

The demand for euro banknotes at the Bundesbank

The volume of euro banknotes in circulation issued by the Bundesbank has continued to grow strongly over the past few years. The value of the cumulative net issuance of euro banknotes by the Bundesbank went up from €348 billion to €635 billion between late 2009 and the end of 2017. This means that, since 2010, the Bundesbank has issued euro banknotes with an average annual net value of €35.8 billion, corresponding to an annual average rate of growth of 7.8%.

Estimates of how German-issued banknotes in circulation are distributed between banknotes held for domestic transaction purposes (domestic transaction balance), domestic hoarding and foreign demand (banknotes in circulation abroad) have been shown to be useful for investigating banknote issuance in Germany. According to such estimates, in the period since 2010, foreign demand for banknotes has played the largest part in the increase in the value of German-issued banknotes in circulation. There has also been an increase in domestic hoarding, which, in terms of value, is the largest component of the volume of banknotes in circulation in Germany. By contrast, the domestic transaction balance remained largely constant in terms of value and explains between 5% and 10% of the Bundesbank's cumulative net issuance of euro banknotes. According to new estimates, the domestic transaction balance of €5 banknotes amounts to around €2 billion, or 23%, the domestic transaction balance of €10 banknotes amounts to €4 billion, or 17%, and the domestic transaction balance of €20 banknotes amounts to around €9 billion, or 19%, of the net issuance of banknotes by the Bundesbank of each denomination.

In the recent past, there has been a focus on the impact of one-off developments on euro banknotes in circulation. Since proposals to discontinue the issuance of €500 banknotes became public knowledge, banknotes of this denomination have been returning to the Bundesbank on a significant scale. Economic agents have been replacing at least some of the returned €500 banknotes with banknotes of a lower denomination, however. Domestic hoarding is also of interest in light of the current low-interest-rate environment. There are no identifiable material changes in the estimated increase in domestic hoarding due to the low-interest-rate setting. This contrasts with the notable growth in the reported cash balances of credit institutions in Germany since 2016. These show that credit institutions are additionally holding banknotes with a value estimated at more than €10 billion in order to avoid negative rates of interest on deposits at the Bundesbank.

Value of euro banknotes in circulation growing

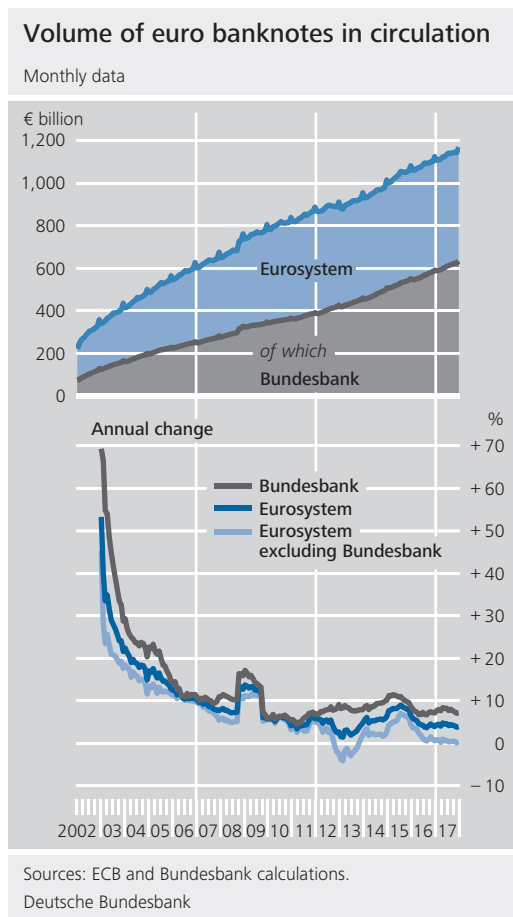
■ Euro banknotes in circulation

At the end of January 2002, shortly after the introduction of euro cash, the value of euro banknotes put into circulation by the Eurosystem totalled €221 billion; at the end of December 2017, the figure was €1,171 billion (see the chart below).¹ Since the launch of euro banknotes and coins, the volume of euro banknotes in circulation has been growing more quickly than economic output and the monetary aggregate M3 in the euro area.² The cumulative net issuance of euro banknotes by the Bundesbank increased at a particularly rapid pace compared with total euro banknotes in circulation.³ Between the introduction of euro cash and the end of December 2017, the cumulative net issuance of euro banknotes by the Bundesbank grew from €73 billion to €635 billion. The chart below shows that, as a rule, the growth rates of the Bundesbank's cumulative net issuance since the launch of euro cash have been

higher than the comparable Eurosystem growth rates if the Bundesbank is excluded.

The question arises as to the reasons for this strong growth, especially in German-issued euro banknotes in circulation. Basically, the interpretation of banknote issuance by national central banks in the Eurosystem is made more difficult by the fact that euro banknotes in circulation can migrate across national borders. Euro banknotes issued by the national central bank of one member country of the euro area may therefore also be located in another euro area country or in a country outside the euro area. It is possible to achieve a better understanding of banknote use in Germany by breaking down Bundesbank-issued banknotes into a domestic and a foreign component. As will be shown below, Germany is a net exporter of euro banknotes both to the rest of the euro area and to non-euro area countries. This means that the value of banknotes issued by the Bundesbank which are in circulation abroad (German gross exports) exceeds the value of those banknotes which are located in Germany and were issued by other Eurosystem central banks (German gross imports). Since Germany is a net exporter of banknotes, domestic demand for banknotes (banknotes in circulation in Germany) is, in mathematical terms, fully covered by the Bundesbank. In order to characterise domestic banknote use in greater detail, banknotes in circulation in Germany can be fur-

Cumulative net issuance by the Bundesbank is composed of banknotes in circulation abroad, the domestic transaction balance and domestic hoarding



¹ This article concentrates on euro banknotes in circulation. At the end of December 2017, a total of 126 billion euro coins with a value of €28.0 billion were in circulation, of which – in mathematical terms – 37 billion euro coins with a value of €8.37 billion were issued by the Bundesbank. As the volume of euro coins in circulation is small in terms of value, growth in euro banknotes in circulation is informative with regard to developments in the value of the demand for euro cash.

² See Deutsche Bundesbank (2016), Cash as a means of payment and a store of value, Annual Report 2015, pp 25-45.

³ The cumulative net issuance of euro banknotes by the Bundesbank corresponds to the sum of the Bundesbank's cash outflows less the sum of banknotes paid in. The euro banknotes issued by the Bundesbank are occasionally described below as "German" euro banknotes. It should be noted in this context that "German" euro banknotes are not necessarily located in Germany and that a considerable part of them are, in fact, in circulation abroad.

ther subdivided into the domestic transaction balance and domestic hoarding.⁴ Earlier studies analysed developments in “German” euro banknotes in circulation up to the end of 2009. The outcome was that the sharp increase in German-issued euro banknotes in circulation was due chiefly to foreign demand and, to a lesser extent, also hoarding in Germany.⁵

early stage. A sophisticated procedure is used to adjust the daily data for calendar and seasonal effects to allow a better assessment of developments, especially at the current end. The box on pages 40 and 41 contains details of how the daily time series of banknotes in circulation is seasonally adjusted.

