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Transaction balances of small denomination banknotes: findings from the introduction of ES2

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Abstract

At the end of 2015, the Deutsche Bundesbank had issued a total net amount of just over €45 billion in €20 banknotes. In statistical terms, each resident living in Germany was therefore issued with around 30 banknotes of this denomination. Up until now, it was not clear how many of these German-issued euro banknotes are actually used for payment purposes. Owing to the introduction of the new Europa series of banknotes on 25 November 2015, it was possible to estimate the volume of €20 banknotes that are held for transaction purposes both in Germany and outside the euro area.

The estimation of the volume of €20 banknotes held for *domestic* transaction purposes (known as the domestic transaction balance) is primarily based on the observed return flows of the old series (ES1) of €20 banknotes received by the Deutsche Bundesbank. The cash balance of €20 banknotes held for domestic transaction purposes was estimated at around €8.5 billion at the end of October 2015. This means that only 19% of the total (net) amount of €20 banknotes issued by the Deutsche Bundesbank up to the end of October 2015 were used for transaction purposes within Germany. The remaining 81% has either migrated abroad, been hoarded or got lost. The results of the analysis are also important as a means of explaining the just over €36 billion worth of ES1 €20 banknotes which are still outstanding in the Deutsche Bundesbank's balance sheet. Given that the cash balance held for domestic transaction purposes has since been almost fully replaced, it is no longer to be expected that ES1 banknotes will flow back to the Deutsche Bundesbank in any sizeable amounts.

The volume of German-issued €20 banknotes – officially stemming from banknote shipments by the Deutsche Bundesbank – held for transaction purposes *outside the euro area* was estimated at just over €3 billion at the end of July 2016 using the biometric method. This estimate represents a lower level for the actual cash balance held for transaction purposes, as it does not incorporate banknote exports resulting from foreign travel and cash amounts sent abroad. It is derived from cumulated shipments of ES2 €20 banknotes up to the end of July 2016 and the value of the ES1 and ES2 €20 notes deposited in July 2016 at the shipment branches. In terms of the Deutsche Bundesbank's cumulated net shipments of €20 banknotes in the amount of around €12 billion at the end of 2015, the estimated cash balance (resulting from shipments) held for transaction purposes outside the euro area accounts for around 28%.

JEL-Classification: C49, E41, E58

Keywords: euro banknotes, biometric method, foreign demand, transaction balances, hoarding, small denominations, ES2

1 Introduction

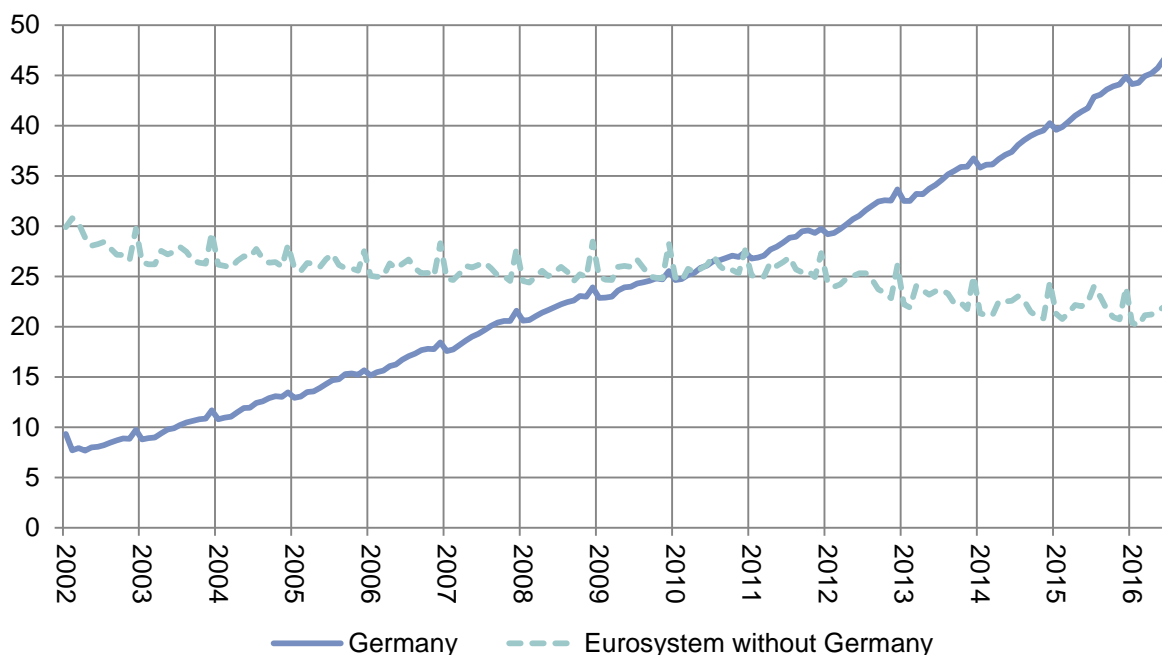
At the end of 2015, the Deutsche Bundesbank had issued a total net amount of around €45 billion in €20 banknotes (German-issued €20 notes). In statistical terms, each resident living in Germany was therefore issued with 30 banknotes of this denomination. Even though cash is still the most commonly used means of payment at the point of sale in Germany, the total number of issued banknotes still seems very high. Presumably, only part of this amount is actually used for payment purposes in Germany (known as the "domestic transaction balance"). The rest may either have been lost, hoarded on a permanent basis or may be in use abroad for transaction and hoarding purposes.

