dummy Q4 2008	+	+	+	+	+		
Dummy Q2 2016	-	+	+				
Step dummy Q3 2016	-	+					

In addition to the variables already discussed, short-run dynamics are also driven by the unemployment rate and uncertainty. In particular, a deterioration of the labour market will have a negative impact on the demand for banknotes. Regarding uncertainty measures, economic policy uncertainty for the euro area presents a negative sign, reflecting the postponement of spending decisions, whereas financial volatility (measured by VSTOXX) positively affects demand for banknotes due to, for example, the role of cash as a safe haven asset (see Table B). Finally, two particular events have proven to be particularly important when modelling cash demand. In the first case a dummy variable was included for the fourth quarter of 2008 due to the collapse of Lehman Brothers in September 2008, which resulted in an abnormal increase in demand for cash. The second episode relates to the ECB's announcement in May 2016 that the €500 banknote would no longer be issued. This announcement had an immediate impact, with the partial replacement of €500 banknotes by €200 and €100 banknotes, which was captured by the dummy for the second quarter of 2016. However, as this substitution continued in subsequent quarters, albeit less strongly, a step dummy was also included in the model, starting from the third quarter of 2016.

Outcome. There is evidence that variables related to demand from abroad influence demand for euro banknotes, especially for the highest denominations.

¹⁷ As in Rua (2020), this analysis considers the real effective exchange rate of the euro against a group of nineteen trading partners based on GDP deflators, where an increase in the index corresponds to an appreciation of the euro.

Limitations. The analysis seeks to capture how fluctuations in economic activity in countries receiving euro banknote flows affect demand for the different denominations. However, it does not include other possible aspects of foreign demand and should be supplemented with the findings of the sections which follow. Furthermore, the construction of the indicator relies on ECB net shipments data which only include foreign demand for banknotes via registered channels. The estimated model is a better fit for greater-value denominations than for lower-value denominations, as the latter present dynamics that are more difficult to model. However, since lower-value denominations are likely to account (in value terms) for a relatively low share of banknotes in circulation, the model reasonably captures total demand for banknotes.

2.3 Analysis of the determinants of euro banknote net shipments

Prepared by Emmanuelle Politronacci, Banque de France, Martial Delmas, Banque de France and Alejandro Zamora-Pérez, ECB

This section analyses the determinants of euro banknote net shipments, using ECB data for net shipments and based on the activities of wholesalers trading euro abroad¹⁸. Wholesalers are responsible for most of the transactions included in the monthly net shipment statistics. Information on their activities, including the destination of euro shipments and reports on international banknote flows, is collected by means of questionnaires and interviews.

2.3.1 Analysis of aggregate net shipments

ECB monthly data on euro banknote net shipments are used to analyse the determinants of euro cash flows abroad. Following Banegas et al. (2015), determinants can be categorised into local factors (shocks affecting countries receiving/sending shipments) and external factors (global or euro area shocks potentially affecting euro cash demand abroad).

In line with the literature review in Section 2.1, local factors include, notably, shocks to the local currency (local inflation and the nominal exchange rate) as well as economic activity (GDP and unemployment) in the main regions receiving inflows of euro cash. In the absence of detailed country data for the final destination of the euro shipments, wholesalers' regional data are used to develop monthly time series indicators of factors such as local inflation, local nominal exchange rate (i.e. local currency unit

¹⁸ See Annex 1, "Methodological notes on the data".

(LCU) to euro) and local unemployment¹⁹. It has only been possible to use wholesaler data to create indicators since 2010, when more disaggregated data on the destination of net shipments became available. The analysis below is therefore restricted to a sample running from January 2010 to December 2019.

External factors potentially affecting cash flows include global and euro area economic uncertainty and volatility, the short-term interest rate as a measure of the opportunity cost of holding euro cash, and tourism in the euro area. Moreover, the USD/EUR exchange rate may be an important factor in capturing the relative attractiveness of euro cash versus the US dollar. In order to account for global uncertainty, the monthly Global Economic Policy Index (Davis, 2016) is used. The euro area short-term interest rate is retrieved from the ECB Statistical Data Warehouse, and Eurostat data on tourist arrivals in most euro countries²⁰ are used to proxy euro area tourism. All of these variables are at a monthly frequency. Finally, the monthly USD/EUR nominal exchange rate is also used.

A vector autoregressive (VAR) model is used to analyse the effects of the above variables on net shipments. In particular, the VAR system consists of eight variables at a monthly frequency from 2010 to 2019²¹: net shipments, three local variables (inflation, the LCU/EUR exchange rate, and unemployment indicators) and four external variables (the USD/EUR exchange rate, the euro area short-term interest rate, euro area tourist arrivals and the Global Economic Policy Uncertainty Index). All of the variables apart from the uncertainty index are non-stationary (integrated of order one) according to the relevant tests and thus the first differences of the levels are included in the system. The VAR has two lags based on various information criteria and autocorrelation diagnostics of residuals, and is deemed to be stable (all inverse roots of the characteristic AR polynomial lie within the unit circle with a modulus of less than one).

Institutional knowledge of the activities of Eurosystem national central banks (NCBs) with regard to cash (and specifically euro net shipments) is applied to define a recursive identification strategy (Cholesky decomposition) used to conduct an impulse response analysis. It is known that when regions with a regular demand for euro cash are affected by local shocks, Eurosystem central banks are able to supply this cash in a responsive manner, i.e. in the same month the shock occurs. Consequently, the impulse response analysis is based on a recursive identification procedure allowing for the contemporaneous effects of all the analysed variables on cash net shipments, although not always vice versa (it is unlikely that net shipments have a

¹⁹ These indicators were constructed by means of a geometric weighted average of country variables (inflation, nominal exchange rate and unemployment) using, as weights, gross shipments to the main geographical regions (confidential wholesaler data). Data were available for the following regions: Africa, the Middle East, Central and South America, North America, EU eastern European countries, non-EU eastern European countries, non-EU western European countries, EU western European countries; information for individual countries was also available for Turkey, Russia and Switzerland, given their relative importance. The monthly series for CPI, the nominal exchange rate and unemployment were retrieved from the World Bank database. GDP or retail sales volume indexes are better proxies for local economic activity, but either they were not available on a monthly basis or data for the relevant countries were missing. Similarly, monthly variables for shocks to local banking systems were unavailable for the relevant countries.

²⁰ Changing composition and excluding France and Ireland due to data unavailability.

²¹ It was not possible to use a longer sample dating back to the first issuance of the euro as disaggregated wholesaler data on the destination of shipments were not available.

contemporaneous effect on these variables). Similar results are obtained once the VAR system has been restricted so that local variables do not affect external euro area variables and vice versa, and so that the former do not affect global uncertainty, pointing to the robustness of the reported results.

Chart 3 below shows the impulse responses for 24 months after the various shocks. Only the responses of net shipments to the set of other variables are reported, given the objectives of this section.

The signs of the effect on the local variables are largely as expected and in line with the literature reviewed in Section 2.1. A one-standard deviation shock to local inflation (as measured by the inflation indicator) has a positive and significant effect in the first month and a (barely) significant effect in the third month after the shock. This results in a significant accumulated effect of around €600 million over the five months after the shock (representing around 19% of the five-month average of euro net shipments for the selected sample). This finding confirms that euro cash is indeed used abroad as a store of value. An equivalent local unemployment shock has a negative and statistically significant impact in the second, fourth and sixth months after the shock, which produces an accumulated significant effect of around -€2,000 million lasting 18 months (around -20% of the eighteen-month net shipments average). If one considers that the monthly unemployment rate is a good proxy for economic activity, these findings indicate that shocks to economic activity (lower unemployment) stimulate demand for euro banknotes abroad²². However, contrary to expectations, a local exchange rate shock does not have a significant effect on net shipments. A similar result was also found by Hellerstein and Ryan (2011) when using a different methodology for investigating the determinants of US dollar flows. They argue that the effects of the exchange rate might have already been captured by the consumer price index.

In general, variables which are external to regions abroad where there is demand for euro banknotes do not have any significant effect on net shipments, which might indicate that euro banknote flows have mainly local determinants. The non-significance of euro area short-term interest rates could imply that euro-denominated short-term assets are not a close substitute for euro cash. Relatedly, the USD/EUR nominal exchange rate has a significant and negative impact on net shipments, i.e. an appreciation of the euro leads to a notable but short-term increase in net shipments to the main regions receiving euro cash, and vice versa. Both the lack of effect of the interest rate and the impact of the USD/EUR exchange rate may confirm that cash abroad serves unique functions which cannot be entirely replaced by foreign currency-denominated short-term assets. It also points to a certain degree of competition between the US dollar and the euro to fulfil these functions in regions where euro cash is in demand, in spite of network effects.

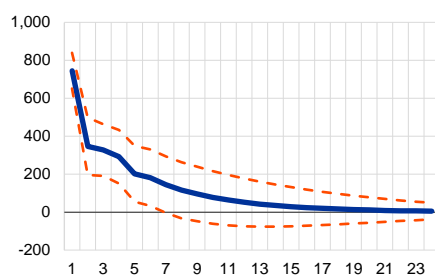
²² These results should be supplemented by those of the previous section, for which an indicator using the GDP of the main destination countries was used to determine the effect of foreign demand on total euro banknote issuance. In this section we observe a coherent impact on euro banknote net shipments by using an unemployment indicator. As will be shown, mainly medium and high denominations seem to be behind this effect.

Chart 3

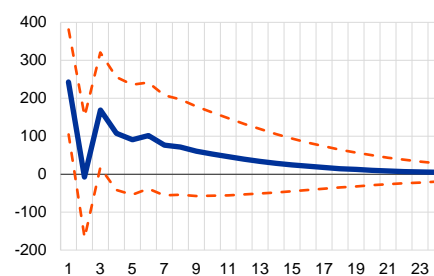
Responses of euro net shipments to one-standard deviation foreign region-specific and external shocks (95% confidence intervals)

(y-axis: value, EUR millions; x-axis: months from shock)

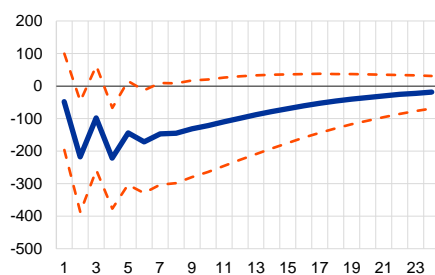
Response to euro net shipments shock



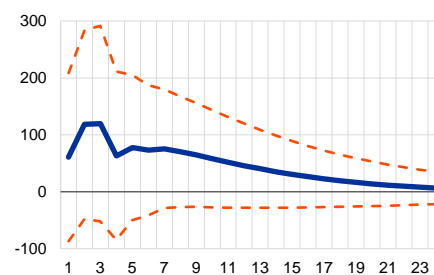
Response to local inflation shock



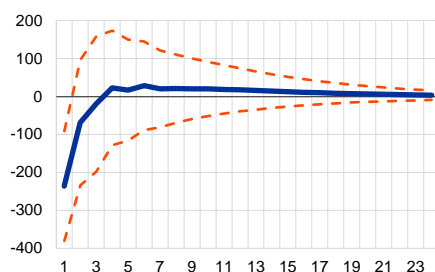
Response to unemployment shock



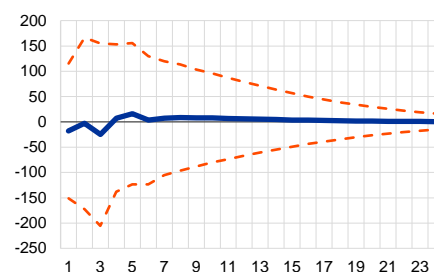
Response to LCU/EUR exchange rate shock



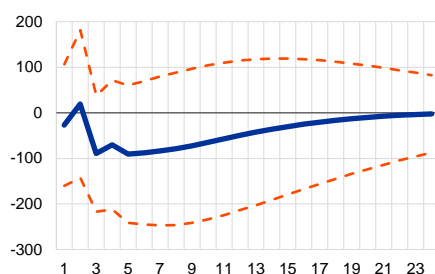
Response to USD/EUR exchange rate shock



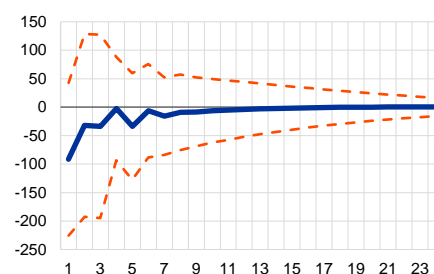
Response to short-term interest rate shock



Response to global economic uncertainty shock



Response to euro area tourism shock



Source: Author's calculation.

Global economic uncertainty does not seem to significantly affect net shipments either²³. It remains an open question, however, whether local uncertainty and shocks to local banking systems increase international flows of euro cash. As for the lack of impact of the tourism variable on net shipments, it should be noted that both of these variables have been seasonally adjusted, which makes it impossible to capture most of the transactional demand present in their seasonal components. The foreign demand of euro cash for tourism is expected to be mostly transactional, so time series methods integrating seasonal components into the analysis (Franses, 1996; Brendstrup et al., 2004) are expected to be more suitable for investigating the effect of tourism.

2.3.2 Per-denomination analysis

An important research question is whether the factors observed above show a similar response in respect of different denomination aggregates of net shipments. In particular, lower and mainly transactional denominations (€5, €10 and €20) would be expected to show different behaviour from medium and high denominations (€50, €100, €200 and €500), which better fulfil the store-of-value function of cash. This would also be in line with the results presented in Section 2.2.

To answer the research question, a VAR approach similar to that described above was used to study the potentially varying effects in two euro net shipment denomination aggregates: low denominations (€5, €10 and €20) and medium and high denominations (€50, €100, €200 and €500). Aggregating denominations in this manner makes it easier to clearly separate the transactional and store-of-value demand for banknotes (Amromin and Chakravorti, 2009), and it also avoids the need to control for substitution patterns between denominations serving similar functions. In particular, two VAR systems were used to study the effect of the same seven variables on the two denominational aggregates of net shipments. As ECB data for net shipments have only included disaggregated denomination data since 2013, the sample is shorter than for all denominations combined (from 2013 to 2019). Charts 4 and 5 show the impulse responses of using a similar identification procedure.

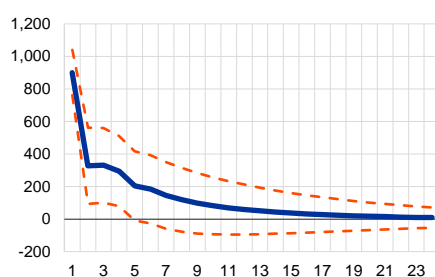
²³ Similar models, including volatility (VSTOXX), geopolitical risk (GRI), and euro area systemic stress (CISS EA) indices, yielded non-significant results for these variables and similar findings for the local indicators.