Robust growth in “German” banknotes in circulation also since 2010

This article follows on from earlier studies and analyses developments in the cumulative net issuance of euro banknotes by the Bundesbank in the period from 2010 up to the current end.⁶ During the observation period of this article, this cumulative net issuance rose by an average of €35.8 billion annually and thus at a comparably rapid pace as in the period from 2003 to 2009, when its average annual growth was €31.3 billion. Reasons for this continuing sharp rise in German-issued euro banknotes in circulation are given by the current estimates of the banknote demand components presented below. Following the introduction of new euro banknotes of the second series (Europa series), it is possible for the first time to estimate transaction balances by denomination, too.⁷ The presented data are not directly observable in most cases and, instead, have to be estimated, which is why the results are subject to a degree of estimation uncertainty.

Particular questions

Recently, there has also been a focus on the impact of one-off developments on euro banknotes in circulation. In the wake of the decision taken in May 2016 to discontinue the production and issuance of €500 banknotes, anomalies arose in the cumulative net issuance of individual banknote denominations. These are described in the box on pages 45 and 46. Information on demand for banknotes in Germany in the context of the current low-interest-rate environment is provided by the estimated time series of domestic hoarding as well as the box on pages 43 and 44. For internal analyses, the Bundesbank constantly observes the daily time series of euro banknotes in circulation with regard to anomalies in order to determine the impact of relevant one-off developments at an

Domestic transaction balance

The domestic transaction balance comprises euro cash held by economic agents to settle cash payments. The domestic transaction balance can be approximated by an estimate of cash held by households for transaction purposes, an estimate of the cash holdings of retailers as well as by means of the available information on cash holdings of the banking industry.⁸

The transaction balance is composed of cash held by households for transaction purposes as well as the cash holdings of retailers and credit institutions

⁴ For information on the determination of these components of banknote demand, see N Bartzsch, G Rösl and F Seitz (2011a), Foreign demand for euro banknotes issued in Germany: estimation using direct approaches, Deutsche Bundesbank Discussion Paper No 20/2011; N Bartzsch, G Rösl and F Seitz (2011b), Foreign demand for euro banknotes issued in Germany: estimation using indirect approaches, Deutsche Bundesbank Discussion Paper No 21/2011; N Bartzsch and M Uhl (2017), Domestic and foreign demand for euro banknotes issued in Germany, in Deutsche Bundesbank International Cash Conference 2017 – War on Cash – Is there a Future for Cash?, Frankfurt am Main, pp 250-287. Estimates of components of the cumulative net issuance of euro coins by the Bundesbank may be found in Deutsche Bundesbank, Euro coins held for transaction purposes in Germany, Monthly Report, April 2015, pp 61-74.

⁵ See Deutsche Bundesbank, Foreign demand for euro banknotes issued in Germany, Monthly Report, January 2011, pp 29-41; Deutsche Bundesbank, The development and determinants of euro currency in circulation in Germany, Monthly Report, June 2009, pp 45-58.

⁶ Statistical information on the volume of euro banknotes in circulation is available up to the end of 2017, although some other data used refer to other points in time. Estimates of the banknote demand components, for example, are available at present only up to the end of 2016.

⁷ The first euro banknote series is designated as ES1 (first euro series) and the second euro banknote series as ES2 (second euro series). “Europa series” is an alternative designation for the second series of euro banknotes.

⁸ See Deutsche Bundesbank, The development and determinants of euro currency in circulation in Germany, op cit. The estimated transaction balance comprises holdings of coins that cannot be separated from the holdings of banknotes. This fuzziness is likely to be acceptable, as the (estimated) euro coins held for transaction purposes are minor in terms of value. See Deutsche Bundesbank, Euro coins held for transaction purposes in Germany, op cit.

Seasonal adjustment of daily data

When analysing currency in circulation, it is often not possible simply to derive new information from the unadjusted data. The unadjusted data also reflect periodically recurring movements which overlap with the underlying economic trends and exceptional movements. For instance, the annual Christmas trading period causes a significant increase in the demand for banknotes at the end of the year without the existence of any potentially crisis-induced hoarding behaviour. Only an undershooting or overshooting of such periodic movements allows conclusions to be drawn about new information captured

in the data. The aim of seasonal adjustment is to eliminate such regularly recurring intra-year movements of similar magnitude, thus making it easier to analyse the demand for cash.

German currency is affected by periodic fluctuations in essentially three ways (see the adjacent chart). First, besides the significant peaks around the turn of the year (upper section of the chart), the enlarged views of progressively smaller sections in the chart show that the volume of currency in circulation rises at the end of the month in connection with wages, salaries, and other payments (middle section of the chart). Second, there are additional peaks at the end of each week when more purchases are made for the coming weekend and the start of the following week (bottom section of the chart).¹ There are, therefore, not only seasonal fluctuations that recur annually but also ones which recur on a monthly or weekly basis. Third, calendar effects occur owing to the variable date of Easter in March or April. Such effects, too, are eliminated as part of seasonal adjustment.²

It follows from these observations that the unadjusted figures of daily currency in circulation (Y_t) at time t are composed of the trend-cycle component (T_t), the seasonal factors of the day of the week $S_t^{(7)}$, day of the month $S_t^{(31)}$ and day of the year $S_t^{(365)}$, as well as the impact of moving holidays (K_t) and the irregular component (I_t):

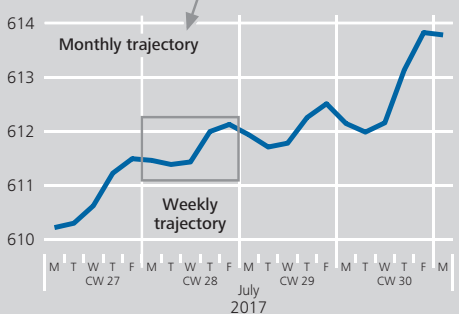
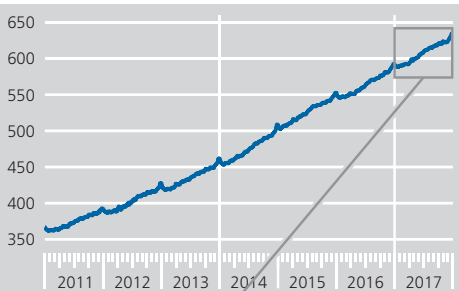
$$Y_t = T_t + S_t^{(7)} + S_t^{(31)} + S_t^{(365)} + K_t + I_t.$$

¹ For further determinants of the demand for cash, see, for example, A Cabrero, G Camba-Méndez, A Hirsch and F Nieto (2002), Modelling the daily banknotes in circulation in the context of the liquidity management of the European Central Bank, European Central Bank Working Paper Series, No 142; N Bartzsch, F Seitz and R Setzer (2015), The demand for euro banknotes issued in Germany: Structural modelling and forecasting, ROME Discussion Paper Series, No 15-03.

² See Deutsche Bundesbank, Calendar effects on economic activity, Monthly Report, December 2012, pp 51-60.

