WORKING paper

BANQUE DE FRANCE
EUROSYSTÈME

Different Motives for Holding Cash in France: an Analysis of the Net Cash Issues of the Banque de France

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October 2022, WP 888

ABSTRACT

The present paper analyzes the net cash issues of the Banque de France. It is divided in two parts. The first estimates cash demand functions for different denominational groups (small, medium, large). We find that many of the different motives for holding cash are present in the French case. In a second step we try to estimate the amounts used for transaction and store of wealth purposes, internal hoardings and foreign demand with indirect methods with a special focus on different variants of the so-called seasonal method. Our results reveal that in 2019 only around 15 % of the cumulated net issues are used for domestic transactions. Around 60 % are held outside France, either in other euro area countries or outside the euro area.

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NON-TECHNICAL SUMMARY

The present paper analyzes the demand motives of the outstanding amount of euro banknotes issued by the Banque de France. Since the introduction of the euro, these cumulated net issues have steadily increased over time from €30 bn. in 2002 to nearly €185 bn. at the end of 2021. This is not only true in absolute terms, but also relative to GDP. Therefore, domestic demand for transaction balances cannot be the only driver. The demand for banknotes can be split into different shares: domestic transactions, store-of-value and foreign demand. Although the central bank knows exactly the amount of cash issued, there is lack of information on who holds it, for what motives and where it circulates. Moreover, within the euro area, the exercise is even more complicated as euro banknotes issued in France may migrate to other euro countries (and vice versa) without any obstacle. In our analysis, we concentrate on the situation from 2002 until the end of 2019 to not distort the results by the Corona pandemic which had huge repercussions on cash demand worldwide.

As a first step we estimate cash demand equations for different denominational groups within a cointegration framework in order to get information on the prevalence of different motives for holding cash. The results confirm that non-transactional as well as transactional motives for holding cash are present in the case of France.

To estimate the corresponding shares, indirect methods are applied which make use of different characteristics of domestic transactions balances compared to cash balances held for other purposes (at home and abroad). We predominantly concentrate on the so-called seasonal method, which is applied to French cumulated net issues of banknotes. The aim of the seasonal methods used is to filter out information about banknotes in circulation not used for transaction balances within France from the "seasonal pattern of banknotes" characteristic.

In 2019, only around 15 % of the cumulated net issues (representing a total of €145 bn.) are used for domestic transactions (see Figure). More than half of the cumulated net issues are held outside France, either in other euro area countries (i.e., France is a net exporter of banknotes within the euro area) or, and mostly, outside the euro area. Finally, we estimate that around 25 % of the cumulated net issues are used for domestic hoarding purposes.

Different motives for holding cash: The case of France in 2019
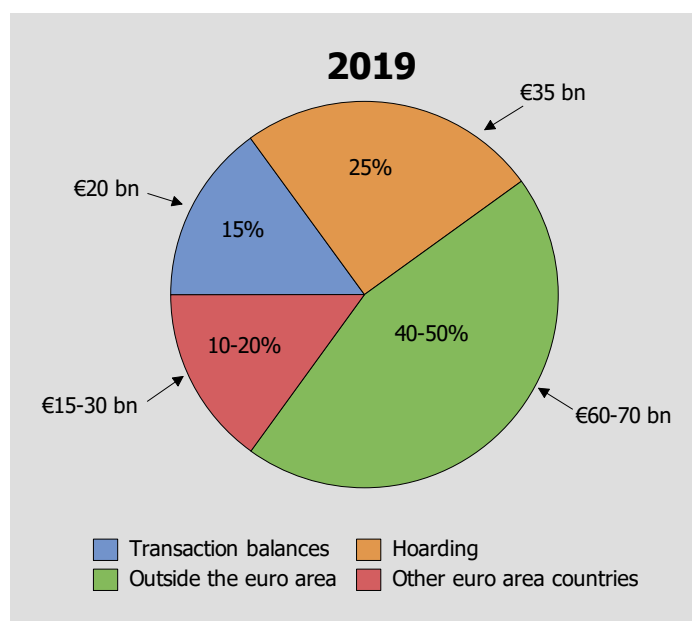
Note: Rounded figures.