Chart 4

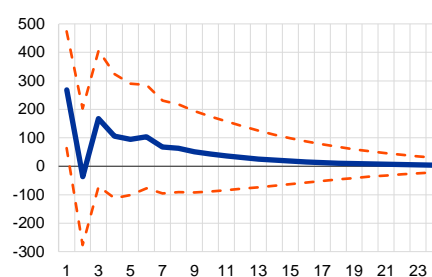
Responses of medium and high-denomination euro net shipments to one-standard deviation foreign region-specific and external shocks (95% confidence intervals)

(y-axis: value, EUR millions; x-axis: months from shock)

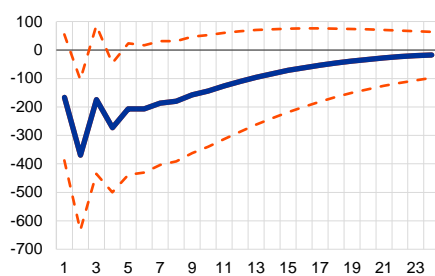
Response to euro net shipments shock (medium and high denominations)



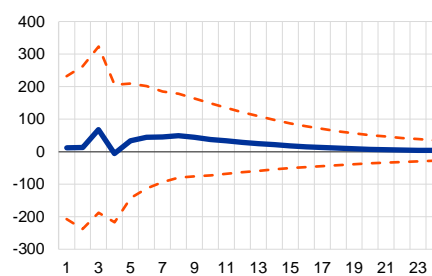
Response to local inflation shock



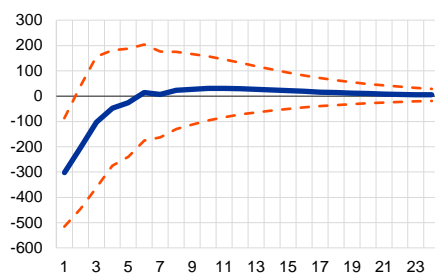
Response to local unemployment shock



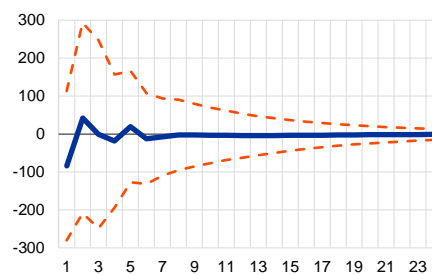
Response to LCU/EUR exchange rate shock



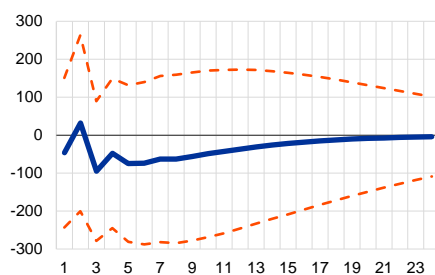
Response to USD/EUR exchange rate shock



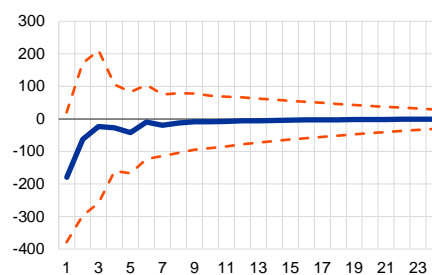
Response to short-term interest rate shock



Response to global economic uncertainty shock



Response to euro area tourism shock



Source: Author's calculation.

For medium and high denominations (see Chart 4 above), all the effects observed in the all-denominations model are present, albeit in a weaker fashion. There is a positive effect from an inflation shock (although only one month after the shock) and a negative effect from an unemployment innovation (although only in the second and fourth months after the shock), while the LCU/EUR exchange rate has no discernible effect. Likewise, an appreciation of the euro against the dollar increases medium and high-denomination flows to countries outside the euro area, although other external variables are insignificant.

For low denominations (see Chart 5 below), the effect of inflation observed both in the high-denomination analysis and in the all-denominations analysis is no longer statistically significant. This is consistent with the fact that low denominations are not commonly used as a store of value. However, a novel aspect of the results for low denominations is that although the inflation effect disappears, appreciation of the euro against the local currencies is now associated with higher net flows of low denominations, which strengthens the plausibility of the conjecture offered above by Hellerstein and Ryan (2011). The significant effect of unemployment also disappears for low denominations, indicating that flows of low denominations may not be associated with foreign economic activity. Finally, appreciation of the euro against the dollar still has a (barely) significant effect on low denominations, although the other external variables have no impact on low denominations.

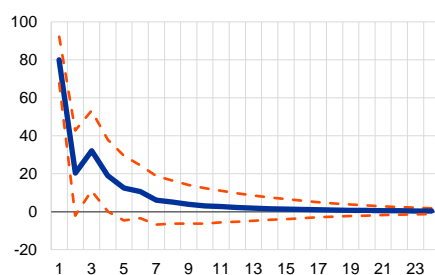
It may be concluded from the two models that high denominations are the main contributor to the results for all denominations combined, although the results here are not directly comparable with those for the aggregate analysis as the sample is three years shorter due to data unavailability.

Chart 5

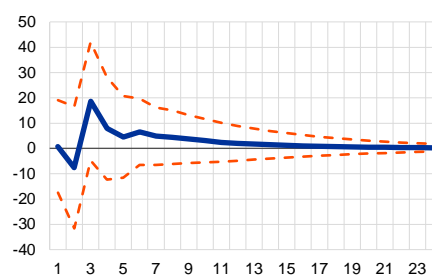
Responses of low-denomination euro net shipments to one-standard deviation foreign region-specific and external shocks (95% confidence intervals)

(y-axis: value, EUR millions; x-axis: months from shock)

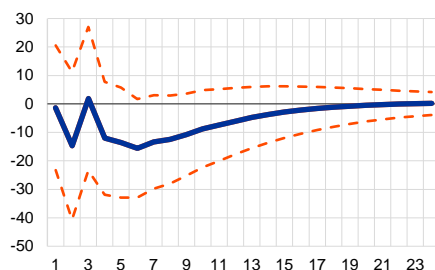
Response to euro net shipments shock (medium and high denominations)



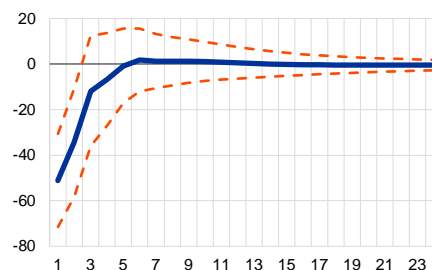
Response to local inflation shock



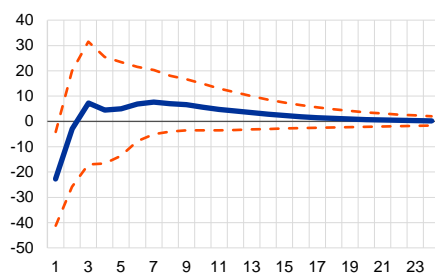
Response to local unemployment shock



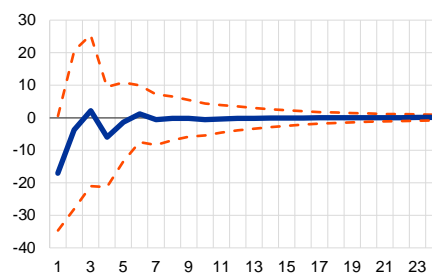
Response to LCU/EUR exchange rate shock



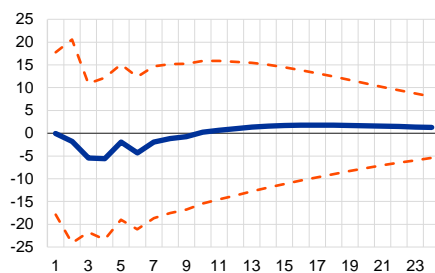
Response to USD/EUR exchange rate shock



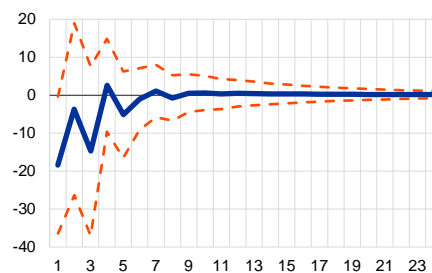
Response to short-term interest rate shock



Response to global economic uncertainty shock



Response to euro area tourism shock



Source: Author's calculation.

2.3.3 Qualitative analysis by region

Qualitative information obtained from NCBs and by interviewing wholesale banks supplements the previous analysis and provides insights into the local drivers of foreign demand for euro banknotes²⁴. In the Americas, sales and purchases of euro banknotes are marginal (see Figures 1 and 2). This is probably due to the strong presence of the dollar in these regions, for historical and geographical reasons. As both the euro and the dollar are risk-free and highly liquid assets, network effects induce investors from these areas to use and hold the currency they are used to. Consequently, tourism appears to be the main driver of demand in these areas.

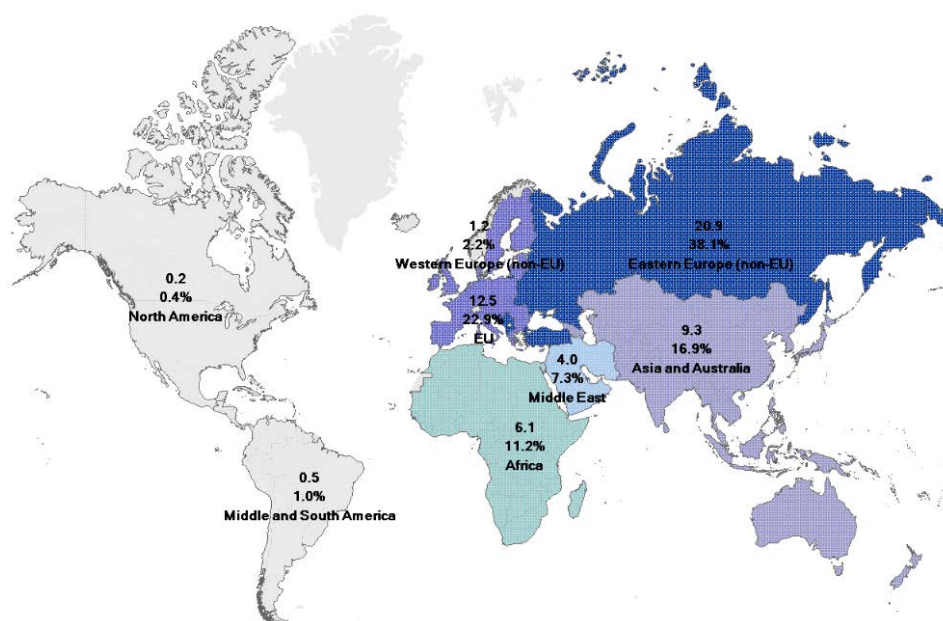
The greatest demand comes from non-EU eastern Europe. Here, too, geographical proximity, shared borders and historical ties, together with the factors described in Section 2.1, account for the higher levels of demand. The significant demand from these regions stems from cross-border transactions, tourism and the search for safe haven assets during periods of economic or political stress.

In Africa, although the volumes are lower, euro banknote flows are caused by the same factors. Banknotes shipped to sub-Saharan countries are mostly used to store value. In northern Africa, tourism and remittances account for the major part of euro cash shipments.

In the Middle East, Asia and western non-EU countries, tourism appears to be the main driver of foreign demand.

Figure 1
Purchases of euro banknotes reported by wholesalers for 2019

(imports corrected for intra sales, EUR billions, percentage of total)



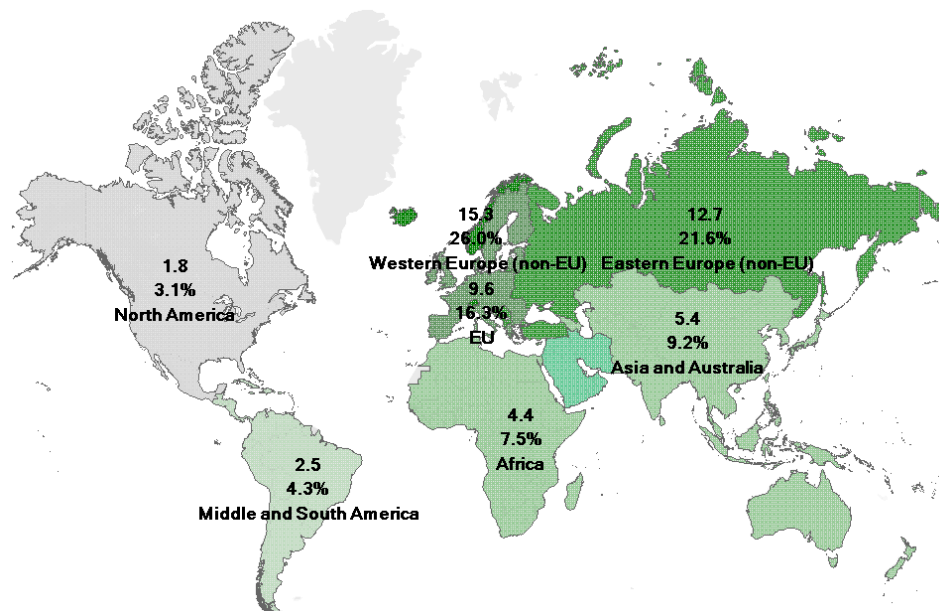
Source: Wholesale banks' reports.

²⁴ The wholesalers' reports include informal knowledge and assumptions as to the reasons for foreign demand.

Figure 2

Sales of euro banknotes reported by wholesalers for 2019

(exports corrected for intra sales, EUR billions, percentage of total)



Source: Wholesale banks' reports.

Outcome. An analysis of net shipments indicates that flows of euro cash abroad for store-of-value purposes are associated with economic activity in the receiving countries. Determinants of euro cash flows are local-specific, i.e. they relate to factors affecting countries which have a demand for euro (local inflation and economic activity) rather than external factors (global uncertainty or short-term interest rates in the euro area). One exception to this, however, is that appreciation of the euro against the dollar appears to lead to higher euro cash flows, and it should be noted that these results are mainly driven by medium and high denominations. Qualitative information obtained from interviews supplements the analysis, suggesting that demand for euro banknotes is essentially motivated by tourism, cross-border transactions and the search for safe assets. In developing countries there is an arbitrage between the euro and the US dollar in terms of holding safe and liquid assets for hedging against depreciation or devaluation. The result of this arbitrage tends to be determined by geographical proximity and historical factors.

Limitations. The above exercise should be seen as an initial analysis of the Eurosystem data for euro cash shipments. Limitations derive fundamentally from data availability – information on the destination of euro cash shipments is only available at a regional level, making it impossible to perform a more reliable panel data analysis of the determinants of cash demand abroad. To deal with this issue, indicators have been constructed using available data such as, for example, wholesalers' data. However, these data may not include complete information for lower denominations, given the fact that there are other common channels for international flows (e.g. tourism). This makes it difficult to capture the actual effects in these denominations. The lack of monthly time series for relevant factors (such as GDP, retail activity or local

uncertainty) in countries receiving euro cash, means it is impossible to capture the effect of these factors. Qualitative evidence gathered from interviews is used to complement the above-mentioned shortcomings, although it can only provide limited information.

2.4 Cash holdings and currency substitution in CESEE countries: evidence from the OeNB Euro Survey

Prepared by Codruta Rusu, Oesterreichische Nationalbank

The mission of the Oesterreichische Nationalbank (OeNB) includes performing an economic analysis of the countries of central, eastern and south-eastern Europe (CESEE) and to this end, the OeNB regularly conducts a survey of households in CESEE²⁵. The OeNB Euro Survey collects information from private individuals with regard to their euro cash holdings, saving behaviour and debt positions, and investigates respondents' economic opinions, expectations and experiences²⁶. The 2019 results are presented in this section.

Foreign currencies in general, and the euro in particular, play an important role in CESEE, which has implications for the conduct of monetary and fiscal policy, and financial stability. However, there is only limited knowledge of the varying extent of euro use in the region.