Currency in circulation in Germany

€ billion; daily data



The series adjusted for calendar and seasonal effects is therefore

$$Y_t - S_t^{(7)} - S_t^{(31)} - S_t^{(365)} - K_t = T_t + I_t$$

and is identical to the sum of the trend-cycle and the irregular component.

The procedures used for the official seasonal adjustment of monthly or quarterly economic indicators, such as Census X-12-ARIMA³ which is employed by the Bundesbank, cannot be used for time series with daily observations. STL serves as the basis for an alternative method of seasonal adjustment.⁴ This established method is characterised by a high degree of flexibility with regard to the periodicity of the underlying data. It is essentially based on a sequence of local regressions. Each individual observation is weighted and regressed to all values which lie in a predefined, temporal neighbourhood.

As STL only ever estimates the seasonal factor for a single given periodicity, such as $S_t^{(7)}$, the procedure has to be performed completely three times in order to capture all the seasonal components relevant to daily data. First, the seasonal figure of the weekly period is adjusted. Calendar adjustment is then performed using a RegARIMA model.⁵ Finally, the effects of the day of the month and the day of the year are eliminated.

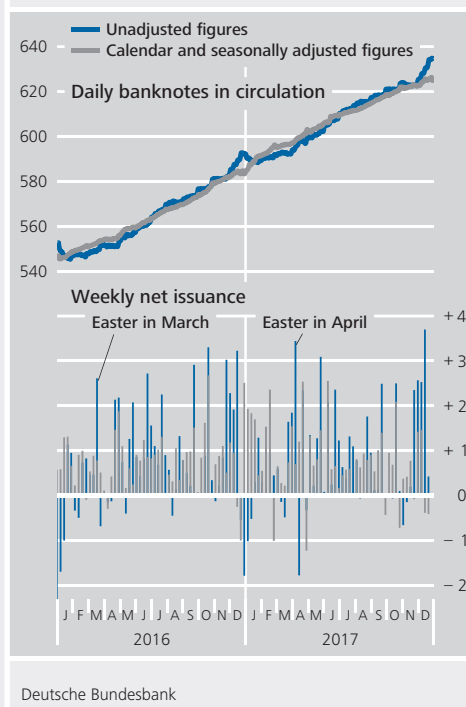
Overall, it is apparent that the increase at the end of 2017 was weaker than usual at this time of year (see the chart on this page). The calendar and seasonally adjusted net issuance of banknotes was slightly negative in this period.

The peaks in March 2016 and April 2017 identified in the unadjusted figures are largely due to the usual greater demand for currency in connection with the Easter holidays. Accordingly, these peaks are adjusted in the context of estimating average calendar effects and can now be classified as not very conspicuous.

Eliminating both periodically recurring intra-year effects and systematically calendar-

Calendar adjusted and seasonally adjusted currency in circulation in Germany

€ billion



related factors of daily currency in circulation makes it possible to focus more strongly on identifying new information. Seasonal adjustment is therefore a useful instrument of economic analysis which can also be applied to time series with daily observations.

³ See Deutsche Bundesbank, The changeover from the seasonal adjustment method Census X-11 to Census X-12-ARIMA, Monthly Report, September 1999, pp 39-50.

⁴ See RB Cleveland, WS Cleveland, JE McRae and I Terpenning (1990), STL: A seasonal-trend decomposition procedure based on Loess, Journal of Official Statistics, 6 (1), pp 3-73. Initially, the unadjusted figures are adjusted for a provisional trend. Subsequently, a seasonal factor is determined for each day of the week, month, and year. Finally, a trend is estimated on the basis of the adjusted series, which is used in the next iteration. These steps are repeated several times and supplemented by the identification of extreme values.

⁵ The RegARIMA model is a combination of a regression model and ARIMA error term:

$\phi_p(L)(1-L)^d\{y_t - \sum_{i=1}^r \beta_i x_{it}\} = \theta_q(L)\epsilon_t$. $\phi_p(L)$ and $\theta_q(L)$ are polynomials of order p and q , and L is the lag operator. In the case of seasonally marked daily data, this model is extended to include periodic regressors or seasonal ARIMA terms.

Sectoral composition of the transaction balance

Sectoral composition of the transaction balance

The estimate of the balances held by households for transaction purposes is based on the study on payment behaviour that is conducted regularly by the Bundesbank; those surveyed in this study provide information on their cash holdings and their usual withdrawal of cash at the counter or an ATM.⁹ This showed that, in 2016, households held euro banknotes with a value of €13.1 billion for payment purposes in total. The cash holdings of retailers are calculated on the basis of assumptions about cash inflows from trading and deposits at commercial banks or the Bundesbank and are estimated at €1.8 billion for 2016. The credit institutions' cash holdings are recorded statistically and stood at €26.0 billion at the end of 2016. Overall, it is estimated that domestic transaction balances of banknotes at the end of 2016 were around €40 billion. Taking into account estimation uncertainty, they therefore have a share of between 5% and 10% of the value of German-issued banknotes in circulation.

The chart on page 47 shows the trajectory of the cited components over time. The estimated transaction balances of households as well as the estimated cash holdings of retailers have been roughly constant over time since 2008. By contrast, the credit institutions' cash holdings went up from €19.5 billion in December 2015 to €26.0 billion in December 2016. This increase is likely to be due chiefly to one-off monetary policy factors (see the box on pages 43 and 44). The total transaction balance computed here, amounting to around €40 billion, is likely to be distorted insofar as credit institutions hold part of their cash not for transaction purposes but because they want to avoid negative rates of interest on deposits at the Bundesbank.

Domestic transaction balance at a comparatively low level in terms of value

Overall, the value of banknotes held in Germany for payment purposes is relatively small in comparison with the total value of German-issued banknotes in circulation. Euro banknotes

used for payment purposes circulate rapidly between consumers, retailers, credit institutions and the branches of the Bundesbank, which means that it is not necessary in terms of value to hold large stocks to settle cash payments.¹⁰ As the value of the domestic transaction balance, according to the estimates, remains relatively constantly at a low level, the domestic transaction balance accordingly does not make a crucial contribution to explaining the growing volume of "German" euro banknotes in circulation. What is immediately striking is the unchanged level of the domestic transaction balance even in light of the fact that cashless payment methods are gaining in importance for the settlement of everyday payments by consumers at the point of sale. According to the estimates in the Bundesbank's study on payment behaviour, cash payments had a share of 74.3% in terms of the number of transactions in 2017, compared with 82.5% in 2008.¹¹ The percentage of cash payments by turnover fell in the same period from 57.9% in 2008 to 47.6% in 2017. According to the estimates, this development is not reflected in a declining cash balance held for transaction purposes and therefore does not have an impact on banknote issuance in Germany either. The declining share of payments in cash is evidently being offset by rising consumption paid for in cash.

⁹ Figures are available for 2008, 2011 and 2014; for years without their own survey, the last available value is adopted. See Deutsche Bundesbank (2009), Payment behaviour in Germany – an empirical study of the selection and utilisation of payment instruments in the Federal Republic of Germany; Deutsche Bundesbank (2012), Payment behaviour in Germany in 2011 – an empirical study of the utilisation of cash and cashless payment instruments; Deutsche Bundesbank (2015), Payment behaviour in Germany in 2014 – third study of the utilisation of cash and cashless payment instruments.