The fact that it is not possible to equate the cumulated net issues of a euro-area country with the national volume of cash in circulation in that country also becomes evident when making international comparisons (Figure 1). The Deutsche Bundesbank's cumulated net issues of €20 notes have been steadily increasing since 2002. The Deutsche Bundesbank therefore issues more €20 banknotes than it receives through inpayments. Conversely, the cumulated net issues of the (entity of) other Eurosystem member countries are steadily declining; in these countries, more banknotes are paid in in the form of deposits than are paid out. A significant share of German-issued banknotes therefore flows out of Germany either through tourists or business travellers, and is deposited by resident commercial banks at other Eurosystem central banks. The Deutsche Bundesbank is therefore making a sizeable contribution to the supply of cash in the Eurosystem and also to the seigniorage revenues of the other central banks.

This raises the question as to how high the volume of €20 banknotes that are in active circulation in Germany actually is. According to our estimates, the value of the *total* domestic transaction balance lies between €35 billion and €55 billion. This equates between 5% and 10% of the Deutsche Bundesbank's cumulated net issues. Calculations for individual denominations are much more difficult as, depending on the face value, banknotes are not all equally suitable for transaction purposes or as a store of value and are also subject to varying degrees of demand from other countries.

In the following, the transaction balances of €20 banknotes are examined in greater detail both in Germany (section 2) as well as outside the euro area (section 3) with the help of data obtained during the introduction of the new Europa series of banknotes (ES2). The results are summarised in section 4.

Figure 1: Cumulated net issuance of €20 banknotes (in € billion)



Source: CIS II.

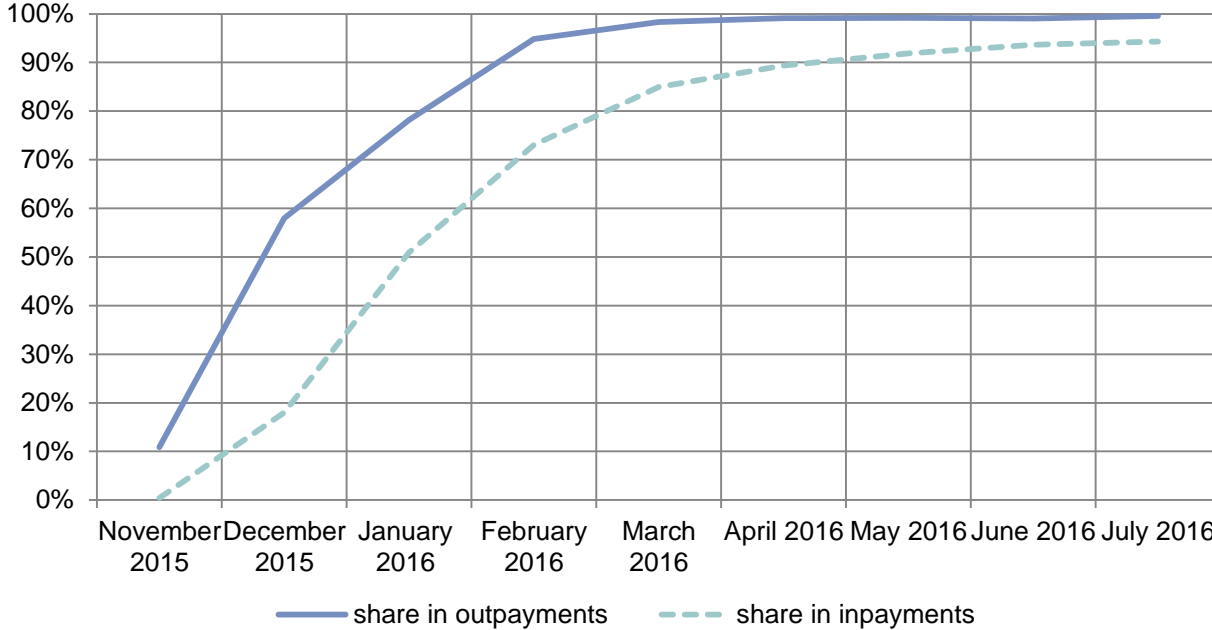
2 The volume of €20 banknotes held for transaction purposes in Germany