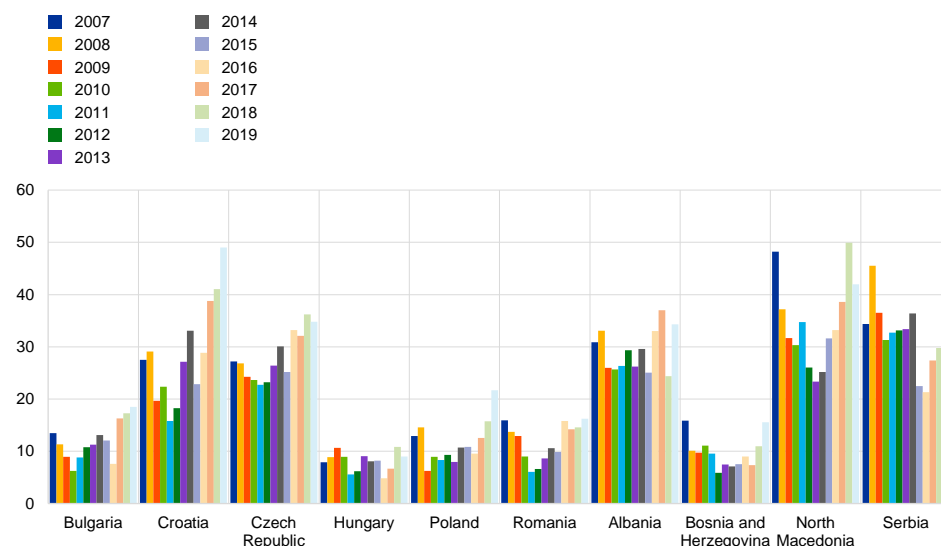
Over the years, the survey has been particularly effective at shedding light on the reasons for holding euro cash and other “safe haven” currencies. A large part of the literature discussed in Section 2.1 on the drivers of foreign euro cash demand is based on data from this survey. As discussed, in addition to closeness to the euro area (CESEE countries are either EU members or potential candidates for membership), one of the most important factors determining whether people hold cash at home rather than at a bank would appear to be trust or, rather, the lack thereof. Stix (2013) finds that a lack of trust in domestic banks and institutions, as well as in the stability of the local currency, has a significant effect on cash savings. Other reasons for holding euro cash include a desire to spend money, either abroad (which is especially prevalent in the Czech Republic, Hungary and Poland) or on domestic purchases such as real estate and cars (see Scheiber and Stern, 2016). Trust in banks also plays a major role when it comes to the transaction function of cash. Png and Tan (2020) conclude that a lack of trust in banks significantly increases the likelihood of cash being used to make retail purchases.

²⁵ The following section draws on data and research work carried out by a team of economists at the OeNB's Economic Analysis and Research Department. The contributions of Thomas Scheiber were particularly helpful in preparing this section.

²⁶ See Annex 1, “Methodological notes on the data”.

Chart 6**Share of respondents holding euro cash**

(percentage of respondents)

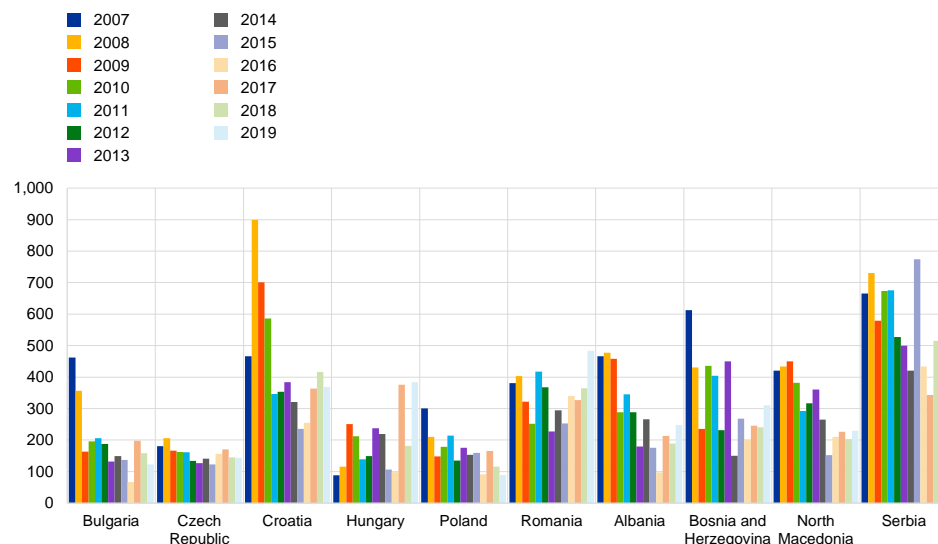


Source: OeNB Euro Survey.

After a drop in the last decade in the aftermath of the global financial crisis, the share of respondents who reported holding euro cash has picked up again in recent years, rebounding to 2007 levels (such as in Hungary, Romania, Bosnia and Herzegovina) or even surpassing them (such as in Bulgaria, Croatia and Poland (see Chart 6)). The only exception to this rebound is Serbia. Scheiber (2019) concludes that the recent rebound in euro cash holdings might be driven either by rising incomes or by a higher prevalence of remittances. Overall, North Macedonia and Croatia have the highest share of respondents with euro cash holdings, ranging from 40% to almost 50%, while Hungary has the lowest share of respondents at almost 10%.

Chart 7**Median amounts of euro cash held by individuals**

(EUR)

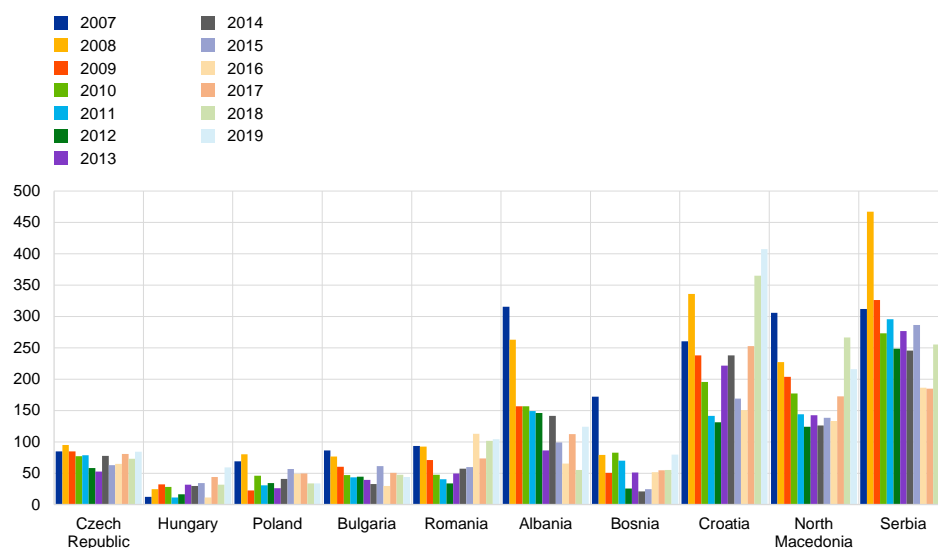


Source: OeNB Euro Survey.

In many cases the median amounts reported paint a very similar picture, i.e. a trend of decreasing euro cash holdings since the onset of the financial crisis, although the amounts have picked up again in recent years in some countries, especially in Serbia, Romania and Croatia (see Chart 7). With a median amount of around €500, Serbia and Romania report the highest amounts, while Poland and Bulgaria report amounts that are around a fifth of this.

Chart 8**Average amounts of euro cash held by individuals**

(EUR)



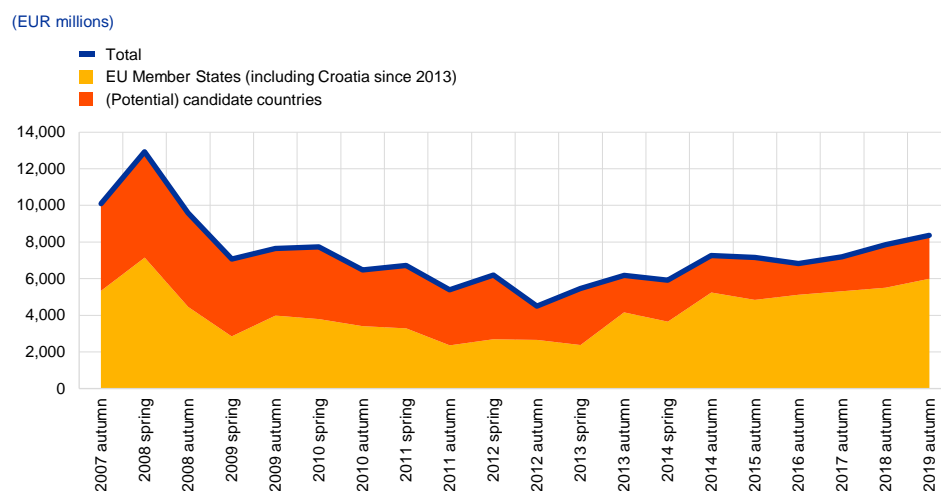
Source: OeNB Euro Survey.

Notes: Per capita values are extrapolated for the entire population aged 14 years and over. For details see Scheiber and Stix (2009).

From the median amounts reported, we can extrapolate per capita values for the entire population aged 14 and over. Once again, it should be noted that this is the lower bound only. In this case, Croatia emerges as the country with the highest euro holdings, at more than €400 per person, while the average per capita amount in Poland is about a tenth of this, at around €40 (see Chart 8).

Chart 9

Projected circulation of euro cash in CESEE (lower bound)



Source: OeNB Euro Survey.

Note: Croatia has been an EU Member State since July 2013.

Based on per capita euro cash holdings per person, we can project the lower bound of euro cash in circulation in these countries (i.e. slightly more than €8 billion, representing less than 1% of the value of total euro cash in circulation at the end of 2019), as shown in Chart 9. Since the results of the OeNB Euro Survey also provide an important input for evaluating both current and potential candidate countries (i.e., Albania, Bosnia and Herzegovina, Northern Macedonia and Serbia) the chart above distinguishes between these countries and CESEE countries that are already EU Member States. Overall, we can see that euro cash in circulation is once again on the rise after a slump in 2012 in the aftermath of the sovereign debt crisis, although the pick-up is not quite as stable in the (potential) candidate countries. Furthermore, it should be noted that euro cash in circulation in CESEE has not recovered to the levels of 2007, i.e. before the global financial crisis.

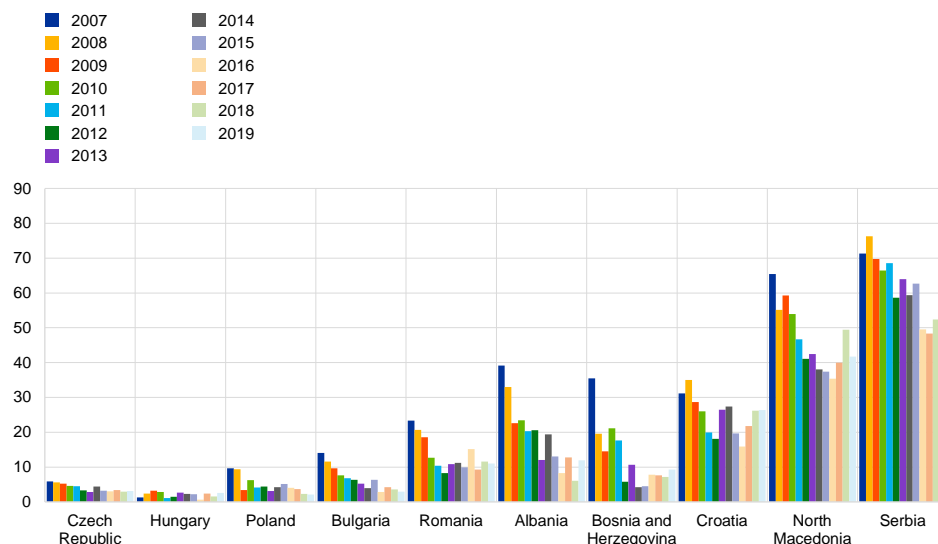
In order to gauge the macroeconomic importance of euro cash in CESEE, we can interrogate two key indices that may be derived from the survey figures: currency substitution and euroisation. First, the currency substitution index (CSI) relates projected per capita euro cash amounts, as derived from the OeNB Euro Survey, to per capita local currency in circulation outside the banking sector. Second, the euroisation index represents per capita euro cash holdings plus per capita euro deposits of the household sector divided by total currency in circulation outside the banking sector plus total household deposits. While the currency substitution index has declined consistently, the euroisation index in south-eastern Europe has remained at a medium to high level over the last decade. Since the reported euro cash amount

has decreased, this phenomenon may be attributed to the continuing underlying euroisation of deposits (see Scheiber 2019).

Chart 10

Currency substitution index

(as a percentage)



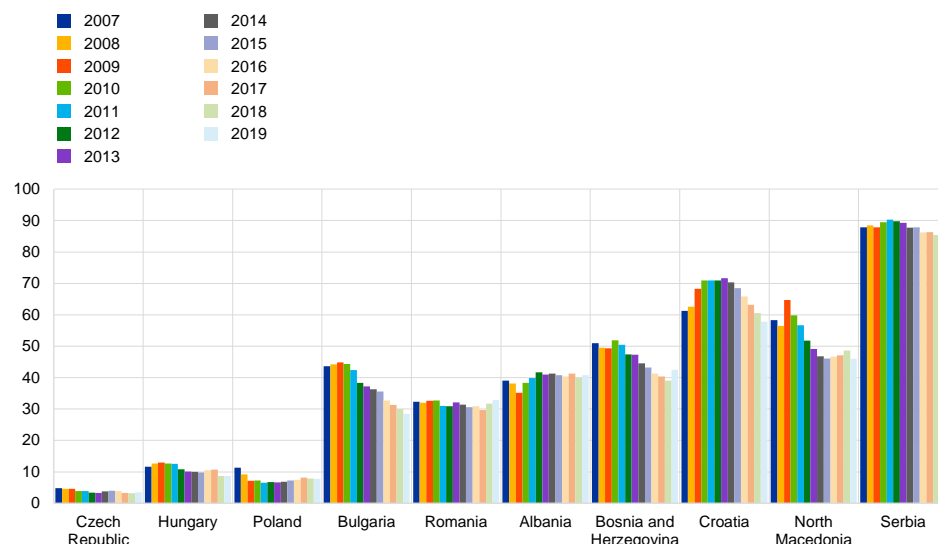
Source: OeNB Euro Survey.

Notes: Currency substitution index = the ratio of euro cash to euro cash plus national currency in circulation. For details see Scheiber and Stix (2009).

Chart 11

Euroisation index for the household sector

(as a percentage)



Source: National central banks and OeNB Euro Survey.

Note: Euroisation index = (euro cash + foreign currency deposits) / (total cash + total deposits).

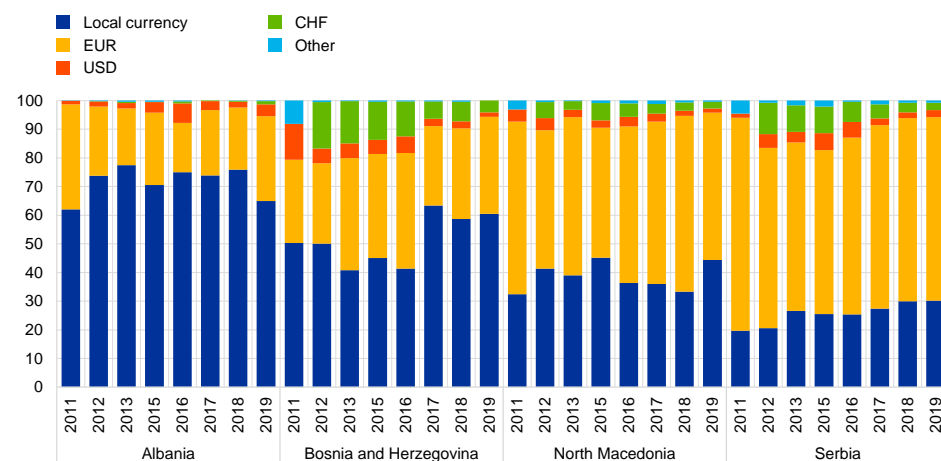
Indeed, if we look at the (potential) candidate countries we can see from Chart 12 that the euro remains the foreign currency of choice when it comes to depositing money. In North Macedonia and Serbia, the euro is even preferred to the respective local

currencies. In line with the findings reported by Stix (2013), we can see that the euro scores consistently higher than the respective local currency when it comes to trust, although the gap has – at least to some extent – closed. This corroborates the well-established finding in the literature that once trust has been lost, it can only be regained gradually, which is especially true for countries that have experienced periods of hyperinflation and/or currency crises. In order to build up trust in the local currency and to promote de-euroisation, CEESE countries that wish to do this should implement macroeconomic policies aimed at establishing a track record of reliable economic policy and fiscal institutions (see Scheiber 2019). However, as Feige and Dean (2004) point out, even if macroeconomic stability is achieved, euroisation is, to a certain extent, irreversible.