¹⁰ The banknote cycle in Germany is described in Deutsche Bundesbank, Cash as a means of payment and a store of value, op cit; and Deutsche Bundesbank, The banknote cycle and banknote recycling in Germany, Monthly Report, January 2011, pp 17-27.

¹¹ See Deutsche Bundesbank (2018), Payment behaviour in Germany in 2017 – fourth study of the utilisation of cash and cashless payment instruments.

Banknote holdings by credit institutions

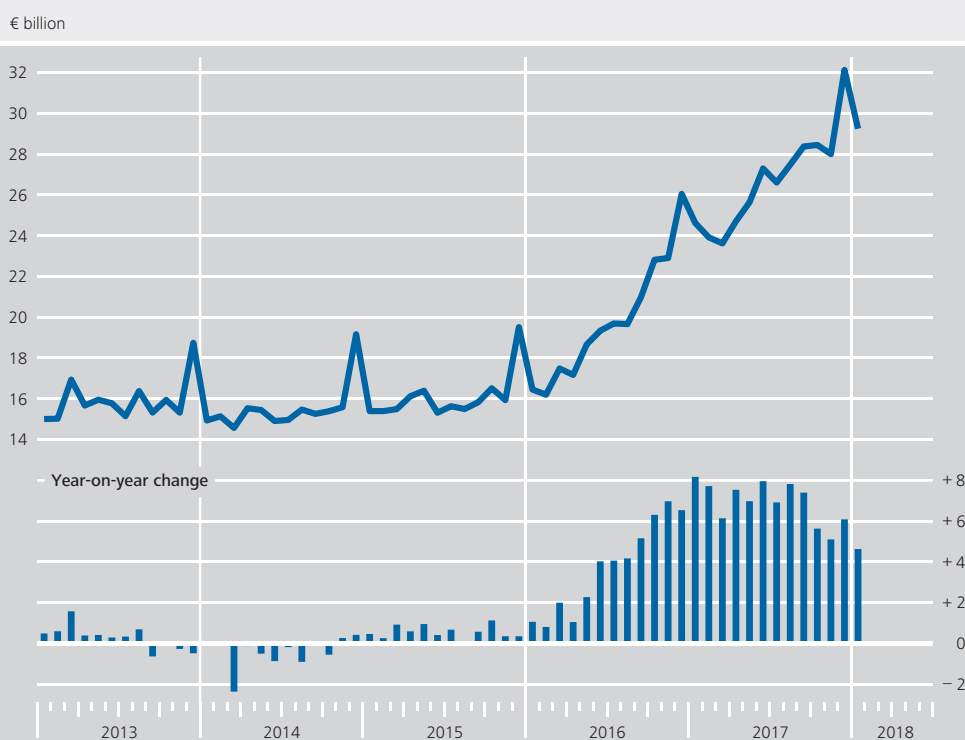
Since 11 June 2014, the interest rate on deposits at Eurosystem central banks has been in negative territory. 16 March 2016 saw a further cut to -0.4% per year. Credit institutions have the option of increasing their cash stocks to avoid paying interest on their balances held with the central bank. The stocks of cash held by credit institutions can be inferred from the data which they are required to report to the Bundesbank.¹ Credit institutions keep these holdings primarily for the purpose of settling cash payment transactions. They result from cash deposits made at credit institutions or are retained by credit institutions to be able to supply cash to their customers.

The chart below shows how the cash holdings of credit institutions have developed over time. The significant seasonal fluctuations – presumably resulting from trading

turnovers – make it more difficult to interpret the reported data. Despite the seasonal fluctuations it can be seen that the cash holdings of credit institutions have been rising markedly since 2016. Whereas cash holdings in 2015 averaged €16.1 billion, they totalled an average of €19.8 billion and €26.7 billion in 2016 and 2017, respectively. In terms of the annual average, cash holdings in 2017 were thus €10.7 billion higher than they were in 2015. The year-end value of cash holdings in 2017 was €32.1 billion – as much as €12.6 billion

¹ The analysis covers credit institutions that fall under the definition of an MFI (monetary financial institution). All institutions that accept deposits or close substitutes for deposits from the general public and grant loans for their own account are classified as MFIs. The term cash holdings includes all currency holdings, including foreign banknotes and coins as well as postage stamps and court fee stamps.

Cash holdings of credit institutions



higher than the 2015 year-end value of €19.5 billion.

As a general rule, credit institutions are likely to factor in the opportunity costs of holding cash when determining their cash balances. It is thus to be expected that, when viewed in isolation, cash holdings will rise whenever interest rates are low.² Against the backdrop of the current low-interest-rate environment, credit institutions could consequently maintain larger stocks of cash for the purpose of settling cash payment transactions than in times of higher interest rates. The particularly striking development in cash holdings from mid-2016 onwards, following the lowering of the deposit interest rate to -0.4%, indicates, however, that the build-up of cash holdings at credit institutions in Germany is probably the result of a move to avoid the negative

rates of interest on deposits at the Bundesbank.

Overall, the trajectory of the reported data shows that credit institutions in Germany are currently holding an additional amount of over €10 billion worth of banknotes in order to avoid negative interest rates. Since mid-2016, the Bundesbank's branches have also been reporting a number of sizeable cash orders by credit institutions on a similar scale.

² The decision-making problem that credit institutions face when determining the number of cash supply trips to make between Bundesbank branches, bank branches and ATMs – taking due account of cash demand and the opportunity costs associated with holding cash – is reminiscent of the Baumol-Tobin model, which looks at cash balances held for transaction purposes. See W Baumol (1952), The transactions demand for cash: an inventory theoretic approach, *Quarterly Journal of Economics*, 66 (4), pp 545-556; J Tobin (1956), The interest-elasticity of transactions demand for cash, *Review of Economics and Statistics*, 38 (3), pp 241-247.

Transaction balances of small banknote denominations

Since May 2013, introduction of new euro banknotes with improved security features

The introduction of the new Europa series of euro banknotes makes it possible for the first time to estimate the size of the domestic transaction balance by denomination, too. Starting in May 2013, the new euro banknotes with improved security features are being issued in stages, with the €5 to €50 denominations being available so far.¹² The chart on page 47 shows the trajectory over time of the Bundesbank's cumulative net issuances separately for old (ES1) and new (ES2) banknotes for the €5, €10, €20 and €50 denominations. In the chart sections for the €5, €10 and €20 banknotes, the cumulative net issuance shows a similar trajectory.¹³ Following the first issuance of the new banknotes, the cumulative net issuance of ES1 banknotes dropped off significantly at first, but only slowly thereafter. Of all the banknote denominations under consideration, a large part of the – in mathematical terms – outstand-

ing ES1 banknotes has so far not returned to the Bundesbank, which reflects the importance of hoarding and, in particular, foreign demand in explaining the volume of German-issued banknotes of these denominations in circulation.¹⁴

The estimates of the domestic transaction balance by denomination are based on this obser-

¹² The new €100 and €200 banknotes of the second series are scheduled to be issued for the first time in the first half of 2019. The second series will no longer contain €500 banknotes.