2.1 Replacement of the old ES1 banknotes

The Deutsche Bundesbank has been putting the new ES2 €20 banknotes into circulation in Germany since 25 November 2015. Figure 2 shows *inter alia* the **share of the new ES2 banknotes in relation to the Deutsche Bundesbank's gross monthly outpayments**. Since April 2016, this share has stood at roughly 99%. Accordingly, ES1 €20 banknotes have accounted for a share of around 1% of gross outpayments since then. Only remaining stocks of ES1 €20 banknotes are paid out again. ES1 €20 banknotes that flow back to the Deutsche Bundesbank are filtered out during processing and destroyed.

Figure 2 also shows **the share that is accounted for by the new ES2 notes in relation to the Deutsche Bundesbank's gross monthly inpayments**. Inpayments made at the Deutsche Bundesbank can be assumed to be a representative sample of the cash in circulation in Germany. These inpayment data therefore provide information about the extent to which the ES1 €20 banknotes have already been replaced with ES2 banknotes (and the last batch of banknotes issued from the first series). In July 2016 the new series has accounted for a share of around 95% of the gross inpayments at the Deutsche Bundesbank. This means that the share of ES2 banknotes held for domestic transaction purposes was roughly the same as the share of these banknotes that was paid out in the last few months (99%). During the period following the launch of the ES2 banknotes at the end of November 2015 up until July 2016, the volume of €20 banknotes held for transaction purposes in Germany therefore appears to have been almost completely replaced.

Figure 2: €20 ES2 banknotes as a share in the Deutsche Bundesbank's gross inpayments and outpayments of total €20 banknotes



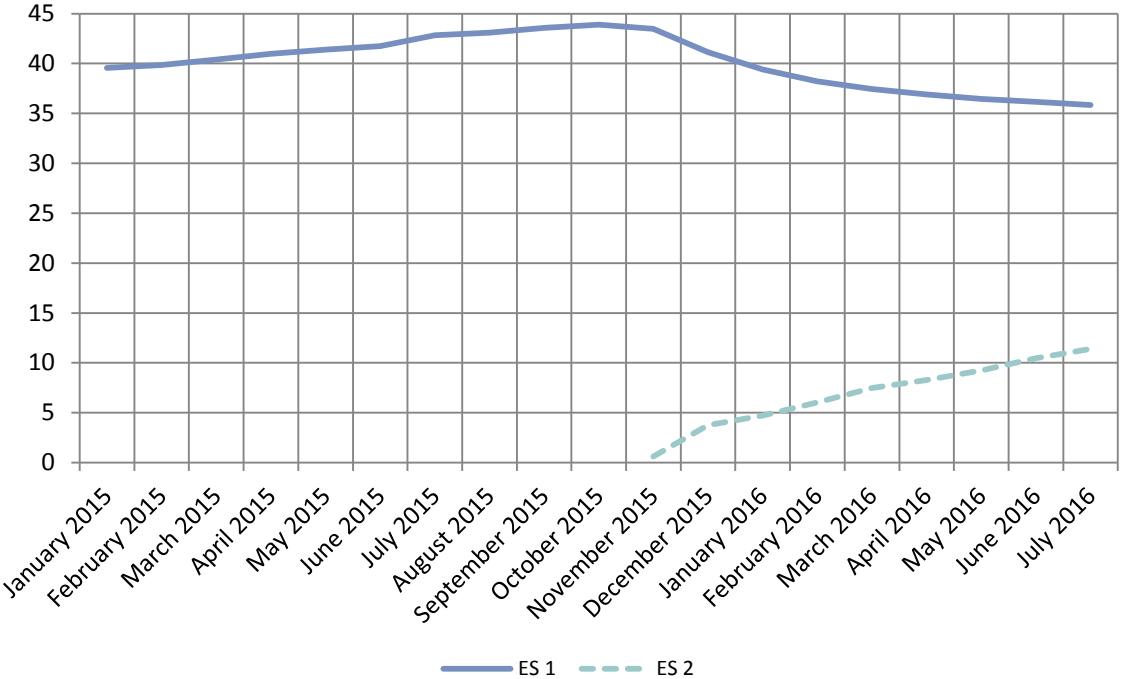
Source: CIS II.