Chart 12

Currency preferences: in what currency would respondents choose to deposit a certain amount of savings?

(percentage of respondents)

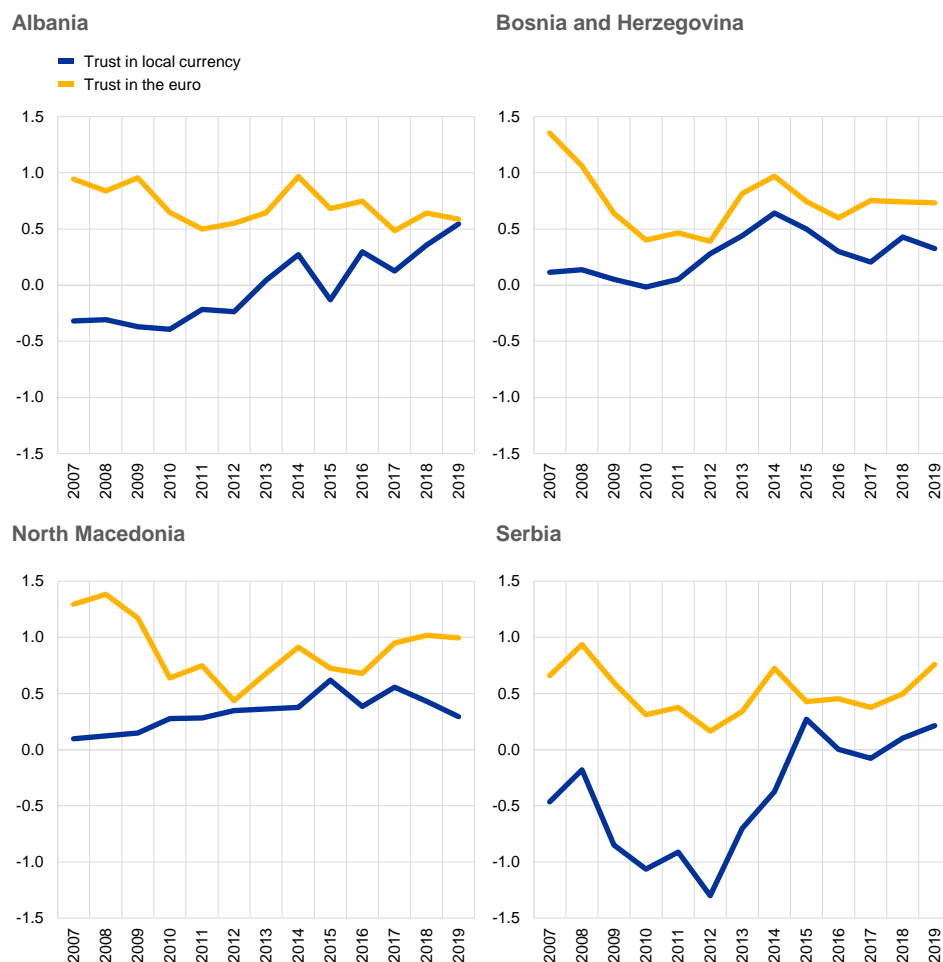


Source: OeNB Euro Survey.

Notes: Weighted percentages, excluding respondents who answered "Don't know" and "No answer". Respondents were asked, "Suppose you had an amount of [about twice the average monthly salary in local currency] to deposit in a savings account. In what currency would you choose to deposit this amount?" This question was not asked in 2014.

Chart 13**Trust in the local currency and in the euro**

(normalised sample means per country; -2.5 fully disagree, 0 neutral, +2.5 fully agree)



Source: OeNB Euro Survey.

Notes: Respondents were asked whether they agreed or disagreed on a scale from +2.5 (fully agree) to -2.5 (fully disagree) with the statement: "Over the next five years the local currency (or the euro) will be very stable and trustworthy". Respondents who answered "Don't know" or "No answer" have been excluded.

Outcome. Although the average amount of euro cash holdings has declined overall in CESEE, euroisation has remained at a relatively stable level due to a continuing preference to save in euro, whether in cash or as a foreign currency deposit. This, in turn, has its roots in lower trust in the local currency compared with the euro (see Chart 13), which is difficult to regain. As such, it may be concluded that the euro will continue to play a significant role in CESEE.

Limitations. The answers to the questions pertaining to the amount and the frequency of euro cash holdings, as well as indicators that can be derived from these, should be interpreted with caution since they rely only on respondents' self-reporting. It should be noted in particular that the amounts presented in this section should be regarded merely as lower bounds due to underreporting, and that the actual amounts are likely to be several times higher.

3 Estimating the share of euro banknote circulation outside the euro area

It is estimated that a large proportion of euro banknote circulation is outside the euro area. The literature offers several methods for estimating the different components of banknote circulation. These may be classified into (i) direct approaches used for point estimates (e.g. net shipments data, surveys) or for upper and lower limits (e.g. remittances), and (ii) indirect approaches used for point estimates (e.g. seasonal methods, age of banknotes) or for upper and lower limits (e.g. banknote ratios, coin issuance, patterns of withdrawal and lodgement).

In the present study, several methods were selected to guarantee the robustness of the outcome. Specifically, the methods used were: direct approaches based on net shipments data (Section 3.1) and the ECB's published methodology using a coin to banknote ratio and assumptions of the net shipments data (Section 3.2); and indirect approaches, i.e. the seasonal method and the age of banknotes method (Section 3.3 and Section 3.4, respectively). Indirect approaches compare the behaviour of the euro banknote population with another banknote population, based on the assumption that there is demand for the euro abroad while there is not for the other currency, and that the domestic use of those currencies as a store of value is of a comparable extent and trend.

3.1 Net shipments data

Prepared by Laure Lalouette, ECB

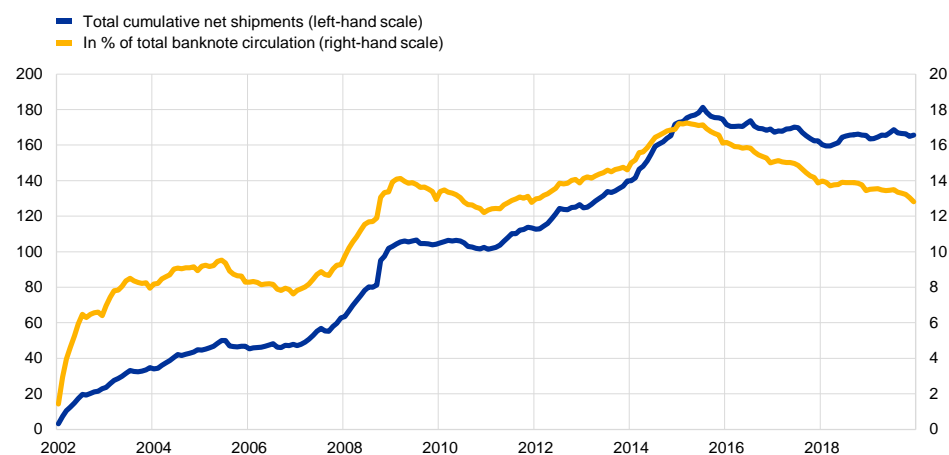
3.1.1 Euro banknotes flowing via registered channels

The Eurosystem collects data from banking institutions on a monthly basis on the exports and imports of euro banknotes to and from regions outside the euro area²⁷. At the end of December 2019, the total cumulated net shipments of banknotes outside the euro area (i.e. exports minus imports) amounted to €165.6 billion (see Chart 14), which represented 13% of the total value of the euro banknotes in circulation.

²⁷ See Annex 1, "Methodological notes on the data".

Chart 14**Net shipments of euro banknotes to/from regions outside the euro area**

(left-hand scale: value, EUR billions; right-hand scale: percentages)



Source: ECB Statistical Data Warehouse (SDW) data; latest observation December 2019.

However, although there is very high coverage of banking channels, other channels are not covered at all. This is clearly illustrated by the breakdown of imports and exports by denomination (see Chart 15 and Chart 16). For example, since the denominational breakdown has become available, €50 banknotes have always recorded negative net shipments. There are two possible explanations for this phenomenon. One is that, before 2013, €50 banknotes were exported outside of the euro area on a huge scale, and these banknotes have, since then, been returning. Another, more likely, explanation is that the split of net shipments by denomination was the same before January 2013, so the inflow of €50 banknotes into the euro area must have migrated outside the euro area previously via channels that were not captured in net shipments data.

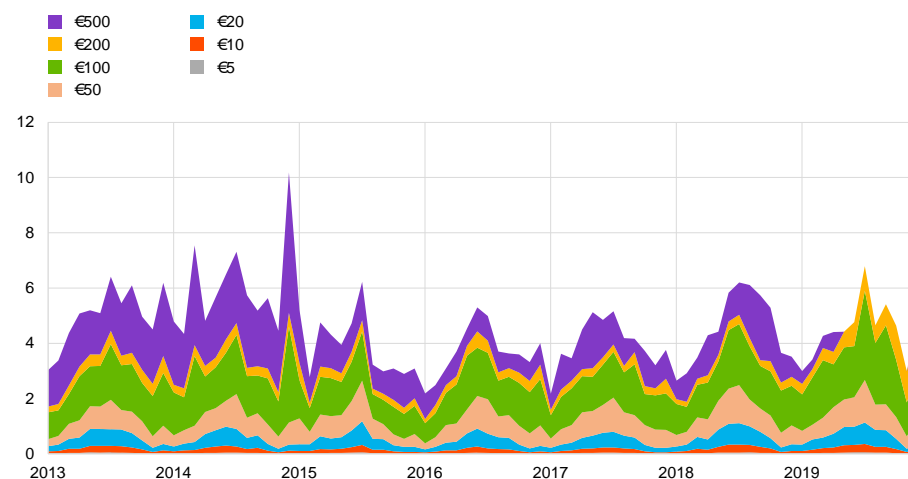
If we consider tourism and the number of cash remitters in the euro area (e.g. short-term workers, frontier workers and migrants) and the variety of remittance channels (of which many are informal), the second hypothesis seems valid.²⁸ If only a part of the cash used abroad is accounted for in the net shipments data, the missing part may be accounted for by NCBs' gross issuance. Only observations of the behaviour of the banknote circulation may offer further information on the latter (the seasonality and the age of banknotes are investigated in Section 3.3 and Section 3.4).

²⁸ See Box 2 "First estimates of net cash remittances over time for the euro area" and Annex 2 "Remittances channels".

Chart 15

Monthly exports of euro banknotes via registered channels

(value of exports, EUR billions)

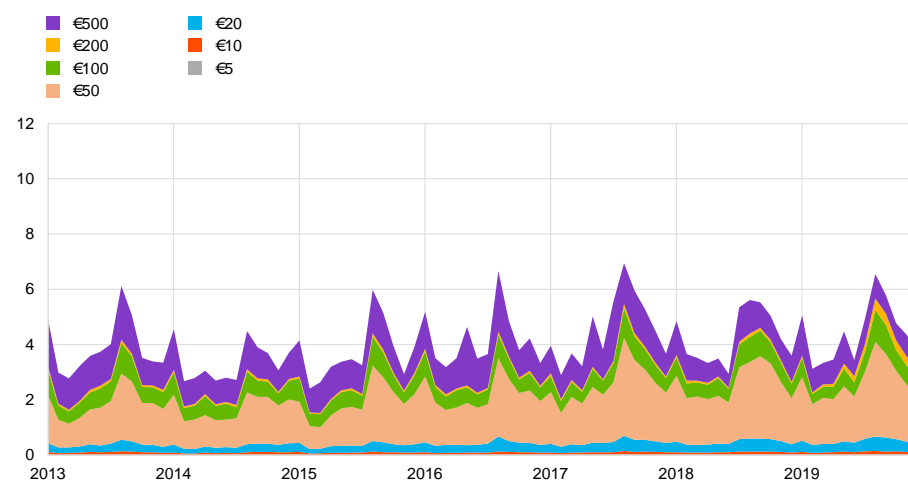


Source: ECB SDW data; latest observation December 2019.

Chart 16

Monthly imports of euro banknotes via registered channels

(value of imports, EUR billions)



Source: ECB SDW data; latest observation December 2019.

Outcome. Data on exports and imports of euro banknotes to/from regions outside the euro area underline the importance of the international role of euro cash.

Limitations. As unregistered flows are not captured, 13% is unlikely to be the true figure for euro banknotes circulating outside the euro area. It is important to establish whether the unregistered outflows are higher than the unregistered inflows in order to determine whether 13% is, instead, the lower bound, as is generally assumed.

3.1.2 Imputing missing values for the outflows of €50 banknotes

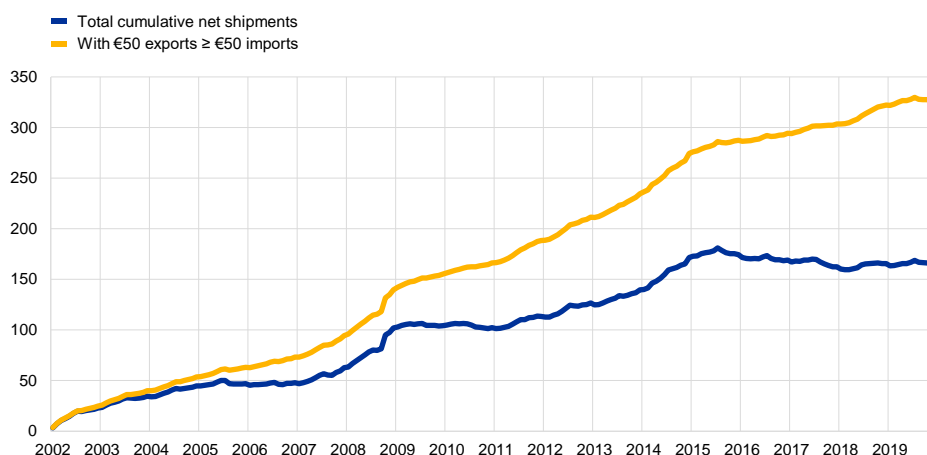
Assuming that the denominational breakdown of the net shipments was the same before January 2013 (i.e. when the split by denomination was first reported), the flows of €50 banknotes into the euro area cannot always have been greater than the outflows of €50 banknotes since 2002. The banknotes must, therefore, have migrated outside the euro area via unregistered channels. The unregistered migration of €50 banknotes may be imputed following the assumption that the imports of €50 banknotes should, at least, be equal to the exports, as it is not possible, for the overall period, for cumulated shipments to be negative.

If the monthly exports of banknotes (X) are greater than the monthly imports (M), then X maintains its value. Otherwise, X takes the value of M for the period from 2002 to the present. All other denominations maintain their values.

Chart 17

Cumulative €50 exports with €50 imports as minimal value

(value of exports, EUR billions)



Source: Author's calculation.

Outcome. Based on this simple approach, the value of euro held outside the euro area would be slightly lower than 30% of the total value in circulation (approximately €350 billion at the end of 2019) (see Chart 17).

Limitations. The approach is rather crude, as it does not take into account the fact that other denominations may also be flowing from and to the euro area via unregistered channels. The method cannot be used on its own to produce a reliable estimate of the circulation value outside the euro area. Therefore, alternative approaches based on observing the behaviour of banknote circulation are presented in the following sections to complement the analysis.