Les différents motifs de détention d'espèces en France : une analyse des émissions nettes de billets de la Banque de France

RÉSUMÉ

Ce document de travail analyse les émissions nettes de billets de la Banque de France. Il est divisé en deux parties. La première estime les fonctions de demande de billets pour différents groupes de dénominations (petites, moyennes, hautes). Dans un premier temps, nous constatons que les différents motifs de détention d'espèces sont présents dans le cas français. Dans un second temps, nous essayons d'estimer les montants utilisés à des fins transactionnelles et détenus pour motif de thésaurisation en France ainsi que les montants détenus à l'étranger. Cet exercice est conduit à l'aide de méthodes indirectes, en nous intéressant plus particulièrement aux différentes variantes de la « seasonal method ». Nos résultats révèlent qu'en 2019, seul environ 15 % des émissions nettes cumulées sont utilisées pour des transactions domestiques. Environ 60 % sont détenues hors de France, soit dans d'autres pays de la zone euro, soit en dehors de la zone euro.

Mots-clés : espèces, billets de banque, émissions nettes, méthode saisonnière.

1. Introduction

The analysis of cash gained prominence worldwide in the last years, especially since the financial and economic crisis 2008/09 (see, e. g., Jobst & Stix, 2017; Ashworth & Goodhart, 2020). What we have seen since then is a trend towards declining transactions balances, but an increase in total cash in circulation.[1] This phenomenon is sometimes called the "paradox of banknotes" (see Zamora-Pérez, 2021). However, cash analyses are complicated by the fact that a central bank or researcher in general only knows the amounts of cash issued by the banking system, but not who holds it and for what motives and where it circulates. Consequently, there is a huge information problem. This is even more pronounced in a monetary union where cash issued by one member central bank is a perfect substitute for that issued by others and can move freely from one country to another.

Since the introduction of euro notes and coins in January 2002, cash in circulation in the euro area has been steadily rising, both in absolute terms (more than a quadruplication from 2002 to 2020), but also relative to GDP. Its share in GDP was more than three times higher in 2020 than in 2002. This overall development in the European Monetary Union masks very different patterns nationally. The individual euro area countries are quite heterogenous, both with respect to the real sector (e. g., Belke, et al., 2017) as well as to the financial (ECB, 2020a) and to the payments environment (Esselink & Hernández, 2017). The latter is especially true for the household sector, the dominant cash holder (ECB, 2020b). For example, in terms of number of transactions, cash payments at the point of sale in 2019 amount to 80 % or more in the southern euro area countries as well as in Germany, Austria and Slovenia, whereas in the Netherlands, Estonia and Finland, this share varied between 35 % and 48 % only (Esselink & Hernández, 2017; ECB, 2020b). The respective figure for France was 59 %. According to the payments statistics of the ECB, annual card payments per capita in 2019 fluctuate between around 60 in Italy and more than 350 in Finland. France stood at nearly 220.[2]

All this would necessitate and imply an analysis of cash holdings in individual euro area countries. However, within a currency union, this is not an easy task as the cumulated net issues of one national central bank may circulate actively or be held passively in the home

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[1] This tendency was even intensified in the course of the Covid-19 pandemic, see Ashworth & Goodhart (2021) and Rösl & Seitz (2021).

[2] Schrooten & Varmaz (2020) make the point that culture is an important aspect to explain these differences in payments behaviour.

country, may flow to other euro area countries or may be held outside the euro area.[3] There are only a few papers which concentrate on this national perspective. Bartzsch, et al. (2013), Bartzsch & Seitz (2016), Deutsche Bundesbank (2018), Rua (2018) and Baldo et al. (2021) analyze the net issues of individual euro area countries, namely Germany Portugal and Italy, whereas Seitz et al. (2020) and Reimers et al. (2021) consider the net issues of a panel of euro area countries. All these papers reveal that the cash holding motives – transactions based and non-transactions based - are relevant to differing degrees for the different denominations.[4] ECB (2020b) presents survey results on the use of cash by households at the point of sale (POS), i. e., it concentrates only on transactions balances. Their results show that in 2019 around 73 % of all payments at the POS were made with cash, with again substantial differences between the euro area countries.