In order to determine how many €20 banknotes are in active circulation in Germany, we calculate how many banknotes flowed back to the Deutsche Bundesbank between the end of October 2015 and the end of July 2016. Given that Germany is a net exporter of €20 banknotes (see Figure 1), only a small amount of foreign banknotes end up in Germany. The return flows to the Deutsche Bundesbank are therefore primarily banknotes from the domestic cash cycle. By adding up these return flows over time, these data can be used to estimate the domestic transaction balance. The sum of the return flows can be determined using the Deutsche Bundesbank's cumulated net issues. Figure 3 shows the development of the Deutsche Bundesbank's cumulated net issues, with separate curves for the old and the new series of €20 banknotes. Between the end of October 2015 and the end of July 2016, the cumulated net issues of ES1 banknotes declined from €43.9 billion to €35.8 billion. During this period, the Deutsche Bundesbank therefore withdrew a net amount of around €8.1 billion old ES1 banknotes from circulation and replaced them with ES2 notes. If it is also taken into consideration that, owing to the parallel issuance of ES1 and ES2 banknotes, around 5% of (active) domestic circulation is still accounted for by ES1 notes that have not yet been replaced by ES2 notes, the calculated €8.1 billion makes up around 95% of the domestic transaction balance. **Based on this calculation method, the domestic transaction balance contains around €8.5 billion (= €8.1 billion divided by 0.95) worth of €20 banknotes. Of the total amount of €43.9 billion German-issued €20 banknotes in circulation at the end of October 2015, only around 19% were accounted for by the domestic transaction balance.** Each resident living in Germany therefore keeps an

average of five €20 banknotes for transaction purposes and not 30 banknotes as estimated on the basis of the net issues.

Since the introduction of the new series of €20 banknotes at the end of November 2015, the total value of these notes has increased from €0 to €11.4 billion. Assuming a relatively constant transaction balance of €8.5 billion, just over 70% of the ES2 €20 banknotes brought into circulation by the Deutsche Bundesbank were in the domestic transaction balance at the end of July 2016.

Figure 3: Cumulated net issuance of €20 banknotes by the Deutsche Bundesbank (in € billion)



Source: CIS II.

2.2 Conclusion

The cash balance of €20 banknotes held for domestic transaction purposes was estimated at around €8.5 billion at the end of October 2015. This means that only 19% of the total amount of €20 banknotes issued by the Deutsche Bundesbank up to that point were in active circulation in Germany. Each resident living in Germany accounted for approximately five €20 banknotes for transaction purposes, and not 30 banknotes as estimated on the basis of the net issues.¹

¹ With regard to the five €20 notes in the transaction balance accounted for by each resident living in Germany on average, it should be noted that the domestic transaction balance is not only accounted for by households, but also includes the cash holdings of credit institutions and the volume of change held by retailers. According to our estimates, the domestic *cash* transaction balance had a value of at least €35 billion in 2015. €13 billion of this amount was accounted for by households, just under €20 billion by the cash holdings of credit institutions and only just under €2 billion by the volume of change held by retailers; the latter can therefore be disregarded. The cash holdings of credit institutions, on the other hand, arise almost exclusively from domestic transactions. They can therefore be interpreted as an external component of the transaction balance of domestic households (Bartzsch, Rösl and Seitz, 2011b, subsection 2.2.2). When considering the domestic *cash*

The calculations are largely in line with our estimations regarding the share of the total domestic transaction balance accounted for by banknotes in relation to the Deutsche Bundesbank's cumulated net issues, which stands at between 5% and 10%. By comparison, the estimated share of €20 banknotes held for transaction purposes in Germany (approximately 19%) seems quite plausible given that the €20 note is a denomination typically used for payment.