Box 1

Recent developments in the net shipments of euro banknotes: the €500 issuance stop and the coronavirus (COVID-19) pandemic

Prepared by Laure Lalouette, ECB

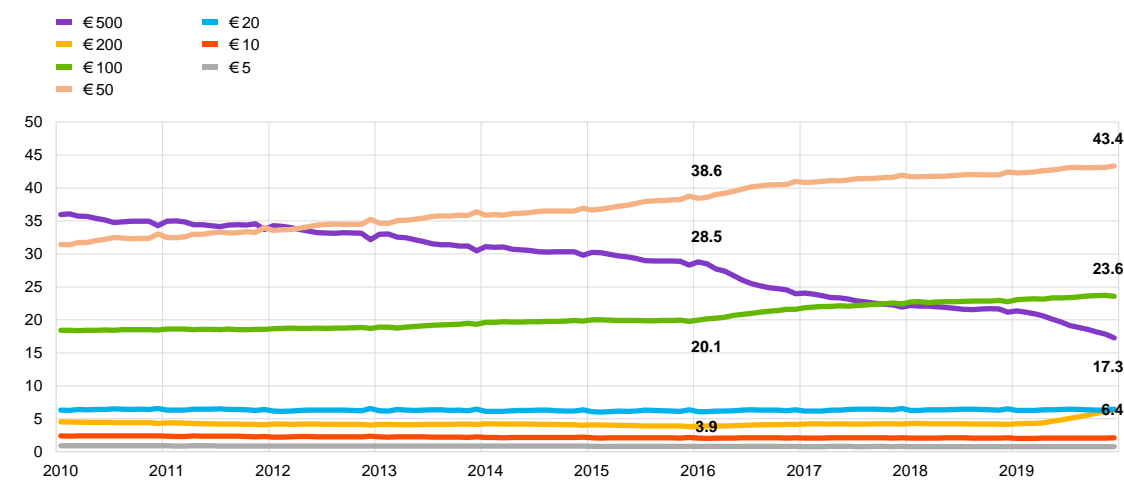
€500 banknote issuance stop

The ECB took the decision to stop the production and issuance of €500 banknotes in May 2016. After the first communication on the topic in February 2016, €500 circulation had started to decrease strongly and €500 demand shifted mainly to €100 and €200 banknotes. With the effective issuance stop, however, demand for the €200 banknote increased rapidly (see Chart A).

Chart A

Share by denomination of euro banknote circulation

(total share of banknote circulation, percentages)



Source: ECB Currency Information System (CIS2).

Note: Last observation is for December 2019.

International demand, as captured by the net shipments data, did not follow the same trend. Despite the €500 banknote issuance stop, total net shipments increased by €0.1 billion in 2019, compared with 2018 (an annual growth of 0.1%). In 2019, exports of the €100, €200 and €500 banknotes amounted to €34.8 billion, compared with exports in the same period in 2018 of €36.5 billion. In other words, the decline in the exports of €500 banknotes was almost entirely offset by an increase in exports of €100 and €200 banknotes. Moreover, the imports of €500 banknotes have continued at the level of the previous year. This suggests that the market has not been overreacting to the issuance stop by lodging more €500 banknotes than usual.

Coronavirus (COVID-19) pandemic

In the context of the coronavirus (COVID-19) crisis, the total demand for euro banknotes accelerated in March. For the €200 banknote in particular, monthly growth was 13.9% or €12.5 billion. OeNB, one of the main NCBs dealing with wholesalers, reported that foreign demand had increased following the Government's announcement of restrictions, and also because of the sudden strong depreciation of the Russian rouble and other currencies in central, eastern and south-eastern Europe. Part of the demand was placed on stock by the wholesalers as a precautionary measure (i.e. to mitigate delays in deliveries induced by airport closures and country lockdowns). Net shipments in March amounted

to €2.3 billion, of which €1.7 billion was for the €200 banknote alone (which explains the 13.9% increase in total demand in March).

3.2 The ECB's external statistics division method

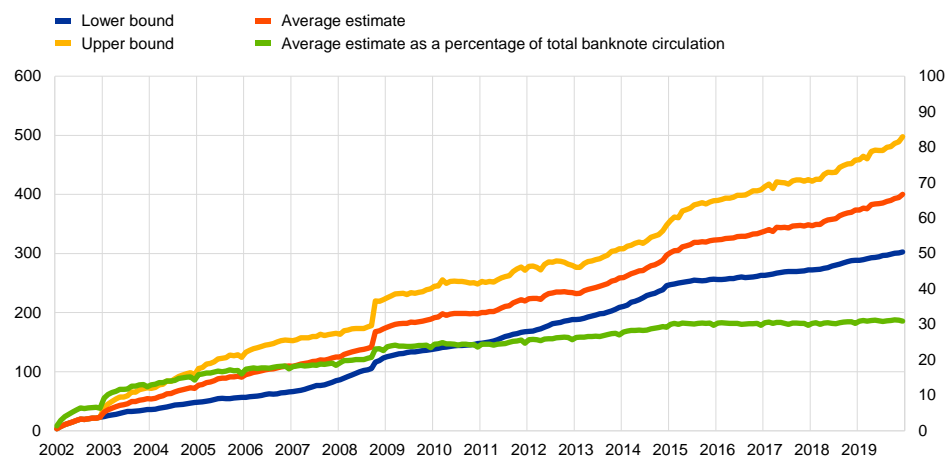
Prepared by Laure Lalouette, ECB

In 2017, the External Statistics Division of the ECB published a methodology for estimating the value of euro banknotes in circulation outside the euro area²⁹. It suggested estimating this value by averaging the estimates of a lower and an upper bound. The lower bound is calculated on the basis of the net shipments of high denominations; the upper bound is calculated as a coin to banknote circulation ratio. This method relies on several assumptions: euro banknotes are mainly used outside the euro area for store-of-value purposes and low denominations are mainly used for transaction purposes (and are therefore more likely to remain within the euro area – coin circulation abroad is negligible and the increase in the value of coins in circulation is entirely the result of transaction requirements within the euro area).

Chart 18

Estimate based on the STC method

(left-hand scale, value, EUR billions, right-hand scale: percentage of total banknote circulation)



Source: Author's calculation.

Outcome. The average of the lower (€300 billion) and upper (€500 billion) bounds indicates that around 30% of the total value of banknotes in circulation (approximately €400 billion) was used outside the euro area at the end of 2019 (see Chart 18).

Limitations. The assumptions underlying the estimates are questionable. There is evidence showing that euro are, to some extent, also used for transaction purposes outside the euro area, especially in neighbouring countries (see Section 2.4). Also, tourists may bring back more coins than banknotes from a trip to the euro area

²⁹ See "Estimation of euro currency in circulation outside the euro area", ECB, April 2017.

(e.g. because of the threshold amounts for converting euro into local currency at bureaux de change). It is not possible to accurately determine the magnitude of the impact of these limitations (which surround both the upper and the lower bounds) on the central estimate.

3.3 The seasonal method

Prepared by Nikolaus Bartzsch, Deutsche Bundesbank

There are a number of indirect approaches (such as the seasonal method³⁰) which incorporate behavioural assumptions as to the characteristics of euro banknotes held in the euro area and abroad.³¹ As any demand for banknotes is met by the Eurosystem, these characteristics reflect demand behaviour. The problem may be formulated as follows (Feige, 1997, page 184).

The shares β_1 and β_2 of two subpopulations C_1 and C_2 , which together produce the total population C , are to be estimated. Let X_1 and X_2 denote the observed and recorded characteristics of subpopulations C_1 and C_2 . The average feature X is then a weighted average of both characteristics, with the weights being the unknown shares β_1 and β_2 :

$$X = \beta_1 X_1 + \beta_2 X_2 \quad (1)$$

As $\beta_1 = 1 - \beta_2$, the shares can be estimated by means of the observed and measured properties:

$$\begin{aligned} \beta_1 &= \frac{X - X_2}{X_1 - X_2} \\ \beta_2 &= \frac{X_1 - X}{X_1 - X_2} \end{aligned} \quad (2)$$

A sensible solution to this problem exists if the characteristics of the two parts X_1 and X_2 differ ($X_1 \neq X_2$) and the calculated shares are between zero and one. Therefore, to implement this approach for our purposes, i.e. to calculate the share of euro banknotes held abroad, the characteristics of banknotes in circulation outside the euro area (X^a) must sufficiently differ from those of banknotes outstanding in the euro area (X^d). These characteristics may involve the age, quality, velocity of circulation, or the seasonal pattern of banknotes in circulation. At the same time, information is required on how the demand for banknotes would have developed if there had been no demand from abroad. According to Equation (2) the domestic share is given by:

³⁰ The seasonal method is described in Assenmacher (2018, 2019), Bartzsch et al. (2011b), Deutsche Bundesbank (2015), European Central Bank (2016) and Judson (2018).

³¹ An overview of a large number of both forms is provided by Feige (1997).

$$\beta^d = \frac{X - X^a}{X^d - X^a} \quad (3)$$

and the corresponding foreign share by:

$$1 - \beta^d = \frac{X^d - X}{X^d - X^a} \quad (3')$$

In this section, we focus on the different seasonal structures of domestic and foreign demand (the seasonal method) whereas in Section 3.4 we use the “age of banknotes” characteristic.

The aim of the seasonal method is to filter out information about banknotes in circulation outside the euro area from the “seasonal structure of banknotes” characteristic. This idea originally came from Sumner (1990) who applied this approach to the calculation of internal cash hoardings. However, since then, this approach has also been adopted for several currencies to investigate the domestic and the foreign component: Porter and Judson (1996) and Judson (2017) for the US dollar, Seitz (1995) for the Deutsche Mark, Fischer et al. (2004) for the euro legacy currencies, Bartsch et al. (2011b) for German-issued euro banknotes in circulation, and Assenmacher (2019) for Swiss banknotes.

The seasonal model is based on the assumption that the time series of the cumulative value-based net issuance of euro banknotes (the volume of euro banknotes in circulation in terms of value) consists of three parts: a trend component T_t , a seasonal term S_t and an irregular component. These should be linked together on a multiplicative basis (multiplicative seasonal model). Assigning the irregular component to the trend for the sake of simplicity and taking into account the fact that euro banknotes are also held abroad (a), yields the following equation:

$$T_t S_t = T_t^d S_t^d + T_t^a S_t^a \quad (4)$$

where t represents the time index and d stands for domestic demand. If β_t now captures the share of the total trend held domestically and, consequently, $(1 - \beta_t)$ is the share held abroad, it follows that:

$$S_t = \beta_t S_t^d + (1 - \beta_t) S_t^a \quad (5)$$

On the assumption that the share of foreign demand does not vary seasonally, i.e. $S_t^a = 1$ for all t , Equation (5) can be further simplified to:

$$S_t = \beta_t S_t^d + (1 - \beta_t) \quad (6)$$

Given the values for the seasonal terms S and S^d , an equation is produced for the unknown value β , the share of banknotes held domestically:

$$\beta_t = \frac{S_t - 1}{S_t^d - 1} \quad (7)$$

The foreign share, in turn, is $(1 - \beta_t)$. S_t corresponds to the seasonal figure for the value-based total of euro banknotes in circulation and can be determined by applying the usual methods of seasonal adjustment (e.g. X12-ARIMA, Tramo/Seats). By contrast, S^d , the seasonal term for the share of euro banknotes held within the euro area, is unknown and has to be approximated. However, Equation (7) does not always deliver meaningful results. If, for example, there is no seasonality in any given period, i.e. $S_t = S_t^d = 1$ for all t , β_t tends to infinity and/or every value of β_t is compatible with Equation (7). It then becomes impossible to identify β_t unambiguously. If the seasonality of all outstanding banknotes is not less pronounced in all periods than that of the banknotes held domestically, problems may also occur.³² This method, therefore, produces plausible results for some, but not all, periods.

In view of the above, further modifications are needed to allow for such cases and so that the method can be applied. It is often the case that meaningful estimation results are only obtained for certain frequencies within a year; see Porter and Judson (1996). With regard to the value-based total of euro banknotes in circulation, the seasonal high is, for example, in December, while the seasonal low is in February. This is, therefore, an example of a two-month frequency. In order to factor this into the equation, we replace the time index t with m, j , where m denotes the m^{th} month and j the j^{th} year. If Equation (7) for February is subtracted from the corresponding equation for the preceding December, the domestic share of euro banknotes β_j is given by:

$$\beta_j = \frac{S_{dec,j} - S_{feb,j+1}}{S_{dec,j}^d - S_{feb,j+1}^d} \quad (8)$$

While S can be calculated from the available data, S^d is unknown and has to be approximated. We do this by choosing banknotes in circulation for a suitable reference country. In other words we try to find a country that is similar to the euro area with regard to the use of banknotes, except for foreign demand which should be negligible

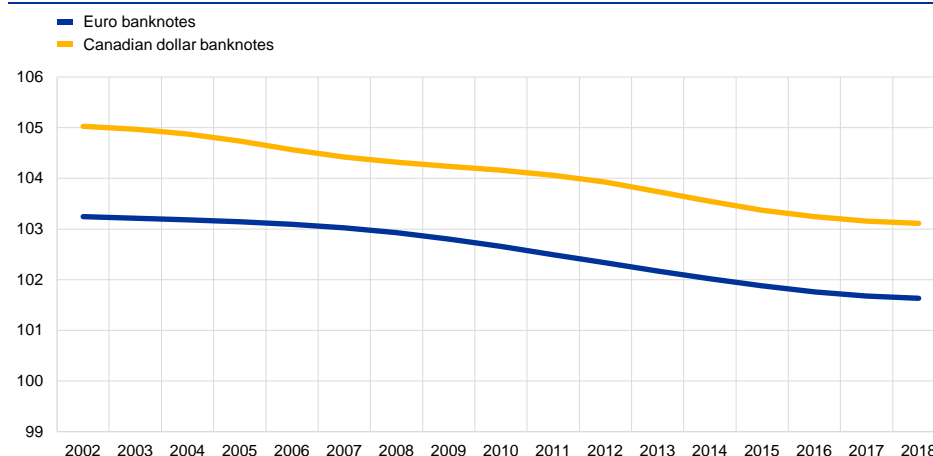
³² If the seasonality of domestic holdings is more pronounced than that of total banknotes in circulation, the equation $S_t < S_t^d$ applies for values greater than 1, while the equation $S_t > S_t^d$ applies for values lower than 1.

in the reference country.³³ We then insert the seasonal factors for banknotes in circulation in this country into Equation (8).

Canada was chosen as a reference country³⁴, and is often used as a reference country when the seasonal method is used to estimate the share of US dollars abroad (see, for example Judson (2017)).³⁵ Moreover, Canada is one of the benchmark countries used by Fischer et al. (2004) to estimate the upper limit of non-resident demand for euro legacy currencies using the seasonal method. As Chart 19 and Chart 20 show, the relevant seasonal pattern for euro banknotes in circulation is a dampened version of the seasonal pattern for Canadian dollar banknotes in circulation.³⁶ This makes Canada a good candidate for benchmarking.

Chart 19

Comparison of seasonal factors for December (seasonal high)



Source: Author's calculation.

³³ The seasonal method relies on the assumption that, in contrast to domestic transaction demand for banknotes, both domestic demand for hoarding purposes and foreign demand for banknotes show little or no seasonality, so total banknotes in circulation displays dampened seasonality factors. Therefore, in the absence of any further assumptions, the seasonal method only allows us to split total banknotes in circulation into 1) domestic transaction demand and 2) the sum of domestic hoarding demand and foreign demand. When choosing a reference country, the identifying assumption for foreign demand is that the domestic use of banknotes should be similar in the reference country and in the euro area, i.e. there should be a similar domestic transaction pattern as well as a similar domestic hoarding pattern. In this case, $\beta(1 - \beta)$ in Equation (8) is an estimate of the share of domestic (foreign) demand of total euro banknotes in circulation.

