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## Economics Letters

journal homepage: [www.elsevier.com/locate/econlet](http://www.elsevier.com/locate/econlet)Estimating the foreign circulation of banknotes<sup>☆</sup>Nikolaus Bartzsch<sup>a</sup>, Gerhard Rösl<sup>b</sup>, Franz Seitz<sup>c,\*</sup><sup>a</sup> Deutsche Bundesbank, Cash Department, Wilhelm-Epstein-Str. 14, D-60431 Frankfurt, Germany<sup>b</sup> University of Applied Sciences, Regensburg, Seybothstrasse 2, D-93053 Regensburg, Germany<sup>c</sup> University of Applied Sciences, Weiden and WSB Poznan, Hetzenrichter Weg 15, D-92637 Weiden, Germany

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## ABSTRACT

In this paper, we analyze the volume of Euro banknotes issued by Germany and circulating in other Euro area countries as well as outside the Euro area with a banknotes' age model. Our approach suggests that about 60% of banknotes, the equivalent of around € 225 billion, is held abroad.

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## 1. Introduction

All Euro-area national central banks issue Euro banknotes. Following the introduction of Euro cash at the start of 2002, banknotes issued by the Deutsche Bundesbank increased from € 73 to € 390 billion at the end of 2011. This growth was much faster than could have been expected on the basis of earlier growth rates for D-Mark currency. Moreover, for each of the seven Euro denominations, the Bundesbank's share in net issuance is higher than its share in the capital of the European Central Bank (ECB) of about 27%. The latter is calculated according to the Euro countries' population and GDP shares.

These developments cannot be explained by an increased holding of transaction balances in cash as German private consumption since 2002 was weak and there was a steady decline in the percentage of cash payments in German retail sales (EHI

Retail Institute, 2010). The huge surge is therefore likely to be due to domestic hoarding and especially to foreign demand for Euro banknotes. This foreign demand may originate from other Euro area countries or from non-Euro-area countries.

There are only few studies on foreign demand for Euro cash. Fischer et al. (2004) estimate that between 8% and 13% of outstanding Euro legacy currencies in 2000 was circulating abroad. Deutsche Bundesbank (2009, 49–51) uses the official shipments of Euro banknotes by banks from Germany to non-Euro-area countries and an additional blanket amount for probable positive net exports of Euro banknotes via other channels (e.g. tourism) to estimate that foreign demand outside the Euro area in 2008 had accounted for between 25% and 35%. The (ECB, 2011a, 31) states that “taking into account a range of different estimates suggests that around 20%–25% of Euro currency was circulating outside the Euro area at the end of 2010”. However, it does not specify these “different estimates” in more detail. And according to a survey by the Austrian central bank, households in central, eastern and south-eastern Europe held approximately € 12 billion in Euro cash in 2008 (Scheiber and Stix, 2009). The present paper on developments in Germany adds a country perspective within a currency union to this research.<sup>1</sup> Specifically, we try to

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<sup>1</sup> Studies of cash movements within a currency area are relatively rare. For a country-specific perspective within the Euro area, see Schneeberger and Süß (2007)

capture demand from abroad with the help of a model of the age of banknotes.

## 2. The general model

The basic problem can be formulated as follows Feige (1997, 184):

The shares  $\beta_1$  and  $\beta_2$  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  $\beta_1$  and  $\beta_2$ .

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

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

$$\beta_1 = \frac{X - X_2}{X_1 - X_2} \quad (2)$$

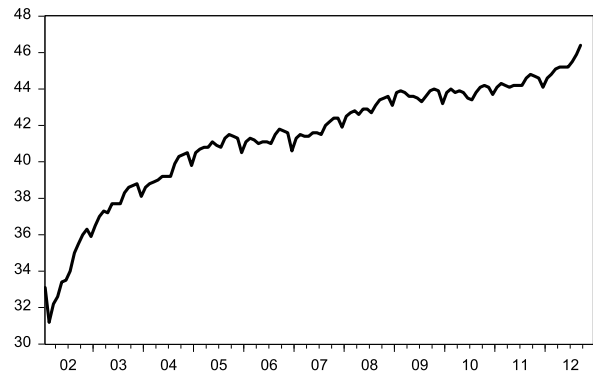
$$\beta_2 = \frac{X_1 - X}{X_1 - X_2}.$$

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 0 and 1. Therefore, to implement this approach for our purpose, the characteristics of banknotes held outside Germany ( $X^a$ ) must differ sufficiently from those of the banknotes outstanding in Germany ( $X^d$ ) so that the foreign share can be identified. In our case, the distinguishing feature is the age of banknotes.

## 3. The age of banknotes and foreign circulation

In the Eurosystem, the fitness of Euro banknotes in circulation is checked by national central banks or by commercial banks as part of the cash cycle. This implies that damaged or soiled banknotes are removed from circulation and replaced by new ones. A banknote issued by the Bundesbank will either be located in Germany, in another Euro area country or outside the Euro area. If it is circulating in another Euro area country, it will be removed from circulation at some point by the respective national central bank. If it is located in a non-Euro-area country, it will either never return to the Bundesbank or do so with a time lag. Foreign demand thus results in banknotes issued by the Bundesbank having a longer (measured) life (with possibly lower quality). The foreign share can be derived by comparing the actual age of notes with the “normal” lifespan.<sup>2</sup> As mentioned, this foreign share includes non-German Euro area circulation of cash. Since the introduction of Euro banknotes and coins in January 2002, Germany's share in total Euro area issuance has steadily increased from about 32%–46% at the end of 2012 (see Fig. 1). One reason for this development is that Germany is a net exporter of cash to other Euro area countries (see Section 3.2 in Bartzsch et al. (2011a)).