Furthermore, the analysis clearly shows that it is not possible to equate the Deutsche Bundesbank's cumulated net issues with the volume of cash in active circulation in Germany, ie the volume of cash held for domestic transaction purposes. This should be borne in mind, especially when assessing the level of market penetration of the new banknote series. The cumulated net issues could, for instance, lead one to assume that just over €36 billion in ES1 banknotes are still in active circulation in Germany, whereas in actual fact, these banknotes were taken out of the German cash cycle quite some time ago. A large share of these notes has migrated abroad and has been paid in at other central banks or will at some stage be paid in at these central banks (see Figure 1). A further share may have been permanently hoarded or lost. It is therefore better to use the inpayment flows at the Deutsche Bundesbank when assessing the level of market penetration of the new series, with the new series currently accounting for a share of just under 95%.

2.3 Review of the estimates

Finally, the estimates of domestic transaction balances of (all of the) small denominations (see Table 2 in section 4) shall be compared with similar estimates from the Deutsche Bundesbank's study of payment behaviour (Deutsche Bundesbank, 2015). Both estimates are juxtaposed in Table 1.

The estimates from the payment behaviour study refer to transaction balances held by *households*. In order to make these estimates comparable with *total* domestic transaction balances (households, credit institutions and retail trade) from Table 2, the latter are multiplied by the estimated percentage share of the total transaction balances of *households*, ie comprising all denominations, in the total *domestic* transaction balances, ie comprising all denominations. The transaction balances of *households* derived from this can be taken from the penultimate row of Table 2. They are about twice as high as the transaction balances of households reported in the 2014 payment behaviour study; see last row of Table 1. One explanation for this discrepancy is that the estimate with the payment behaviour study only captures balances held in *wallets* but not total regular cash withdrawals for transaction purposes. In the absence of data on composition by denomination, only an estimated value for households' total transaction balances, ie comprising all denominations, can be derived for withdrawals. For all three waves of Deutsche Bundesbank's payment behaviour survey,

transaction balance, *coin holdings* can be disregarded as they only account for an estimated value of around €2 billion (Altmann and Bartzsch, 2014).

this estimated value is around twice as high as the estimated value derived from the stock of cash held in wallets.

Table 1: Comparison between estimates on domestic transaction balances and estimates based on the 2014 payment behaviour study

	€5 banknote	€10 banknote	€20 banknote
Domestic transaction balances according to the estimate from Table 2	€1.8 billion	€4.0 billion	€8.5 billion
Estimated households' transaction balances as a percentage of total domestic transaction balances (across all denominations in each case)	44% (end-2013)	38% (end-2014)	38% (end-2015)
Derived households' transaction balances according to the estimate from Table 2	€0.8 bn (= 0.44 * €1.8 bn)	€1.5 bn (= 0.38 * €4.0 bn)	€3.2 bn (= 0.38 * €8.5 bn)
Households' transaction balances in their wallets according to the 2014 payment behaviour study	€0.4 billion	€1.0 billion	€1.5 billion

Sources: Deutsche Bundesbank and author's own estimates.

On balance, the estimates of domestic transaction balances from Table 2 are a very good fit with the estimates of households' transaction balances derived from the study on payment behaviour.

2.4 Outlook

Whether the approach outlined in this paper could also be used to calculate the volume of cash held for domestic transaction purposes in other euro-area countries would have to be examined on a case-by-case basis. The calculations are based on the assumption that the domestic demand for euro banknotes is fully met by the Deutsche Bundesbank's cumulated net issues. This approach is therefore only suitable for countries that are net exporters of €20 banknotes. This assumption is plausible in the case of Germany as Germany has, over time, issued just under 68% of the current aggregate demand for €20 banknotes (see Figure 1) which is a disproportionately high share. This assumption is not true of other countries, however. As soon as the remaining denominations of the ES2 series have been brought into circulation in Germany, the volume of banknotes held for domestic transaction purposes is also to be calculated for these denominations using the method presented in this paper.

3 Volume of German-issued €20 banknotes held for transaction purposes outside the euro area

3.1 The biometric method

The early 1990s saw the launch of a new series of US dollar banknotes featuring a security thread. Back then, Porter and Judson took advantage of this opportunity to estimate the volume of \$50 and \$100 notes in circulation abroad.² The introduction of the ES2 €20 notes, which were issued for the first time on 25 November 2015, was similarly used to gauge the volume of German-issued €20 banknotes (ie notes brought into circulation by the Deutsche Bundesbank) outside the euro area. To this end, use was made of the "biometric" method, originally devised by the Danish biologist Carl Petersen. Biologists are often confronted with the problem of not knowing the size of the total population N (eg the number of fish in a lake). By marking newly added fish of population size M and taking a random sample from the lake some time later it is, however, possible to produce a ratio estimator. This allows a conclusion to be drawn concerning the size of the population N .