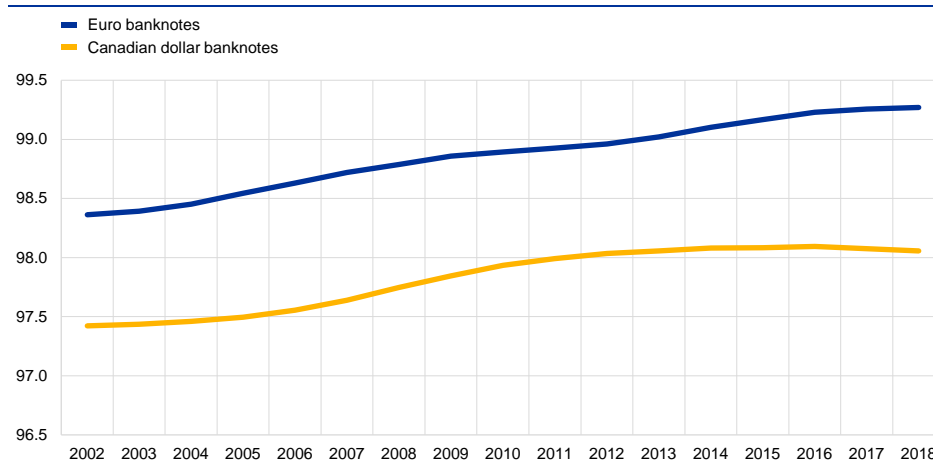
³⁴ Other countries have turned out to be unsuitable as reference countries. Engert et al. (2019) analyse why, unlike the situation in most other countries, aggregate cash demand in Sweden has been falling steadily. They attribute this to falling demand for larger banknotes, typically used as a store of value, due to Sweden's financial crisis management, the recent proliferation of cashless bank branches and the operation of Swedish legal tender rules. As a consequence, the domestic hoarding pattern for Swedish banknotes differs from the hoarding pattern for euro banknotes. Like Sweden, Norway is one of the very few countries in which the value of currency has been falling in recent years – a decline which may be attributed to the two highest denominations. Therefore, hoarding cash as a store of value does not seem to be prevalent in Norway. Denmark is not suitable as a reference country because the seasonal high for Danish banknotes in circulation in December is below that for euro banknotes in circulation. Moreover, foreign demand for euro banknotes estimated using Denmark as a reference country is partly smaller than cumulated net shipments. The latter may be regarded as a lower bound for foreign demand for euro banknotes.

³⁵ For the *age of banknotes* characteristic Canada has not been a suitable reference country since the Bank of Canada introduced a new series of polymer banknotes between November 2011 and November 2013. By contrast, euro banknotes are made of paper.

³⁶ As is shown below for Canada, the decline in the seasonal patterns in Chart 19 and Chart 20 is due to the fact that growth of banknotes in circulation is mainly driven by non-transactional demand.

Chart 20

Comparison of seasonal factors for February (seasonal low)



Source: Author's calculation.

However, for Canada to be a suitable reference country, the domestic-store-of-value function in Canada must be similar to that of the euro area. The domestic store of value function is likely to show the same lack of seasonal pattern as foreign demand and therefore affects S^d , the seasonal term for the share of euro banknotes held in the euro area, in Equation (8). Unfortunately, exact estimates are not available for the volume of domestic banknote hoarding in the euro area and in Canada. Nevertheless, we can draw a number of conclusions from the literature. The ECB has estimated that in 2008 about one-third of the value of euro banknotes in circulation was held as a store of value in the euro area (ECB, 2011). Given that since 2008 the value of euro banknotes in circulation has grown faster than private consumption and, taking the low interest rate environment into account, this share is likely to have grown further. More up-to-date estimates are available for Germany. According to an update of the estimate by Deutsche Bundesbank (2018), domestic hoarding in Germany alone amounted to about €200 billion in 2018. This amounts to about three-quarters of the domestic circulation of German-issued euro banknotes, or 30% of all German-issued euro banknotes. Given that Germans' affinity for cash is representative of the average euro area citizen's preference for cash, this might be indicative of significant domestic hoarding within the euro area.³⁷

The nominal value of the highest denomination banknote in Canada, the CAD 100 note, is only about €64.³⁸ One might therefore expect Canadian dollar banknotes to be used less frequently for domestic hoarding than euro banknotes. However, Engert, Fung and Segendorf (2019) paint a different picture. Their paper explains why aggregate cash demand in Sweden has been falling steadily while cash in most countries, including Canada, has been stable for decades, and has even risen in

³⁷ As Esselink and Hernández (2017) show, in 2016 Germans' preference for cash at point of sale corresponded exactly to the euro area average. The share of cash in the number of payments at point of sale was 80% in Germany and 79% in the euro area. The share of cash in the value of payments at point of sale was 55% in Germany and 54% in the euro area.

³⁸ CAD 1000 banknotes have been withdrawn from circulation since 2000. Nevertheless, they remain legal tender, as is the case for all banknotes that have been placed in circulation by the Bank of Canada since 1935.

recent years. They revealed a long-term downward trend in the use of low-denomination banknotes relative to gross domestic product (GDP) in both Canada and Sweden. This mirrors similar experiences of decreasing cash use for transactions over time, owing to the adoption of payment innovations. They show that the difference in cash demand trends between these two countries is due more to the behaviour of higher-denomination, store-of-value banknotes. They argue that holdings of high-denomination banknotes are motivated mainly by store-of-value considerations, rather than by payment needs, since the greater value of the banknotes makes them generally unsuitable for day-to-day transactions and comparatively more useful as a store of value. The strong demand for Canadian high-denomination banknotes in recent years is reflected in a rise in the ratio of large banknotes (CAD 50 and CAD 100) to GDP, whereas in Sweden the corresponding ratio has been declining.³⁹

Another premise that would make Canada a good reference country would be negligible foreign demand for Canadian banknotes – a condition that is only likely to be partially fulfilled. Although there are no estimates available of foreign demand for Canadian banknotes, some anecdotal evidence suggests there has been an increase in foreign demand for high-denomination Canadian banknotes in recent years (Flannigan and Parsons, 2018), although this phenomenon is not well understood. Reasons for overseas demand include travel, wealth diversification and capital flight. The Canadian banknotes sent abroad are believed to be predominantly CAD 100 banknotes, and overseas demand for this denomination stems mainly from Asia. Flannigan and Parsons (2018) estimate that shipments of this denomination to Hong Kong accounted for about 5% of all CAD 100 banknotes issued in 2016.

Consequently, although its volume is not known, foreign demand for Canadian banknotes is probably not negligible. Therefore, on condition that the Canadian dollar is used for domestic hoarding as often as the euro, and according to Equation (8) with Canada as a reference country, the share of domestic demand for euro banknotes is likely to be overestimated and, correspondingly, the share of foreign demand for euro banknotes is likely to be underestimated.⁴⁰ The latter estimate is shown in Chart 21 and Chart 22.

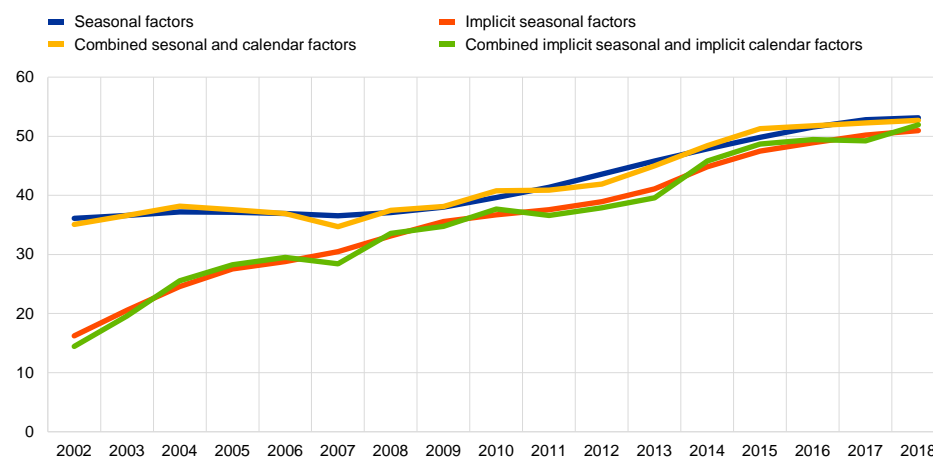
³⁹ The amount of Canadian dollar banknotes in circulation had risen from CAD 36 billion in January 2002 to CAD 90 billion in July 2019, with the bulk of this increase represented by the highest-denomination CAD100 notes.

⁴⁰ The seasonal pattern of Canadian banknotes in circulation, S^d , is dampened by foreign demand for Canadian banknotes. Therefore, without foreign demand, S^d would be higher in December and lower in February. The denominator in Equation (8) would therefore rise and the share of euro banknotes held in the euro area of total euro banknotes in circulation, β , would fall.

Chart 21

Share of euro banknotes held abroad in total euro banknotes in circulation

(percentages)



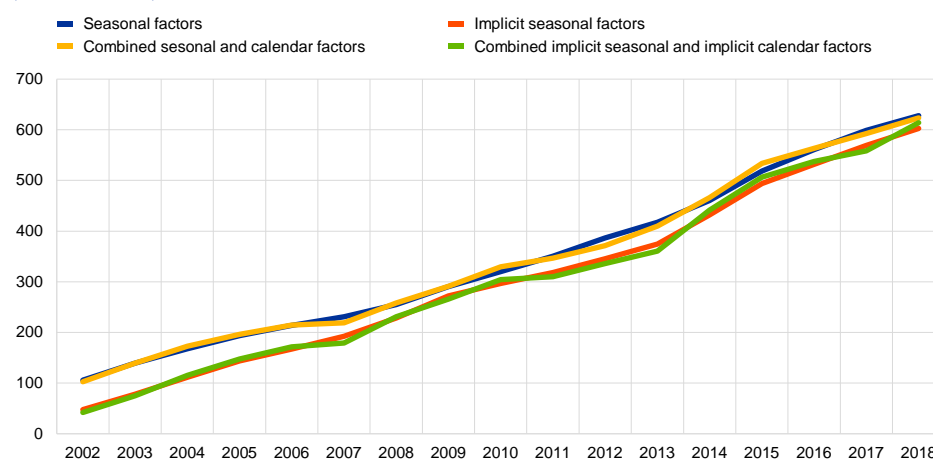
Source: Author's calculation.

Chart 21 shows the estimated share of euro banknotes held abroad of total euro banknotes in circulation, according to Equation (8). To check robustness we have used four ways of calculating S and S^d : 1) seasonal adjustment of banknotes in circulation as an aggregate ("seasonal factors"), 2) combined seasonal and calendar adjustment of banknotes in circulation as an aggregate ("combined seasonal and calendar factors"), 3) seasonal adjustment of banknotes in circulation as a sum of the individual denominations ("implicit seasonal factors"), 4) combined seasonal and calendar adjustment of banknotes in circulation as a sum of the individual denominations ("combined implicit seasonal and implicit calendar factors"). Except for the first few years after the cash changeover, the estimates are quite similar. The estimated foreign share of euro banknotes shows a positive trend, amounting to about 50% in 2018.

Chart 22

Euro banknotes held abroad

(value, EUR billions)



Source: Author's calculation.

Outcome. Chart 22 shows the corresponding estimates on a value basis. According to this chart, foreign demand for euro banknotes rose from between €50 billion and €100 billion in 2002 to about €600 billion in 2018, which represents 49% of the total value of euro banknotes in circulation.

Limitations. According to the selection criteria, there are a number of assumptions underlying this approach that need to hold up. When choosing a reference country for the seasonal method the euro area and the reference country must use domestic banknotes in a similar manner. This implies that the reference country must have a similar domestic transaction pattern as well as a similar domestic hoarding pattern. An additional assumption is that the reference country must have no significant foreign demand for banknotes. In the case of Canada, which is chosen as a reference country here, both of these assumptions are only partially fulfilled. The first assumption cannot be accurately verified because exact estimates are not available for the volume of domestic hoardings of banknotes in the euro area and Canada. Despite this, the literature points to a strong store of value demand in both the euro area and Canada. Additionally, banknote denominations differ between the Canadian dollar and the euro, and card payments are more widespread in Canada than in the euro area, which may affect hoarding and transaction patterns differently. With regard to the second assumption, this is also only partially fulfilled as there is evidence of fairly weak foreign demand for Canadian banknotes.

3.4 The age of banknotes method

Prepared by Marco Brandi, Banca d'Italia

This method relies on the assumption that the age of banknotes⁴¹ depends mainly on their usage. Banknotes that are exported tend to return to NCBs less frequently, so their average age is greater than those of a currency that is not exported.

The model used is shown below, using same technique introduced in Section 3.3.

The shares of two quantities β_1 and β_2 in respect of the characteristics X_1 and X_2 lead to a weighted average:

$$X = \beta_1 X_1 + \beta_2 X_2 \quad (9)$$

Where $\beta_1 = 1 - \beta_2$

The shares may be estimated such as:

⁴¹ The *age of banknotes* methodology is described in Bartzsch et al. (2013), and is formulated following Feige (1997).

$$\beta_1 = \frac{X - X_1}{X_1 - X_2}$$

$$\beta_2 = \frac{X_1 - X}{X_1 - X_2}$$
(10)

An additional assumption is that the age characteristic of the banknotes held outside the euro area (X^a) differs sufficiently from that of the outstanding banknotes within the euro area (X^d). The average age (or rather lifespan) of banknotes (LS) is calculated using the LifeSpan indicator from the Eurosystem cash database, CIS2, which is a weighted mean of inflows and outflows:

$$LS_t = 2 * \frac{n_t}{q_t + v_t}$$
(11)

where n denotes the average number of banknotes in circulation, q the average number of new banknotes issued, v the average number of banknotes destroyed (withdrawn from circulation) and t the corresponding year⁴².

In principle, the indicator can be used to derive the domestic share of euro banknotes in circulation β^d , and the foreign share of euro banknotes in circulation β^a , as in the formula for β_2 above (Feige, 2009):

$$\beta^a = \frac{LS^d - LS}{LS^d - LS^a}$$
(12)

While an estimate for LS is available in CIS2, LS^d must be estimated using a reference country which is similar to the euro area in respect of banknote demand but has no foreign demand. However, the age (or lifespan) of euro banknotes abroad, LS^a , is unknown. Therefore, we calculate the share of euro banknotes abroad, β^a , as follows:

$$\beta^a = \frac{LS^{EA} - LS^{DK}}{LS^{EA}}$$
(13)

Denmark is used as the reference country. While its economy and public behaviour are similar to the euro area, there is no foreign demand for Danish krone banknotes⁴³. The average age of Danish krone banknotes, LS^{DK} , was 8.9 years in 2019⁴⁴, in line with expectations for the normal lifespan of non-exported euro banknotes, whereas the actual average age of euro area banknotes, LS^{EA} , was 17.1 years in 2019. As is

⁴² The averages, or rather weighted means, refer to the individual denominations.

⁴³ Canadian dollars are not considered because the material of the banknotes is different (polymer instead of paper), which could lead to misleading results.

⁴⁴ It is not possible to apply the *age of banknotes* method to previous years using the lifespan due to the introduction of new series with different timing (Danish krone 2009-2011, euro 2013-19), which could lead to misleading results.

to be expected, euro banknotes are older than Danish banknotes because of the time they spend abroad.

Outcome. The estimates produced using this method point to an average share of banknotes circulating outside the euro area of 48% in 2019.

Limitations. The main assumption which needs to be fulfilled is that a difference in the age of banknotes between two different currencies must derive from stronger foreign demand for one of the currencies. However, the difference in the age of banknotes between the euro and the Danish krone may not only be due to the international role of the euro. Domestic hoarding patterns may also be different, which would also affect the differing age of banknotes. In particular, it is worth noting that two denominations of euro banknotes have a larger value than the highest denomination of Danish banknotes, which may result in a greater store-of-value function in the euro area. If euro area citizens hoard more cash than Danish citizens, the calculation based on the age of banknotes will tend to overestimate the foreign circulation of euro banknotes as the difference in age does not account for the higher level of domestic hoarding in the euro area. It should also be noted that banknote recirculation (i.e. private cash handlers returning banknotes to circulation) is not accounted for in the LifeSpan indicator. This means that the LifeSpan indicator only takes into account outflows from and inflows to central banks, although it does allow for the fact that the same banknote could be circulated several times in the private sector. For this reason, taking into account the different recirculation patterns in Denmark and the euro area would also affect the presented results.