¹³ The new €50 banknote was first issued on 4 April 2017. At the present point in time, it is not possible to make a final assessment as to whether the cumulative net issuance of ES1 banknotes of this denomination will behave in a way that is comparable to those of the other banknotes under consideration.

¹⁴ The cumulative net issuance of ES1 banknotes for the €5, €10 and €20 denominations by the Eurosystem excluding the Bundesbank have negative values in each case at the present stage. This means that, overall, more ES1 banknotes of these denominations have been paid into the Eurosystem excluding the Bundesbank than these central banks have paid out in total. This is likely to be due to banknote migration from Germany to the other euro area countries.

The return flow of €500 banknotes

On 4 May 2016, the Governing Council of the ECB decided to discontinue the production and issuance of the €500 banknote, responding to concerns that the denomination could facilitate illicit activities.¹ The end of €500 banknote issuance will coincide with the introduction of the new €100 and €200 banknotes of the second series. The €500 banknotes already in circulation will remain legal tender and can be exchanged at the national central banks of the Eurosystem indefinitely.

Media reports covering a potential move to discontinue the €500 banknote began appearing in February 2016 and, as the chart below shows, €500 banknotes have been returning to the Eurosystem on a significant scale in net terms since then. Between February and December 2016, net issuance of €500 banknotes by the Bundesbank stood at -€7.6 billion, while issuance by the Eurosystem as a whole amounted to -€36.0 billion. In 2017, the Bundesbank placed €1.4 billion net worth of €500 notes into circulation; issuance by the Eurosystem as a whole was -€13.2 billion in net terms. The cumulative value of €500 banknotes issued by the Bundesbank thus rose slightly in 2017. This development – which deviates from that of the Eurosystem – is likely to be largely due to credit institutions maintaining holdings of €500 banknotes in order to avoid negative interest rates (see the box entitled “Banknote holdings by credit institutions” on pages 43 and 44). Demand for €500

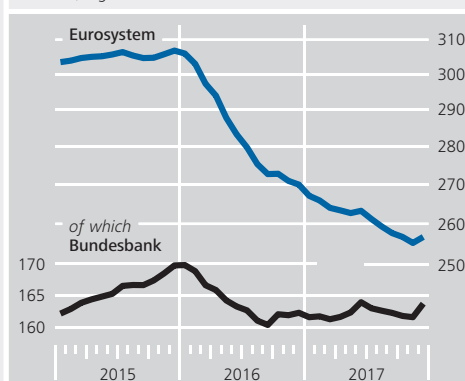
banknotes from the Bundesbank on the part of non-banks is probably declining similarly to the demand for €500 banknotes from the Eurosystem as a whole.

It is possible that the decision to stop issuing €500 banknotes could reduce the overall demand for euro banknotes. A drop in the total demand for euro banknotes in the wake of the end to issuance might be expected, for instance, if economic agents from both within and outside of the euro area were to increasingly hold their financial assets in the form of deposits with credit institutions or banknotes in other currencies. The tables on page 46 show the net issuance of euro banknotes by the Eurosystem and the Bundesbank across all denominations combined, as well as individually for the banknotes with a nominal value of €50 and higher, for the period from 2013 to 2017. Net issuance of €500 banknotes in 2016 was significantly lower than in the previous years, although economic agents swapped at least some of their €500 banknotes for banknotes of a lower denomination. This is shown by the fact that the

¹ For a more detailed account of the discussion surrounding high-denomination banknotes, see Deutsche Bundesbank, Policy options for cash payments, Annual Report 2015, pp 36-38; P Sands (2016), Making it harder for the bad guys: the case for eliminating high denomination notes, M-RCBG Associate Working Paper No 52; K Rogoff (2016), The curse of cash, Princeton University Press.

Cumulative net issuance of €500 banknotes

€ billion, log scale



Sources: ECB und Bundesbank calculations.
 Deutsche Bundesbank

Net issuance of euro banknotes by the Eurosystem, by denomination

€ billion

Year	€500	€200	€100	€50	Total
2013	- 2.2	2.9	14.4	26.3	43.6
2014	11.5	1.0	16.6	27.3	60.4
2015	3.8	0.6	12.9	44.5	66.9
2016	- 36.9	5.3	28.8	41.7	42.8
2017	- 13.2	2.6	19.1	29.7	44.5

Source: European Central Bank.
Deutsche Bundesbank

Net issuance of euro banknotes by the Deutsche Bundesbank, by denomination

€ billion

Year	€500	€200	€100	€50	Total
2013	5.7	3.5	10.4	9.4	34.0
2014	12.9	2.7	12.3	13.0	46.9
2015	8.9	2.3	12.2	13.4	44.2
2016	- 7.5	5.2	20.6	14.3	39.5
2017	1.4	3.2	16.9	12.8	42.5

Deutsche Bundesbank

Eurosystem's net issuance of €200 banknotes rose to €5.3 billion and its net issuance of €100 banknotes climbed to €28.8 billion in 2016, while between 2013 and 2015 net issuance of €200 banknotes and €100 banknotes had averaged €1.5 billion and €14.6 billion, respectively. The total volume of euro banknotes in circulation rose by €42.8 billion in 2016, following an average increase of €56.9 billion between 2013 and 2015. However, it is not possible to tell conclusively from this kind of comparison whether ceasing the issuance of the €500 note curbed the growth of euro banknote circulation overall in 2016. There are a number of factors that may conceivably influence developments in euro banknotes in circulation, such as the level of interest rates, the broader economic backdrop or the exchange rate of the euro against the US dollar.² This is why previous years' net issuance figures cannot serve as a direct indicator of what net issuance might hypothetically have been were it not for the decision to discontinue issuing €500 banknotes.

Shifts from euro banknotes to banknotes in other currencies are also a possibility. For example, cash users within and outside of the euro area could increase their demand for US\$100 banknotes or CHF 1,000 banknotes. It is hard to investigate substitutions of this kind empirically, not least because preferences in terms of cash use are persistent and any changes in behaviour on the part of cash users are likely to be evident only in the long term. Moreover, banknote circulation of a particular currency is influenced by many factors and it is not always possible to directly identify the precise impact of events such as discontinuing the issuance of the €500 banknote. Net issuance of US\$100 banknotes amounted to US\$72.6 billion in 2016 compared with US\$67.7 billion in 2015 and US\$89.8 billion in 2014. At CHF 3.0 billion, net issuance of CHF 1,000 banknotes was lower in 2016 than in 2015 when it totalled CHF 4.7 billion. These figures do not reveal any clear effect stemming from the end of €500 banknote issuance.

² The factors that influence euro banknote circulation are discussed, inter alia, in papers modelling demand for euro banknotes econometrically. See N Bartzsch, F Seitz and R Setzer (2015), The demand for euro banknotes issued in Germany: structural modelling and forecasting, ROME Discussion Paper Series, No 15-03.