3.2 Estimation procedure

Measuring the volume of cash in circulation presents a similar problem inasmuch as the volumes circulating in Germany and abroad are not known.³ The biometric method can be used to estimate the volume of German-issued €20 banknotes held for transaction purposes outside the euro area (non-euro-area countries), the intrinsic assumption being that these notes are in free and random circulation.⁴ **The biometric method can therefore only capture the volume in circulation in the strict sense, that is German-issued €20 notes held for transaction purposes that are actually in circulation in non-euro-area countries, and not those being hoarded in these locations.** The term "hoarded banknotes" refers to notes that return to branches at a much slower pace than notes in circulation in the narrower sense. This definition encompasses not just notes used as a long-term or temporary store of value but also notes that have gone astray or been destroyed.⁵ If, as presumed, the notes are circulating in an unhindered and random fashion, after some time the share of marked banknotes in the random sample matches the share of marked banknotes among the population as a whole.

$$\frac{M}{N} = \frac{m}{n} \quad (1).$$

² See Porter and Judson (1996).

³ However, Bartzsch, Rösl and Seitz (2011a, 2011b) have demonstrated that Germany is a net exporter of euro banknotes both to other euro-area countries and to non-euro-area countries.

⁴ See Porter and Judson (1996, p 893). For a more precise account Porter and Judson (1995, section 3.2). Since Germany is a member state of the European monetary union, the term "abroad" refers to two categories of country: other euro-area countries and non-euro-area countries. In this context, the biometric method therefore takes a different approach to that deployed by Porter and Judson for the United States.

⁵ Banknotes paid in to the Deutsche Bundesbank via shipments stem either from the volume of cash held for transaction purposes or from temporary hoarding. The problem here is that it is not possible to visibly discern *whether a given note belongs to the former or latter category.*

M denotes the collective value of all marked notes (ES2 €20 banknotes). n represents the value of all €20 notes belonging to the random sample while m denotes the value of all marked €20 notes included in that sample. If these volumes are broken down according to the value of all German-issued €20 notes belonging to shipments held in non-euro-area countries for transaction purposes, N , this results in the following:

$$N = \frac{n}{m} M \quad (2).$$

Variables n , m and M on the right-hand side of equation (2) refer to "shipments". This term refers to all €20 banknotes paid in to branches of the Deutsche Bundesbank via official deliveries of banknotes to countries outside the euro area or any such notes brought into circulation by these branches.⁶ In other words, the random samples n and m are only taken from branches handling shipments (**shipment branches**). The above works on the assumption that banknotes in these random samples (forming part of a shipment) were brought into circulation by the *Deutsche Bundesbank* (and not other Eurosystem central banks). This assumption can be justified by the fact that the vast majority of shipments occurring within the Eurosystem are handled by the Deutsche Bundesbank. Shipment branches thus comprise branches that strive to satisfy not just the demand coming from within Germany and from other euro-area countries but also from non-euro-area countries alike. In order of importance, these are first and foremost the Deutsche Bundesbank's branches in Frankfurt am Main and Mainz, followed by its branches in Freiburg *and* Villingen-Schwenningen (which "replaced" the Lörrach office), with Berlin and Munich in third place.⁷ Variable n denotes the value of all €20 notes (ES1 and ES2) paid in to the above branches in July 2016 *from countries outside the euro area*. Variable m stands for the value of all the ES2 €20 notes included in this volume. Drawing of the random sample was held off until July 2016 in order to give the €20 notes from the old and new series enough time to achieve a good mix. Inpayment flows at the Deutsche Bundesbank have been used to assess the level of market penetration of the new series, with the new series accounting for a share of 94% in July 2016.

Apart from via shipments, German-issued euro notes are mainly transported abroad to non-euro-area countries either as a result of travel or as cash taken by migrants back to their home countries.⁸ These channels are not captured by the biometric method, notwithstanding the fact that inpayments arising from the shipments also include notes that were originally exported abroad through travel to countries outside the euro area. **N from equation (2) thus relates only to that share of the volume of German-issued €20 notes held for transaction purposes in non-euro-area countries that is attributable to shipments.** However, presumably most of German-issued €20 banknotes kept outside the euro area stem from shipments.