Box 2

First estimates of net cash remittances over time for the euro area

Prepared by Alejandro Zamora-Pérez, ECB and Marco Brandi, Banca d'Italia

Using remittance data as a proxy for non-registered cash remittances

Ludwig (2016) uses a simple approach to derive an interval estimate of net cash remittances in Germany. Using the World Bank's annual remittance data, Ludwig uses extreme assumptions to estimate the upper and lower bounds for the share of remittances made in cash⁴⁵. Freund and Spatafora (2005) have estimated that the value of informal remittances represents between 35% and 75% of the value of formal transfers in the global remittance market. This wide range should only be used as a reference, as it may vary widely across countries and over time. In particular, the interval also takes into account remittances between developed countries, which has led Ludwig to conclude that informal remittances in Germany should be closer to the lower end of the range. It is also the case that the range should not apply equally to inward and outward remittances. In Germany, as in most major euro area countries, it may be assumed that the share of cash remittances is larger for outflows than for inflows. Migrants transferring money from the euro area to developing and transition countries, where residents may have poor access to formal saving channels or distrust the financial system (see the discussion in Section 2.1.) may resort more frequently to informal channels than the

⁴⁵ Formal remittances are settled, inter alia, via money transport operators, bank transfers and state-recognised hawala systems. Informal remittances comprise cash takings and non-state recognised hawala systems. Only informal remittances lead to exports or imports of cash, but not all informal remittances, e.g. non-state recognised hawala systems, involve cross-border flows of cash.

other way round. Finally, not all informal remittances involve flows of cash out of or into a country (e.g. non-state recognised hawala systems).

- Assumptions for the upper bound:
 - (a) Cash remittance outflows represent 40% of the value of formal outflows.
 - (b) Cash remittance inflows occur exclusively via formal channels.
- Assumptions for the lower bound:
 - (c) Cash remittance outflows represent 20% of the value of formal outflows.
 - (d) Cash remittance inflows represent 10% of the value of formal inflows.

A first interval estimate of net cash remittances for the euro area

First estimates of net cash remittances in the euro area can be produced following the above method. Using the latest release of the World Bank's remittance data (April 2020)⁴⁶ and considering these assumed parameters to be valid for the whole of the euro area, similar estimates can be produced for the euro area. In order to calculate the interval estimates, the remittance series are corrected for intra-euro area remittances⁴⁷.

Following this approach, in 2018 cumulated net cash remittance outflows represented between 6.6% (€81 billion) and 24.6% (€302.5 billion) of total cash in circulation. Given the uncertainty of the assumptions, no central estimate was produced using this approach. Chart A below plots the interval estimate for net cash issuances over time.

Although these first estimates are a valuable first approximation, there is a significant amount of uncertainty surrounding them and a number of important caveats should be made. First, the assumptions underlying the upper bound are likely to be too extreme – it is almost certain that only a small proportion of remittance flows into the euro area are made in cash. In addition, it is likely that cash remittances represent much less than 40% of formal remittances, given that a significant share of remittances go to non-euro area developed countries and transition countries in which formal channels may be used predominantly. It should also be noted that these shares only partly account for net cash remittances, i.e. cash is not necessarily kept permanently outside the euro area as it could return to the euro area via other channels (e.g. recipients of cash abroad may exchange it in local bureaux de change or (less likely) carry it with them when travelling in the euro area). Also, euro area countries show widely different compositions of remittance flows. For example, according to

⁴⁶ For the purposes of this report, we use World Bank data instead of ECB data on money remittances, as these are reported as a memorandum item, i.e. on a voluntary basis (see Guideline ECB/2014/15 on monetary financial statistics). Money remittance – as defined in Article 4 of Directive 2007/64/EC of the European Parliament and of the Council – is a simple payment service that is usually based on cash provided by a payer to a payment service provider, which remits the corresponding amount (e.g. via a communication network) to a payee or to another payment service provider acting on behalf of the payee. In some Member States supermarkets, merchants and other retailers provide the public with a corresponding service supporting the payment of utility and other regular household bills. These bill-paying services should be treated as money remittances, unless the competent authorities consider the activity to be one of the other payment services listed in the Annex.

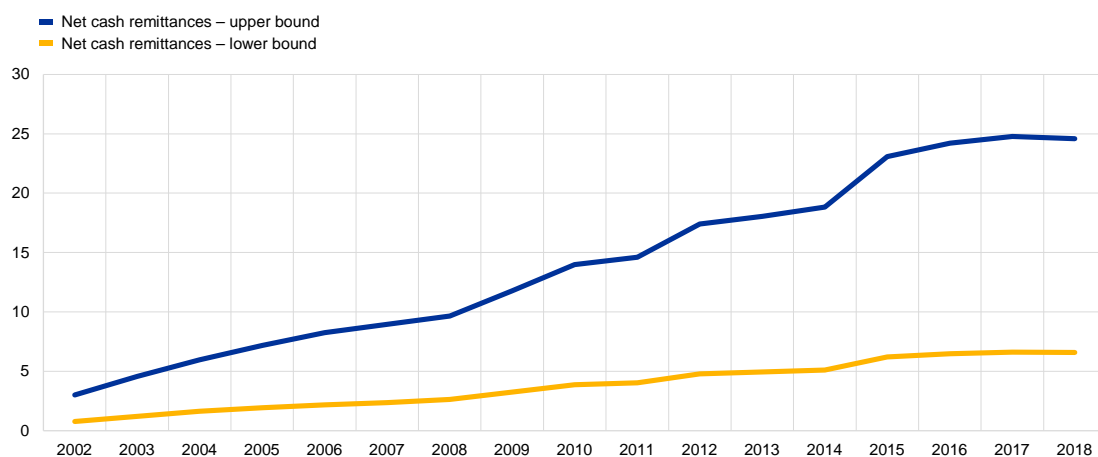
⁴⁷ In the following analysis, this correction is made using the World Bank's latest bilateral remittance data. These estimates were only published from 2010 to 2017: the average of the available data points are used for the remaining years. The sensitivity of this assumption has been tested and relaxing it does not significantly change the final results. One explanation is that the shares of intra-euro remittances of total remittances have not varied significantly over the years considered (35.5% to 37.5% for inflows and 31.5% to 35% for outflows), and there is no clear trend over time.

World Bank data, remittance outflows to non-euro area countries from Greece, Cyprus and Slovakia represent around 90% of total outflows, while in Luxemburg, Portugal and Belgium they only represent between 10% and 35% of total outflows. Finally, as the parameters are fixed over time, they do not account for trends in financial innovation and the reduction in costs for formal remittance channels in recent years (World Bank, 2018). It is therefore likely that cash remittance flows have reduced over time, and time-varying assumptions for the upper and lower bound are probably more reliable for developing future estimates.

Chart A

Estimate of net cash remittances over time

(percentage of total circulation)



Source: Authors' calculation.

Recommendation for future research: assessing the size and determinants of the informal channels

Future research should be undertaken to narrow the interval and reduce uncertainty by comparing the assumptions with Eurosystem survey data or accounting for trends in the use of different transfer channels.

Using survey data for the Netherlands, Kosse and Vermeulen (2014) shed light on what determines whether migrants use formal or informal channels. The results they obtained suggest that general payment behaviour (e.g. the frequency of using internet banking for other purposes), education, the remittance amount, the perceived costs of different channels and the availability of remittance options have an impact on the decision to use cash instead of formal channels for remittances. Carrying out new surveys to analyse whether similar conclusions can be drawn for other countries would significantly improve our knowledge of this matter, thus reducing the uncertainty of the above estimates.

Potential improvements could also be achieved by following indirect approaches. Ferriani and Oddo (2019) find a strong positive correlation between money remittances transferred through registered financial intermediaries and the cost of travel between Italy and a migrant's home country. They use three different methods to estimate the size of the informal outflow to the geographical area of the migrant's home country (e.g. Asia, Eastern Europe, Central and South America, Northern Africa, etc.). All the methods proposed lead to estimates that are higher for the geographically closest areas. This indicates that distances and transport costs can affect the alternative channels (i.e. the informal

channels for remitters are more attractive when travel costs are low and the fees of registered channels are high). Having assessed the importance of the informal channel, the authors assume that remittances in this channel are exclusively made in cash.

4 Conclusion: foreign demand, a key to the paradox of banknotes

A multitude of factors explain foreign demand for euro banknotes. The relevant literature points to local factors as the main cause of international flows of euro in cash. These factors include inflation in the domestic country (current inflation or the memory of past inflation), political uncertainty, the degree of trust in financial institutions, opportunity costs versus other assets, and the relative attractiveness of holding other foreign currencies (as measured by the exchange rate). In addition, demographic factors also play a role in the preference for cash, e.g. financial inclusion, education and income levels. In general, if the domestic currency is not trusted to preserve its value (or has not been trusted in the past), a foreign currency that is strong, safe and backed by reliable and trusted governments represents a store-of-value opportunity in foreign countries.

A macro-econometric model for the demand for euro banknotes (D€notes) has provided evidence that variables related to demand from abroad influence overall demand for euro banknotes, especially for the highest denominations. Furthermore, a first analysis of the determinants of euro cash net shipments corroborates some of the findings of the literature, confirming that euro cash is used abroad as a store of value and its flows are associated with economic activity in the receiving countries. Determinants of euro cash flows are mainly local-specific, meaning that they are found in factors which affect countries with a demand for euro (local inflation and economic activity) rather than external factors (global uncertainty or short-term interest rates in the euro area). One exception is that appreciation of the euro against the dollar seems to lead to higher euro cash flows. These results seem to be driven mainly by medium and high denominations.

Regional peculiarities have also been identified thanks to research based on OeNB Euro Survey data. It has been shown that the euro is preferred in neighbouring countries (i.e. areas of influence). In this case geographical proximity, a shared history and the outlook for euro adoption play an important role. These countries are also providers of migrant and short-term workers who generate cash remittances (as described in Box 2, distance from the home country may have an impact on the importance of informal remittance channels). In general, the role of tourism and cross-border shopping in the euro area (i.e. the transaction motive) should also not be neglected. Finally, developments in the first weeks of the coronavirus (COVID-19) crisis showed that fears of an interruption in euro supplies caused foreign entities to build up precautionary stocks.

The study points to a usage of euro banknotes abroad of between 30% and 50% of the total value in circulation. To ensure the results are robust, direct approaches (based on net shipments data) and indirect approaches (the seasonal method, the age of banknotes method and an ECB-published estimation method) were used in this research to estimate the share of euro banknotes circulating outside the euro area.

These methods point to a circulation of banknotes abroad of between 30% and 50% of the total value in circulation. The ECB methodology yields a central estimate of €400 billion for foreign circulation at the end of 2019 (30% of the total value in circulation). The impact on the average estimate of the limitations surrounding the upper and lower bounds is not immediately obvious. The results of the seasonal and age of banknote methods coincide, producing an estimate of around €600 billion (close to 50% of total circulation). A simple method has also been used to obtain a rough interval estimate of the cumulated net remittances of euro cash. However, the estimate of cumulated net cash remittances is surrounded by a number of uncertainties and should, therefore, be interpreted with caution.

Annex 1: Methodological notes on the data

Net shipments data

The net shipments data cover the registered imports and exports of euro banknotes between the euro area (the EU Member States and institutions of the euro area, in changing composition) and the rest of the world (non-resident credit institutions and national central banks – NCBs). Net shipments represent cumulated banknotes exported minus banknotes imported.

Pursuant to Article 2 of the Guideline on statistical reporting requirements in the field of external statistics⁴⁸, a threshold applies for reporting banknote shipments data to the ECB, i.e. the NCBs must report data on cross-border shipments of euro banknotes if the best estimate of the total amount of all cross-border shipments within the previous year exceeds €1,000 million. Annex 1 stipulates that NCBs should deliver a breakdown by denomination on a best-estimate basis. Currently, seven NCBs send data to the ECB on a regular basis, with Germany and Austria being by far the largest contributors.

According to the ECB's External Statistics and Sector Accounts Division, based on regular feedback from reporters, the available data are estimated to account for approximately 99% of the cross-border euro banknote shipments which take place via banking channels. All series expected from reporting NCBs are received consistently and in a timely manner.

Wholesome trade data

Banknote wholesalers trade in foreign currency banknotes and act as intermediaries between NCBs and commercial banks, bureaux de change and central banks in regions outside the euro area. They are responsible for most of the transactions included in the monthly net shipments statistics. The ECB has been collecting euro banknote trade data from these international banknote wholesalers on an annual basis since 2006. The outcome of the annual exercise is sent to the Banknote Committee (BANCO) via the “Annual report on banknotes and coins” and is published in the ECB's report entitled “The international role of the euro”. The volumes reported have been corrected for transactions between the reporting wholesalers. Generally, no breakdown is provided for the denominations sold and purchased (although the breakdown for high denominations has been reported since 2009, and including the €100 banknote since 2019).

⁴⁸ Guideline ECB/2011/23 as amended on the statistical reporting requirements of the European Central Bank in the field of external statistics.

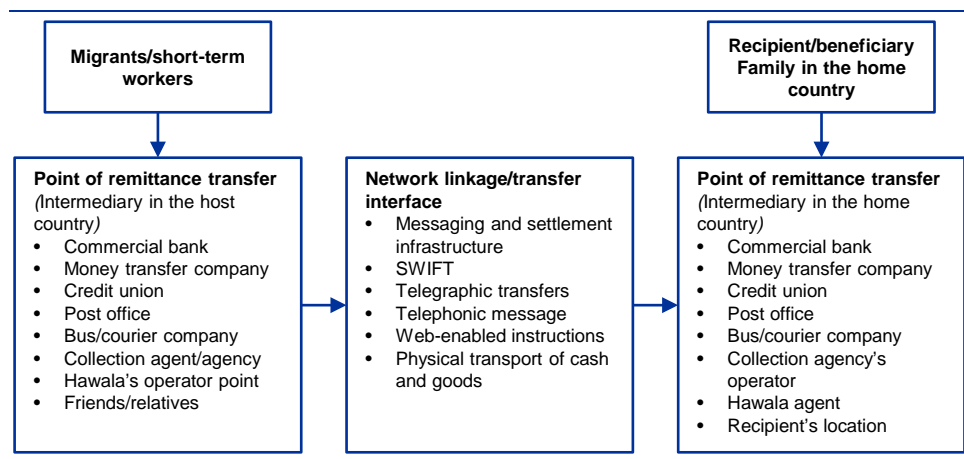
Survey of households in CESEE

The survey, which covers six EU Member States (Bulgaria, the Czech Republic, Croatia, Hungary, Poland and Romania), three EU candidate countries (Albania, North Macedonia and Serbia) and the potential candidate country Bosnia and Herzegovina, has been conducted since autumn 2007. From 2007 to 2014, surveys were conducted twice a year, in spring and autumn, although in 2015 the survey frequency was reduced to once a year (autumn). In each country, face-to-face interviews are carried out with about 1,000 randomly selected individuals aged over 14 years. The sample is representative in respect of age, gender and regional distribution.

Annex 2: Remittance channels

Cross-border remittances are difficult to measure because they are heterogeneous and consist of numerous small transactions conducted by individuals through a large variety of channels.

Figure A.1
Remittance channels



Source: IMF, "Understanding Remittances: Demography, Transaction Channels, and Regulatory Aspects"
Note: Not all funds transferred via these channels are remittances.

Annex 3: Euro bill tracker

Prepared by Martti Naski

Euro bill tracker is a website that enables people to monitor the movement of banknotes worldwide. The goal is to record as many banknotes as possible in order to establish details of their distribution and movements (such as where a banknote has been seen) and generate statistics and rankings (e.g. which countries show the most movements).