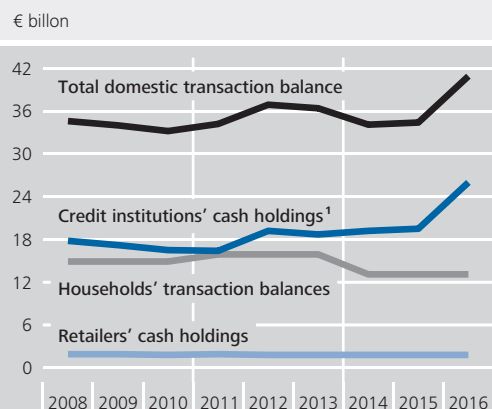
Estimating the domestic transaction balance by denomination on the basis of the ES2 introduction

At the time of the initial issuance of the new series of banknotes, the total volume of ES1 banknotes in circulation of each denomination was made up of the domestic transaction balance, domestic hoarding and banknotes in circulation abroad. ES1 banknotes used for transaction purposes have a quick circulation time and are consequently rapidly replaced by ES2 banknotes, whereas hoarded banknotes or ES1 banknotes in circulation abroad do not flow back to the Bundesbank, or do so only slowly, and are therefore only partially replaced by ES2 banknotes. In view of these considerations, net returns of ES1 banknotes up to a given date are generally attributable to the transaction balance, which means that this decline in the cumulative net issuance of ES1 banknotes up to a given date can be used to estimate the domestic transaction balance accounted for by the respective denomination.

Quick turn-around in domestic transaction balance

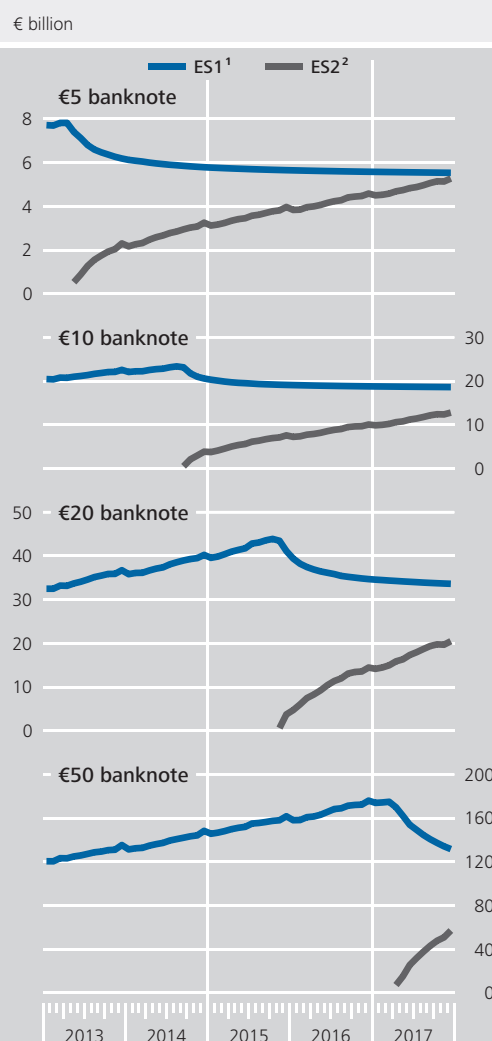
In order to operationalise this estimation procedure, it is necessary to set a time limit as at which the bulk of the ES1 banknotes in the domestic transaction balance are assumed to have been replaced by ES2 banknotes. The launch of the new banknotes was successful insofar as economic agents were already primarily using banknotes of the second series for payment purposes within a short period of time following their introduction. By way of illustration, the chart on page 48 shows how the shares of ES2 banknotes developed over a period of 12 months following their initial issuance in relation to the total volume of these denominations paid in and out at the Bundesbank's branches. Nine months after the initial issuance of the new ES2 banknotes, around 90% of the €5 banknotes paid in and 95% of the €5 banknotes paid out were banknotes from the second series. In the case of €10 and €20 banknotes, this figure was as high as around 95% of the inflows and almost 100% of the outflows after this same period. According to these figures, it can be assumed that the holdings of these banknotes for transaction

Components of the domestic transaction balance of euro banknotes



¹ Year-end data.
 Deutsche Bundesbank

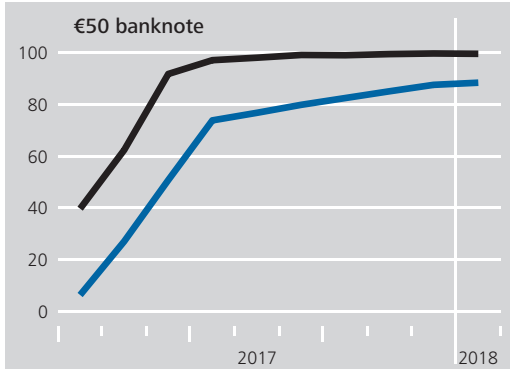
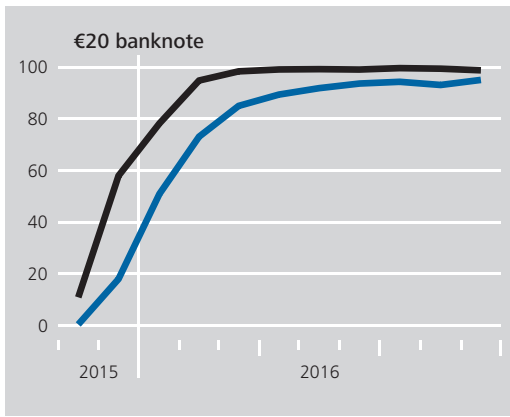
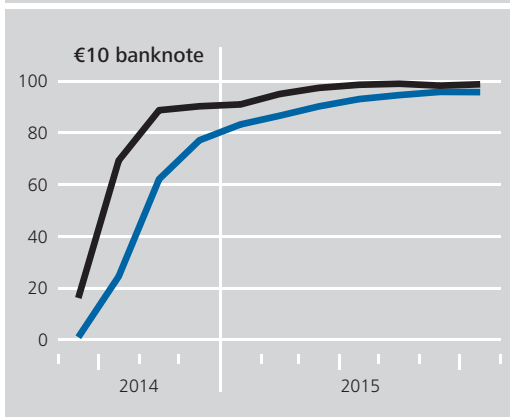
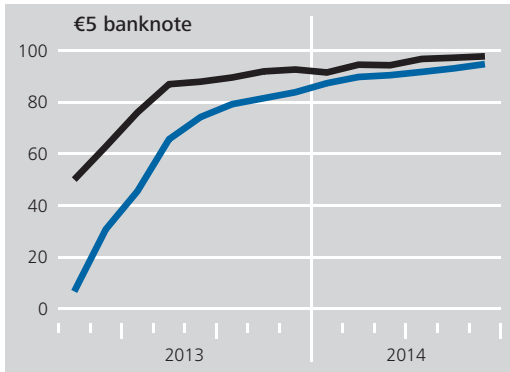
Cumulative net issuance of "small" euro banknotes by the Bundesbank



¹ "Old" euro banknotes of the first euro banknote series.
² "New" euro banknotes of the second euro banknote series.
 Deutsche Bundesbank

ES2 series* banknotes as a share of the Bundesbank's gross cash inflows and outflows

% — Cash paid out — Cash paid in



* The ES2 series comprises the "new" euro banknotes of the second euro banknote series.
 Deutsche Bundesbank

purposes were almost completely replaced within the space of nine months.¹⁵

The estimation results for the domestic transaction balances of €5, €10 and €20 banknotes on the basis of the ES2 introduction are shown in the table on page 49.¹⁶ For each of the denominations observed, the domestic transaction balance accounts for roughly one-fifth or less of their total volume in circulation (cumulative net issuance). By comparison, according to the estimates previously shown, the share of the total domestic transaction balance in relation to the Bundesbank's cumulative net issuance is between 5% and 10%.