⁶ The shipments are processed by wholesale banks active in the international wholesale banknote market.

⁷ The Lörrach office, which occupied an important position in the international wholesale banknote market in terms of the Swiss banking system's logistical links with the euro cash cycle, was closed on 30 September 2012.

⁸ At the end of 2015, German euro notes worth an estimated €272 billion were to be found in circulation outside the euro area. Of this amount, €158 billion stemmed from shipments, with €113 billion arising from foreign travel. These figures represent an update of the estimate made by Bartzsch, Rösl and Seitz (2011a, section 3.1). No data is available showing how the various denominations break down regarding German euro notes exported through travel.

Value M denoting the volume of ES2 €20 notes brought into circulation by shipment branches between 25 November 2015 and 31 July 2016 and destined for non-euro-area countries comes to €1.4 billion.⁹ The sum total n comprising all €20 notes (ES1 and ES2) paid in to shipment branches in July 2016 as shipments from non-euro-area countries amounts to around €150 million. Value m denoting the volume of ES2 €20 notes included in n totals €65 million.¹⁰ **In equation (2), it follows that N , which constitutes the volume of German-issued €20 notes held for transaction purposes outside the euro area and deriving from shipments, had an estimated value of around €3.3 billion at the end of July 2016.** In the next section we investigate whether this estimation is plausible.

3.3 Review of the estimates

Viewed in relation to the total volume of German-issued €20 banknotes in circulation, which amounted to €44.9 billion at the end of 2015, the estimated cash balance held for transaction purposes (arising from shipments) outside the euro area accounts for no more than just over 7% of the whole. At first glance this would appear to be a very low figure. But this result was to be expected for a number of reasons. First, a large share of German-issued €20 banknotes is to be found in other euro-area countries (see Figure 1). Second, euro banknotes kept outside the euro area are primarily being hoarded.¹¹ The cumulative value of net shipments of German-issued €20 banknotes (in countries outside the euro area) as at the end of 2015 was estimated to have reached a level of €11.6 billion, equivalent to one-quarter of the (mathematical total) volume of this denomination in circulation. An estimated share of no more than around 28% of these cumulated net shipments (worth €3.3 billion) relate to transactions. The remaining share, worth €8.3 billion, is hoarded. At the end of 2015, the total cash balance of German-issued €20 banknotes held outside the euro area came to an estimated amount of about €13 billion.¹²

Finally, we use the following tests to check the estimate derived in subsection 3.2 relating to the volume of German-issued €20 notes held for transaction purposes outside the euro area (arising from shipments), N .

Test 1 " N may not be larger than the total volume of shipments (ie the cumulative value of net shipments) of €20 notes effected by the Deutsche Bundesbank since the introduction of euro coins and banknotes."

⁹ This represents the cumulative value of net outward payments from Germany to countries outside the euro area (ie the sum total of all outward payments less all inpayments) in the context of the official shipments described above.

¹⁰ According to the ECB guideline dated 9 December 2011 on the statistical reporting requirements of the ECB in the field of external statistics (ECB, 2011), national central banks are obliged to supply monthly data on the importing and exporting of euro notes to and from non-euro-area countries. These figures are meant to be broken down according to denomination using the most accurate estimates available. To this end, the Deutsche Bundesbank makes use of the BMS cash management system, which records shipment banknotes according to denomination, also differentiating between types ES1 and ES2. Inpayments (imports) data broken down by denomination have only been available since January 2013. For the period between 2002 and 2012 it was, however, possible to derive estimates of cumulative net shipments according to denomination using inpayment shares (in value terms) from the year 2013.

¹¹ See Bartzsch, Rösl and Seitz (2011a, section 3.4).

¹² According to an estimate based on the seasonal method, the volume of German-issued €20 notes held outside the euro area rose linearly from just under €3 billion in 2003 to €8 billion in 2009 (Bartzsch, Rösl and Seitz, 2011b, subsection 2.2.2). Extrapolating from this, the year-end figure for 2015 stands at €13 billion.

N is a partial amount of the total volume of shipments. Therefore, it may not exceed the latter. With respect to shipments information, only data on the cumulative outpayments are broken down by denomination. Inpayments data have only been broken down by denomination since January 2013. Assuming that the proportion of €20 notes among inpayments arising from shipments in 2013 can also be applied to the period between 2002 and 2012, the estimated (net) cumulative value of shipments of €20 notes effected by the Deutsche Bundesbank is found to stand at €11.6 billion at the end of 2015. This figure lies well above the estimated value of N (€3.3 billion) which has therefore not been disproved by test 1.