The application also allows “hits” to be followed, i.e. where the same banknote is used more than once. The main drawback of using these data is the fact that data collection is decentralised and there are no effective checks available to verify the validity of the statistics.

This tool shows information on banknote migration, both within and outside the euro area, which is caused mainly by tourism. Approximately 194 million euro banknotes have been registered, representing 1% of all euro banknotes in circulation. According to Euro bill tracker statistics, last year euro banknotes were present in 140 countries worldwide. More than 90% of the banknotes were registered in the euro area, with 9.9% registered in neighbouring countries. The number of banknotes reported has declined in recent years (the peak was reached in 2009 with 16.2 million banknotes tracked, compared with 9.2 million banknotes tracked in 2019), which suggests that the website is not as popular as it used to be. The available data show that the most frequently recorded denominations are €5 and €10 notes. Irrespective of the banknotes’ value, this shows that tourists are willing to take foreign banknotes back to their countries when they return home.

In conclusion, the data shed light on banknote movements, offering an anecdotal description of movements induced by tourism outside the euro area. They are, however, too limited to provide any useful basis for analysis.

Annex 4: A tourist's journey

Figure A.2

The journey of a tourist from non EA countries

Withdrawal for holiday to euro area country



Option 1. Tourists withdraw euro banknotes from ATM's in their home country before departure

Option 2. Tourists withdraw euro banknotes from ATMs in the euro area upon arrival

Replenishments during the holiday



At ATMs within the euro area

Cash in wallet before departure to home country



Option 1. Tourists exchange all their euro before departure – no cash left

Option 2. Tourists exchange a part of their euro before departure

Option 3. Tourists do not exchange their euro before departure

Cash at home



Option 1. Tourists exchange all their euro in their home country

Option 2. Tourists exchange a part of their euro in their home country to spend on shopping, although they may also travel again

Option 3. Tourists do not exchange their euro in their home country and do not travel again

→ Decreases return frequency of banknotes but banknotes come back

→ Decreases return frequency of banknotes and banknotes do not come back

References

- Alhassan, A., Li, L., Reddy, K. and Duppati, G. (2019), "The impact of formal financial inclusion on informal financial intermediation and cash preference: evidence from Africa", *Applied Economics*, March.
- Amromin G. and Chakravorti, S. (2009), "Whither Loose Change? The Diminishing Demand for Small-Denomination Currency", *Journal of Money, Credit and Banking*, Vol. 41, No 2-3, pp. 315-335.
- Assenmacher, K., Seitz, F. and Tenhofen, J. (2018), "The use of large denomination banknotes in Switzerland, War on cash: Is there a future for cash? *International Cash Conference 2017, Conference volume*, Deutsche Bundesbank, pp. 148-199.
- Assenmacher, K., Seitz, F. and Tenhofen, J. (2019), "The demand for Swiss banknotes: some new evidence", *Swiss Journal of Economics and Statistics*, Vol. 155, No 14.
- Banegas, A., Judson, R., Sims, C. and Stebunovs, V. (2015), "International Dollar Flows", *Discussion Paper*, No 1144, Board of Governors of the Federal Reserve System International Finance.
- Banerjee, A. V. and Duflo, E. (2007), "The Economic Lives of the Poor", *Journal of Economic Perspectives*, Vol. 21, No 1, pp. 141-167.
- Bailey, A. (2009), "Banknotes in Circulation – Still Rising. What does this Mean for the Future of Cash?" *Keynote address, Banknote 2009 Conference*, Washington, DC.
- Bartzsch, N., Gerdesmeier, D., Landau, B., Maddaloni, G., Rocco, G., Roffia, B. and Rua, A. (2019), "Forecasting the Demand for Banknotes in the Euro Area", *International Cash Conference 2019*, Deutsche Bundesbank.
- Bartzsch, N., Rösl, G. and Seitz, F. (2011a), "Foreign demand for euro banknotes issued in Germany: estimation using direct approaches", *Discussion Paper, Series 1: Economic Studies* (20/2011), Deutsche Bundesbank.
- Bartzsch, N., Rösl, G. and Seitz, F. (2011b), "Foreign demand for euro banknotes issued in Germany: estimation using indirect approaches", *Discussion Paper, Series 1: Economic Studies* (21/2011), Deutsche Bundesbank.
- Bartzsch, N., Rösl, G. and Seitz, F. (2013), "Estimating the foreign circulation of banknotes", *Economics Letters*, Vol. 119, pp. 165-167.
- Beck, T., Demirgüç-Kunt, A. and Levine, R. (2003), "Law and finance: why does legal origin matter?", *Journal of Comparative Economics*, Vol. 31 No 4, pp. 653-675.
- Beckmann, E. (2013), "Financial Literacy and Household Savings in Romania", *Numeracy*, Vol. 6, No 2, Article 9.

- Beckmann, E., Hake, M. and Urvova, J. (2013), “Determinants of Households’ Savings in Central, Eastern and Southeastern Europe”, *Focus on European Economic Integration*, No 3, Oesterreichische Nationalbank, Vienna, pp. 8-29.
- Brendstrup B., Hylleberg, S., Nielsen, M.Ø., Skipper, L. and Stentoft, L. (2004), “Seasonality in economic models”, *Macroeconomic Dynamics*, Vol. 8, pp. 362-394.
- Brown, M. and Stix, H. (2015), “The euroization of bank deposits in Eastern Europe”, *Economic Policy*, Vol. 30, No 81, pp. 95-139.
- Calvo, G.A. and Vegh, C.A. (1992), “Currency Substitution in Developing Countries: An Introduction”, *IMF Working Paper*, No 92/40.
- Claessens, S., and Rojas-Suarez, L. (2016), “Financial Regulations for Improving Financial Inclusion”, *CGD Task Force Report, Center for Global Development*, Washington, DC.
- Coupé, T. (2011), “Mattresses versus Banks – The Effect of Trust on Portfolio Composition”, *Discussion Papers*, No 40, Kyiv School of Economics and Kyiv Economics Institute.
- Consultative Group to Assist the Poor (2012), *Social Cash Transfers and Financial Inclusion: Evidence from Four Countries*, Washington, DC.
- Davis, S.J. (2016), “An Index of Global Economic Policy Uncertainty”, *NBER Working Paper*, No 22740.
- Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S. and Hess, J. (2018), *The Global Findex Database 2017: Measuring financial inclusion and the fintech revolution*, World Bank Group, Washington, DC.
- Deutsche Bundesbank (2015), “Seasonal Method”, *Monthly Report*, April, pp. 64-65.
- Deutsche Bundesbank (2018), “The demand for euro banknotes at the Bundesbank”, *Monthly Report*, March, pp. 37-51.
- Dupas, P. and Robinson, J. (2013), “Savings Constraints and Microenterprise Development: Evidence from a Field Experiment in Kenya”, *American Economic Journal: Applied Economics*, Vol. 5, No 1, pp. 163-192.
- Dupas, P., Karlan, D., Robinson, J. and Ubfal, D. (2018), “Banking the Unbanked? Evidence from Three Countries”, *American Economic Journal: Applied Economics*, Vol. 10, No 2.
- Engert, W., Fung, B. and Segendorf, B. (2019), “A tale of two countries: Cash demand in Canada and Sweden”, *Staff Discussion Papers*, No 2019-7, Bank of Canada.
- European Central Bank (2011), “The use of euro banknotes – results of two surveys among households and firms”, *Monthly Bulletin*, April.
- European Central Bank (April 2017), *Estimation of euro currency in circulation outside the euro area*.

European Central Bank (June 2018), *The international role of the euro*, interim report.

European Central Bank (June 2019), [The international role of the euro](#) (accessed 5 May 2020).

Esselink, H. and Hernández, L. (2017), "The use of cash by households in the euro area", *Occasional Paper Series*, No 201, ECB, Frankfurt am Main.

Evans, D.S. and Pirchio, A. (2015), "An Empirical Examination of Why Mobile Money Schemes Ignite in Some Developing Countries but Flounder in Most", *Review of Network Economics*, Vol. 13, No 4.

Feige, E.L. (1997), "Revised estimates of the underground economy: Implications for US currency held abroad", *MPRA Discussion Paper*, No 13805.

Fischer, B., Köhler, P. and Seitz, F. (2004), "The demand for euro area currencies: Past, present and future", *Working Papers*, No 330, ECB, Frankfurt am Main.

Ferriani, F. and Oddo, G., (2019), "More distance, more remittance? Remitting behavior, travel cost, and the size of the informal channel", *Economic Notes*.

Flannigan, G. and Parsons, S. (2018), "High-denomination banknotes in circulation: A cross-country analysis", *Bulletin*, Reserve Bank of Australia, March, pp. 14-30.

Franses, P.H. (1996), "Recent advancements in modelling seasonality", *Journal of Economic Surveys*, Vol. 10, No 3, pp. 299-345.

Freund, C. and Spatafora, N. (2005), "Remittances: transaction costs, determinants, and informal flows." *Policy Research Working Paper*, Vol. 3704, World Bank, Washington, DC.

Grosjean, P. (2011), "The institutional legacy of the Ottoman Empire: Islamic rule and financial development in South Eastern Europe", *Journal of Comparative Economics*, Vol. 39, No 1, pp. 1-16.

Grohmann, A., Klühs, T. and Menkhoff, L. (2018), "Does financial literacy improve financial inclusion? Cross country evidence", *World Development*, Vol. 111, pp. 84-96.

Guiso, L., Sapienza, P. and Zingales, L. (2004), "The Role of Social Capital in Financial Development", *American Economic Review*, Vol. 94, No 3, pp. 526-556.

Haasl, T., Schulhofer-Wohl, S. and Paulson, A. (2018), "Understanding the Demand for Currency at Home and Abroad", *Chicago Fed Letter*, No 396.

Hellerstein, R. and Ryan, W. (2011), "Cash dollars abroad", *FRBNY Staff Report*, No 400.

Hubrich, Kirstin and Karlsson, Tohmas (2010), "Trade consistency in the context of the Eurosystem projection exercises: an overview", *Occasional Paper Series*, No 108, ECB, Frankfurt am Main.

- Jack, W. and Suri, T. (2014), "Risk Sharing and Transactions Costs: Evidence from Kenya's Mobile Money Revolution", *American Economic Review*, Vol. 104, No 1, pp. 183-223.
- Jiang, J.H. and Shao, E. (2020), "The cash paradox", *Review of Economic Dynamics*, Vol. 36, pp. 177-197.
- Judson, R. (2012), "Crisis and Calm: Demand for U.S. Currency at Home and Abroad from the Fall of the Berlin Wall to 2011", *Board of Governors of the Federal Reserve System International Finance Discussion Paper*, No 1058.
- Judson, R. (2017), "The future of cash in crisis and calm", *International Cash Conference 2017, Conference volume*, Deutsche Bundesbank, pp. 200-249.
- Judson, R. (2017), "The death of cash? Not so fast: Demand for U.S. currency at home and abroad, 1990-2016", "War on cash: Is there a future for cash?", *International Cash Conference 2017, Conference volume*, Deutsche Bundesbank, pp. 200-248.
- Klapper, L. and Singer, D. (2014), "The Opportunities of Digitizing Payments," *The World Bank Development Research Group, the Better Than Cash Alliance, and the Bill & Melinda Gates Foundation, prepared for the G20 Global Partnership for Financial Inclusion*.
- Knell, M. and Stix, H. (2009), "Trust in banks? Evidence from normal times and from times of economic crises", *Working Papers*, No 158, Oesterreichische Nationalbank, Vienna.
- Kosse, A. and Vermeulen, R. (2014), "Migrants' choice of remittance channel: Do General payment habits play a role?", *World Development*, No 62, pp. 213-227.
- Lalouette, L. and Esselink H. (2018), "Trends and developments in the use of euro cash over the past ten years", *Economic Bulletin*, Issue 6/2018, ECB, Frankfurt am Main.
- Ludwig, J. (2016), "Schätzung der Bargeldsendungen von Migranten in Deutschland in ihre Heimatländer" [Remittances of migrants in Germany to their home countries], *Arbeit im Rahmen des Referendariats der Deutschen Bundesbank*, mimeo.
- Mark, N., Ogaki, M. and Sul, D. (2005) "Dynamic Seemingly Unrelated Cointegrating Regressions", *Review of Economic Studies*, Vol. 72, No 3, pp. 797-820.
- Newman, C., Tarp, F. and Van Den Broeck, K. (2014), "Social Capital, Network Effects, and Savings in Rural Vietnam," *The Review of Income and Wealth*, Vol. 60.
- Png, I. and Tan, C. (2020), "Privacy, trust in banks and use of cash," *Macroeconomic Review*, Special Feature C, April, pp. 109-116.
- Porter, R. and Judson, R. (1996) "The Location of U.S. Currency: How Much Is Abroad?", *Federal Reserve Bulletin*, No 82 (10), pp. 883-903.

- Prian, N. and Stix, H. (2011), "The effect of raising deposit insurance coverage in times of financial crisis – Evidence from Croatian microdata", *Economic Systems*, Vol. 35, No 4, pp. 496-511.
- Ritzberger-Grünwald, D. and Scheiber, T. (2012), "Euro Cash in Central, Eastern and Southeastern Europe", *Monetary Policy & the Economy*, No 1, Oesterreichische Nationalbank, Vienna, pp. 41-55.
- Rua, A. (2018), "Modelling currency demand in a small open economy within a monetary union", *Economic Modelling*, Vol. 74, pp. 88-96.
- Rua, A. (2020), "Modelling currency demand: the case of the euro", *Empirical Economics*.
- Scheiber, T. and Stern, C. (2016), "Currency substitution in CESEE: why do households prefer euro payments?", *Focus on European Economic Integration*, No 4, Oesterreichische Nationalbank, Vienna, pp. 73-98.
- Scheiber, T. and Stix, H. (2009), "Euroization in Central, Eastern and Southeastern Europe – New Evidence on Its Extent and Some Evidence on Its Causes", OeNB Working Paper, No 159.
- Scheiber, T. (2019), "The use of euro cash in CESEE and the role of euro adoption expectations", *Focus on European Economic Integration*, No 3, Oesterreichische Nationalbank, Vienna, pp. 76-94.
- Seitz, F. (1995), "The circulation of Deutsche Mark abroad", Discussion Paper 1/95, *Economic Research Group*, Deutsche Bundesbank.
- Stix, H. (2011), "Euroization: what factors drive its persistence? Household data evidence for Croatia, Slovenia and Slovakia", *Applied Economics*, Vol. 43, pp. 2689-2704.
- Stix, H. (2013), "Why do people save in cash? Distrust, memories of banking crises, weak institutions and dollarization", *Journal of Banking & Finance*, Vol. 37, No 11.
- Sumner, S.B. (1990), "The transactions and hoarding demand for currency", *Quarterly Review of Economics and Business*, No 30 (1), pp. 75-89.
- Williams, J.C. (2012), "Cash is dead! Long live cash!", *Federal Reserve Bank of San Francisco Annual Report*.
- World Bank Group (2018), *Remittance Prices Worldwide*, Washington, DC.
- Zinsa, A. and Weill, L. (2016), "The determinants of financial inclusion in Africa", *Review of Development Finance*, Vol. 6, No 1, pp. 46-57.
- Zimmerman, J., Bohling, K. and Parker, S.R. (2014), "Electronic G2P Payments: Evidence from Four Lower-Income Countries", *CGAP (Consultative Group to Assist the Poor) Focus Note 93/2014*.

Acknowledgements

The authors would like to thank the members of the Banknote Committee and Björn Fischer (European Central Bank) for their useful comments. We also thank the Bank of Canada and Danmarks Nationalbank who provided the data we needed to develop our analysis.

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PDF ISBN 978-92-899-4510-3, ISSN 1725-6534, doi:10.2866/965881, QB-AQ-21-001-EN-N