In the Currency Information System 2 (CIS2) of the European Central Bank, all of the Eurosystem national central banks provide their issuance data on a monthly basis, including the average volume of banknotes in circulation, the volume of new issuance, and the number of banknotes removed from circulation (ECB, 2011b). However, due to the changeover from CIS1 to CIS2, it has been possible to consistently examine the data only since



Source: Deutsche Bundesbank.

Fig. 1. Germany's share in total Euro area cash issuance (%).

Source: Deutsche Bundesbank.

September 2008. For our purposes, this means that we cannot derive a time series for foreign demand since 2002, but confine ourselves to the average holdings in 2009. In the calculations below we do not differentiate between different denominations, but use total banknotes issued instead.

Formulas for calculating the average life of banknotes have been developed by central banks and the institutions charged with printing banknotes.<sup>3</sup> We use the Eurosystem formula which calculates the average lifetime  $AL$  as a weighted arithmetic mean of inflows and outflows.

$$AL_t = \frac{n_t}{\frac{q_t + v_t}{2}}, \quad (3)$$

where  $n$  denotes the (average) volume of banknotes in circulation,  $q$  the (average) volume of new issuance,  $v$  the (average) number of banknotes destroyed (each in units) and  $t$  the corresponding year. Eq. (3) produces meaningful results given stable banknote developments and if the banknote has been in circulation for a sufficiently long period of time. To achieve this, the currency must have already existed with the same denomination structure for some years and show no extreme banknote movements during the observation period. The first condition is undoubtedly fulfilled for the Euro. However, distortions in the results might be produced by the insolvency of Lehman Brothers in September 2008 and its impact on the demand for cash (see also Bartzsch et al., 2011a, Section 3.4), which could still be felt in 2009. Therefore, we also present results for 2010/11.

To calculate the “normal” lifespan of German banknotes, we use France as a reference country. The idea behind selecting a reference country is to find a country that is similar to Germany in its use of banknotes, except for foreign demand from non-Euro-area countries.<sup>4</sup> Detailed reasons for this decision are given in Bartzsch et al. (2011b, 13 f). As there is no significant non-Euro-area demand for banknotes issued by France (this is indicated, for example, by the fact that the official net shipments of banknotes are carried out almost entirely by German banks), “French” banknotes should have a shorter lifespan than “German” banknotes. This is precisely the case. While the average age of “French” Euro banknotes in 2009 was around two years, German banknotes were more than twice as old during the same period, with an average age of just under five years. In France there are slight differences in the ages of the banknotes when broken down by denomination, but with

and Bartzsch et al. (2011a,b). The situation in the US is analyzed by Judson and Porter (2004).

<sup>2</sup> Originally, an attempt was made to draw conclusions about the hoarding of currency from the life of banknotes (Boeschoten, 1992, Section 3.3).

<sup>3</sup> For a formal description of the calculation of the lifespan of banknotes, see Den Butter and Coenen (1982). Different ways of estimating the age of banknotes may be found in Cao and Negueruela (2012).

<sup>4</sup> In the US case, usually Canada is taken as the reference country.

no clear trend. In Germany, by contrast and as expected, higher denominations are generally older than lower denominations.

Given the methodology of Section 2, the age characteristics can be used to derive the domestic share ( $\beta^d$ ) and the foreign share ( $\beta^a = 1 - \beta^d$ ) (Feige, 2009, 185 ff).

$$AL = \beta^d AL^d + (1 - \beta^d) AL^a$$

$$\Leftrightarrow \beta^d = \frac{AL - AL^a}{AL^d - AL^a} \quad (4)$$

Specifically, by comparing the average ages of German and French Euro banknotes, the foreign share of “German” banknotes ( $\beta^a$ ) in 2009 can be calculated using Eq. (5)

$$\beta_{2009}^a \equiv 1 - \beta_{2009}^d = \frac{(AL_{2009}^D - AL_{2009}^F)}{AL_{2009}^D} \quad (5)$$

where *D* and *F* stand for the countries Germany and France. The percentage of foreign holdings calculated using this equation amounted to just over 60% in 2009. Applying this method to the years 2010 and 2011 yields 62% and 64%, respectively. Thus, the foreign share has slightly increased. In absolute terms, this corresponds to about € 225 billion banknotes being held abroad. Bartzsch et al. (2011b) find that “German” banknotes also circulate in other Euro-area countries and to a significantly greater extent than “French” banknotes. Therefore, this figure refers to *total* foreign demand (intra Euro area *and* extra Euro area). It represents a lower limit compared with most of the time series results in Bartzsch et al. (2011a,b) In light of the estimation uncertainties and the fact that the changeover from CIS1 to CIS2 did significantly reduce the age of German banknotes, this figure is compatible with the foreign holdings of banknotes estimated earlier.

#### 4. Summary and conclusion

This paper has endeavored to use a life of banknotes model to determine foreign demand for Euro banknotes issued in Germany. It has been found that around 60% of the cumulated net issuance was held outside Germany (approx € 225 billion). This means that only 40% are used in Germany for transaction and hoarding purposes.

As demonstrated by Seitz and Setzer (2009), the statistical-econometric quality can be raised and the economic interpretation

of cash demand functions for Germany can be made easier if arguments for foreign demand are incorporated. Given our results, this comes as no surprise. Aksoy and Piskorski (2005, 2006) have determined for the US that the indicator properties of narrow monetary aggregates with regard to cyclical and price developments can be improved considerably by taking foreign demand into account. Whether this is also the case for Germany or the Euro area as a whole should be the subject of future research.

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