Test 2 " N should be low"

This test also works on the assumption that €20 notes held in non-euro-area countries are seldom used for transaction purposes. Presumably, most euro notes in these countries are being hoarded.¹³ At the end of 2015, N (€3.3 billion) made up just 7% of the total volume of German-issued €20 notes in circulation (€44.9 billion).¹⁴ Similarly, when compared with the (estimated) volume of €20 notes held *in Germany* for transaction purposes amounting to €8.5 billion, N accounts for a rather modest share (around 38%) of the total figure. The estimated value of N is thus also compatible with the hypothesis presented in test 2.

4 Summary and conclusions

Table 2 gives an **overview of the key estimates**, including existing estimates for €5 and €10 banknotes.¹⁵

Table 2: Components of the (arithmetical) volume of small-denomination "German" banknotes in circulation

€ billion	€5 banknote	€10 banknote	€20 banknote
Total arithmetical volume in circulation (cumulated net issues)	8.5	24.5	44.9
Cash balance held for transaction purposes in Germany	1.8 (21.2%)	4.0 (16.3%)	8.5 (18.9%)
Total volume of such cash kept outside the euro area	-	8.5 (34.7%)	13.2 (29.4%)
<i>of which</i> (cumulated net) shipments	0.56 (6.6%)	6.2 (25.3%)	11.6 (25.8%)
<i>of which</i> held for transaction purposes	0.24 (2.8%)	0.5 (2.0%)	3.3 (7.3%)
<i>of which</i> hoarded	0.32 (3.8%)	5.7 (23.3%)	8.3 (18.5%)

¹³ See Bartzsch, Rösl and Seitz (2011a, section 3.4).

¹⁴ At the end of 2015, (cumulative net) shipments of German-issued €20 notes (with an estimated value of €11.6 billion) accounted for one quarter of the total volume of German-issued €20 notes in circulation.

¹⁵ See Bartzsch and Seitz (2016).

Residual (ie hoarded in Germany or hoarded/held for transaction purposes in other euro-area countries)	6.1 (72.2%)	12.0 (49.0%)	23.2 (51.7%)
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Sources: Deutsche Bundesbank and author's own estimates.

Notes:

1) Percentage share of cumulated net issuance in brackets.

2) €5 banknote: Volume of cash held in Germany for transaction purposes as at beginning-May 2013; cash balance held for such purposes outside the euro area arising from shipments as at end-January 2014. All other figures relate to end-2013.

3) €10 banknote: Volume of cash held in Germany for transaction purposes as at end-August 2014; cash balance held for such purposes outside the euro area arising from shipments as at end-May 2015. All other figures relate to end-2014.

4) €20 banknote: Volume of cash held in Germany for transaction purposes as at end-October 2015; cash balance held for such purposes outside the euro area arising from shipments as at end-July 2016. All other figures relate to end-2015.

The volume of German-issued €20 notes arising from shipments and held outside the euro area for transaction purposes accounts for an estimated value of around €3.3 billion (end-July 2016). Therefore, of the cumulated net shipments (with an estimated value of about €11.6 billion as at end-2015) and hence of the total volume of German-issued €20 notes held outside the euro area (estimated total of around €13.2 billion at end-2015), the vast majority of notes are hoarded. The (total) volume of German-issued €20 notes in circulation amounting to €44.9 billion (end-2015), less 1) the estimated value of €20 notes held for transaction purposes in Germany amounting to €8.5 billion (end-October 2015) as derived in section 2 and less 2) the (extrapolated) estimated value of the total volume of German-issued €20 notes held outside the euro area amounting to €13.2 billion (end-2015) **leave an estimated residual value of €23.2 billion. This figure represents around half of the cumulated net issues of German-issued €20 notes. It consists of hoards in Germany and (transaction and hoarding-related) balances in the rest of the euro area.** Demand for €20 notes there is to some extent met by the Deutsche Bundesbank.

Domestic transaction balances account for roughly one-fifth of the total volume in circulation of all three denominations (cumulated net issuance). However, in the case of €10 and €20 banknotes, cumulated net shipments account for around one-quarter of the total volume in circulation of each denomination, which is significantly higher than in the case of the €5 banknote, at only 7%. The reason for this difference is that there is typically less demand for the €5 abroad than for the two next higher denominations.

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