Domestic transaction balances of €5, €10 and €20 banknotes account for roughly one-fifth or less of the respective volumes in circulation

The presented estimates of the breakdown of the transaction balance by denomination on the basis of the ES2 introduction are confirmed by the findings of the study on payment behaviour. Based on an estimated value for the domestic transaction balance of around €35 billion at the end of 2015, the €5 banknote accounts for a 5.2% share, the €10 banknote for an 11.6% share and the €20 banknote for a 24.7% share of the total domestic transaction balance. This composition of the domestic transaction balance can be compared with the information contained in the payment behaviour study reporting the breakdown of the cash

Results of the payment behaviour study confirm the estimates

15 In order to take account of the fact that part of the transaction balance still consisted of ES1 banknotes at this time, the decline observed up to then in the cumulative net issuance of ES1 banknotes is weighed using the inverse of the share of ES2 banknotes in gross cash inflows at this point in time. See N Bartzsch (2017), Transaction balances of small denomination banknotes: findings from the introduction of ES2, in Deutsche Bundesbank International Cash Conference 2017 – War on Cash – Is there a Future for Cash?, Frankfurt am Main, pp 288-311.

16 An estimate of the domestic transaction balance's share in €50 notes on the basis of the ES2 introduction is not included here, as it is unclear whether the cumulative net issuance of the €50 banknotes of the first series has already reached a stable level. The €50 banknote is also presumably hoarded to a greater extent in Germany than €5, €10 and €20 banknotes, which means that a larger share of the ES1 banknotes that have made their way back to the Bundesbank could also have been the result of people cashing in their hoarded cash stocks following the introduction of the ES2 banknotes.

carried by individuals in Germany.¹⁷ According to the results of the 2017 study, the share in terms of value of the total volume of euro banknotes carried by individuals in their wallets was broken down as follows: €5 banknotes accounted for 6.2%, €10 banknotes for 13.7% and €20 banknotes for 22.9%. The estimate of the overall composition of the transaction balance on the basis of the ES2 introduction therefore strongly concurs with the estimate for the composition of the cash carried by individuals determined as part of the payment behaviour study.¹⁸

■ Domestic hoarding

In terms of value, domestic hoarding is the largest component of domestic demand

Domestic hoarding includes all stocks of banknotes in Germany that have not been covered up to now, especially those held as a store of value. From a methodological perspective, estimating banknote hoarding is particularly challenging and the presented results are therefore subject to greater uncertainty than the estimates of the domestic transaction balance and of German-issued banknotes in circulation abroad. The results presented below are based on the seasonal method.¹⁹ According to the estimates, the stocks of hoarded euro banknotes in Germany amounted to €150 billion in 2016, which, in rounded terms, is equivalent to €1,800 per inhabitant. In terms of value, domestic hoarding is thus the most significant component of domestic demand. The chart on page 50 shows the development of the estimated domestic hoarding stocks over time. Domestic hoarding increased by an estimated €50 billion, or an annual average of around €7 billion, between 2010 and 2016 and thus contributed in part to the increase of €244 billion in German-issued euro banknotes in circulation observed during this period.

Results of the seasonal method do not indicate large-scale shifts from deposits to cash

As a result of the low interest rates, the opportunity costs of holding cash are currently low. Since 11 June 2014, deposits held with Eurosystem central banks have been remunerated at a negative rate of interest and in some instances,

Domestic transaction balances of small German-issued euro banknotes

Item	€5 banknote ¹	€10 banknote ²	€20 banknote ³
Cumulative net issuance ⁴	7.9	23.4	43.9
Transaction balances ⁴	1.8	4.0	8.5
Percentage share of cumulative net issuance	22.7	17.1	19.4

1 As at May 2013. **2** As at August 2014. **3** As at October 2015.
4 In € billion.

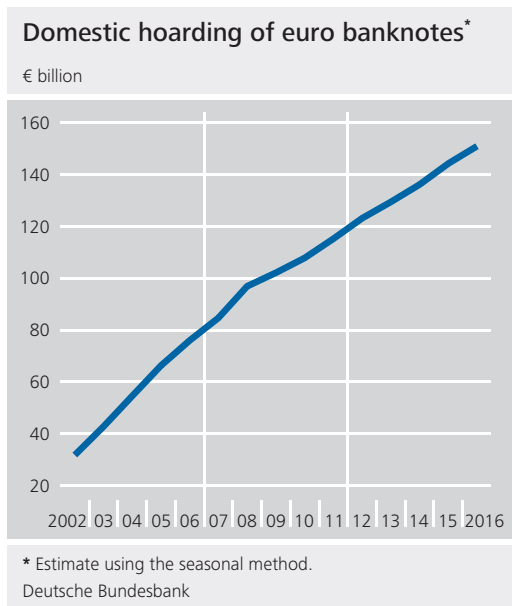
Deutsche Bundesbank

credit institutions in Germany have also been imposing negative interest rates on their customers' deposits. Against this backdrop, developments in euro banknote hoarding are currently of particular interest because economic agents in Germany could, in principle, show a

17 See Deutsche Bundesbank, Payment behaviour in Germany in 2017, op cit.

18 The deposits made at the Bundesbank's branches can be used as a sample of the domestic transaction balance, as these result primarily from the use of euro banknotes as a means of payment. Measured in terms of the overall value, €5 banknotes accounted for 2.3%, €10 banknotes for 7.7% and €20 banknotes for 14.6% of the total volume of deposited banknotes in 2017. The estimated shares of these banknotes in the domestic transaction balance are therefore higher than their shares in the deposits made at the Bundesbank's branches. Smaller-denomination banknotes are presumably deposited less frequently at the Bundesbank's branches than higher-value banknotes, as they are often reused as change.

19 After estimating foreign demand and the domestic transaction balance, it would also be possible to calculate domestic hoarding as the residual figure. Calculations on the basis of the residual figure are problematic, as each estimation error that occurs when calculating the other components is reflected in the estimate for domestic hoarding. For example, the method used for estimating banknotes in circulation abroad does not take account of banknote flows resulting from migrants or cross-border transactions. Estimates of domestic banknote hoarding as a residual figure as well as on the basis of the seasonal method both come to comparable results at the current end, although their trajectories differ over time. For details on the seasonal method, see S Sumner (1990), The transactions and hoarding demand for currency, Quarterly Review of Economics and Business, 30 (1), pp 75-89; N Bartzsch, G Rösl and F Seitz (2011b), op cit; F Seitz (1995), Der DM-Umlauf im Ausland, Deutsche Bundesbank Discussion Paper, No 01/1995; Deutsche Bundesbank, Seasonal method, Monthly Report, January 2011, p 36.



greater tendency to use cash as a store of value in the current climate. According to the estimates of banknote hoarding using the seasonal method, domestic hoarding stocks did in fact rise by just over €8 billion in 2015 and by around €7 billion in 2016. However, these increases are nothing out of the ordinary when compared with the increases in previous years, as it is estimated that domestic hoarding stocks rose by around €12 billion in 2008, for example, the year in which the financial crisis escalated. Furthermore, compared with the non-bank sight deposits in the amount of €1,898 billion at the end of 2016, the calculated stocks of hoarded banknotes in the amount of €150 billion are low. There are therefore no clear indications of any large-scale shifts from deposits to cash by non-banks in the context of the low-interest-rate environment.

Banknotes in circulation abroad

Euro banknotes issued by the Bundesbank can migrate to other euro area countries and non-euro area countries through various channels. Possible channels of international banknote migration are deliveries of euro banknotes to countries outside the euro area by international wholesale currency shippers, euro banknotes

taken abroad by travellers as well as by foreign workers and migrants, and cross-border payment transactions settled in cash. Deliveries by international wholesale currency shippers and cash taken abroad by travellers are recorded statistically.²⁰ On the basis of account transactions with international wholesale currency shippers, it is possible to determine to what extent, in net terms, these euro banknotes are in circulation outside the euro area. In 2016, these net deliveries by international wholesale currency shippers amounted to -€7 billion, which means that there were net return flows to the Bundesbank. Based on a household survey on foreign travel conducted by the Bundesbank, it is possible to determine how much euro currency has been taken abroad to other euro area countries and also to countries outside the euro area.²¹ In 2016, a net amount of €16.5 billion migrated abroad as a result of foreign travel, a net €7.5 billion of which was taken outside of the euro area and €9 billion to other euro area countries. The cumulative net flows since the introduction of the euro currency provide information about the holdings of German-issued euro banknotes in circulation abroad.

The results are shown in the chart on page 51. Accordingly, Bundesbank-issued euro banknotes with a value of €390 billion were in circulation abroad at the end of 2016, around €270 billion of which were in countries outside the euro area and around €120 billion in other euro area countries. This means that around 70% (in terms of value) of “German” euro banknotes were in circulation abroad, 50 percentage

In terms of value, 70% of German-issued euro banknotes are in circulation abroad, 50 percentage points of which are held outside the euro area and 20 percentage points in other euro area countries

Estimating foreign demand on the basis of net shipments and foreign travel

²⁰ See N Bartzsch, G Rösl and F Seitz (2011a), op cit; and Deutsche Bundesbank, Recording euro currency in the balance of payments and the international investment position, Monthly Report, March 2015, pp 91-93.

²¹ As part of the balance of payments statistics, the Bundesbank conducts household surveys on how much euro cash residents in Germany take with them when they travel abroad. As there are no comparable surveys on euro cash inflows generated by foreign travellers to Germany, these are estimated based on the assumption that foreign travellers to Germany behave similarly to German travellers abroad. The household survey looks at cash carried, though this is primarily likely to constitute banknotes. For information about German-issued euro coins in circulation abroad, see Deutsche Bundesbank, Foreign demand for German euro coins, Monthly Report, April 2015, p 72.

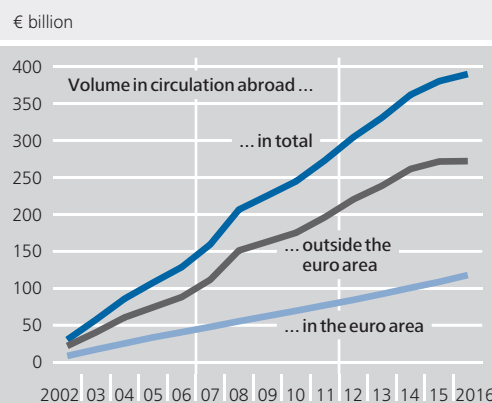
points of which were held in countries outside the euro area and 20 percentage points in other euro area countries. Viewed in relation to the period since the introduction of the euro currency, the bulk of the growth in the cumulative euro banknote issuance by the Bundesbank is attributable to foreign demand. In the years from 2010 to 2016, the demand from abroad rose by around an estimated €165 billion, which consequently explains the largest part of the increase in German-issued euro banknotes in circulation during this period. In recent years, however, the increase in German-issued euro banknotes in circulation abroad has tailed off. Whereas this foreign demand rose by just under €31 billion in 2014 and by almost €19 billion in 2015, the increase only amounted to just over €9 billion in 2016. The decrease in banknote outflows abroad is due mainly to a corresponding decline in the net deliveries from wholesale currency shippers, which fell from €14 billion in 2014 to just over €2 billion in 2015 and -€7 billion in 2016.²²

■ Conclusions

Estimating banknote demand components as a way of analysing banknote issuance in Germany

Estimates of the components of German-issued banknotes in circulation can be used to investigate the determinants of banknote issuance in Germany. These estimates show that less than 10% in terms of the value of euro banknotes issued by the Bundesbank is held for domestic transaction purposes, over 20% is hoarded domestically and around 70% is in circulation abroad. In the period under review, the level of the domestic transaction balance has remained largely unchanged since 2010, meaning that the observed increase in German-issued banknotes in circulation can be better explained by increases above all in foreign demand as well as, to a lesser extent, in domestic hoarding. These conclusions confirm earlier findings which also stressed the significance of banknotes in circulation abroad and domestic

German-issued euro banknotes in circulation abroad*



* Estimate based on data from deliveries of euro banknotes by international wholesale currency shippers and cash taken abroad by travellers.

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hoarding for developments in the circulation of German-issued euro banknotes for the period from 2002 to 2009.²³

In the period since 2010, the volume of euro banknotes in circulation issued by the Bundesbank has continued to grow strongly on the back of strong demand, as have euro banknotes in circulation issued by the Eurosystem as a whole. This development reflects the popularity of euro banknotes as a means of payment and as a store of value both in Germany and abroad.

Demand for euro banknotes is growing

²² With the introduction of E52 banknotes, it was possible to derive – in addition to the described estimate of the total value of German-issued euro banknotes in circulation in countries outside the euro area – the transaction balances of small euro banknote denominations. See N Bartzsch (2017), op cit. According to the results, the transaction balances of the low-denomination German-issued euro banknotes in circulation outside the euro area are small, amounting to €250 million in the case of the €5 banknote, €500 million in the case of the €10 banknote and just over €3 billion in the case of the €20 banknote. The results also indicate that hoarding is likely to account for the bulk of the German-issued euro banknotes of these denominations in circulation outside the euro area.

²³ See Deutsche Bundesbank, The development and determinants of euro currency in circulation in Germany, op cit and Deutsche Bundesbank, Foreign demand for euro banknotes issued in Germany, op cit.