There are also a few papers which cover the French case with respect to specific aspects of cash demand. Bouhdaoui & Bounie (2012) compare different payment choice models in their ability to replicate observed payment behaviour in France. Banque de France (2020) presents survey results on the use of cash and non-cash payments in France in 2019.[5] In volume terms, cash was still the dominant payment media (59 %), whereas in value terms cash only accounted for 25 % of payments. Both figures are significantly lower than the euro area average. The average cash payment at the POS amounts to €12.3, one of the lowest values in the euro area. On average, French people have 45 euros in their wallets which is again much lower than the euro area average (76 euros). Avouyi-Dovi et al. (2022) estimate the French shadow economy in a sample from 1990 to 2019. They find that cash demand motives are becoming less important in the last years (especially after 2010). Politronacci et al. (2017) use different direct and indirect methods to estimate the national demand for euro banknotes in France. Their results reveal that in 2015 only around 10 % of the French net issues are used for transactions purposes.[6] Adding an estimate of the cash use in shadow economic activities increases this figure to around 20 %.

All the estimations presented in this paper are conducted from 2002 to 2019. The special situation of the years 2020/21 which are heavily affected by the corona virus pandemic is

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[3] Different approaches to estimate currency in circulation of a member country of a monetary union, with an application to the euro area, are presented in Dias (2019).
[4] Rösl & Seitz (2021) present worldwide evidence of a shift from transactional to non-transactional demand for cash over time.
[5] In an international study (including France) Bagnall et al. (2016) find significant cross-country differences with respect to consumer cash usage. The use of cash strongly correlates with transaction size, demographics and point-of-sale characteristics.
[6] Ninlias & Torre's (2016) descriptive analysis of the French net issues concentrates on the year 2015 only.

excluded to not distort the overall results. However, we make some remarks with respect to these peculiarities in the concluding section. A deeper analysis necessitates a separate investigation, especially for section 3.

The paper is structured as follows. The next section establishes cash demand functions for small, medium and large denominations within an econometric framework. This provides a first indication on the different motives for holding cash in the French case. Section 3 tries to estimate the shares of transactions balances used in France, the non-transactional domestic part and foreign holdings (within and outside the euro area) of banknotes issued by the Banque de France with indirect methods. Section 4 summarizes and concludes.

2. The demand for euro banknotes at the Banque de France

2.1. Data used

The variable to be explained is the cumulated net issues of banknotes or cash (banknotes and coins) of the Banque de France.[7] As the motives for holding banknotes are fulfilled by the different denominations to different extents, it is implausible to assume that the coefficients of the variables determining the demand for banknotes are the same for all denominations. For example, the transaction motive should be more important for small- and medium-value banknotes. By contrast, store of wealth considerations may dominate the demand for high-value banknotes. At the same time, substitution effects may exist between banknotes of similar value. Therefore, we do not only estimate an equation for total banknotes, but additionally three separate relations for small, medium and large denominations, respectively. Our preferred classifications are €5 - €20 for "small" notes (possibly supplemented with coins), only €50 as the "medium" note and €100 - €500 for "large" notes. This classification is chosen because large notes are not distributed by ATMs, which primarily serve to "top up" transaction balances. Moreover, the €50 banknote may probably be the smallest denomination that is used (amongst other things) for hoarding

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[7] French overseas territories (see Sèze et al., 2011) are included in these net issues. An alternative would be to analyze the two parts of the net issues, specifically inpayments and outpayments of banknotes at the central bank, see on that topic, e. g., Deutsche Bundesbank (2009).

purposes.[8] We estimate specifications in real terms and use the private final consumption deflator as price variable.[9]

Due to the anonymous nature of cash, it is not always easy to find good empirical proxies for the determinants of cash demand. Therefore, we follow an eclectic approach in that we use a large set of variables which reflect the various motives for holding banknotes and which we test for statistical and economic significance.

With respect to the transaction variable, it would be optimal to include a variable capturing all cash transactions (Snellman et al., 2000). Since no data is available on the number of cash transactions in France, we use, as is common in cash demand studies, total private consumption, retail sales or GDP (in real terms), with a preference for the first two. This is, however, only a rough proxy given the large number of cashless transactions in an economy. As real property purchases and especially expenses incurred in the construction sector may be partially made in cash, we also take a house price index into account.[10]

As opportunity costs of holding cash, we consider different *levels* of interest rates. Appropriate choices include money market rates, bank deposit rates or the ten-year government bond yield. However, against the background of the other determinants of cash demand, it is often hard to detect a significant additional influence of interest rates (see the results below). We try the traditional semi-log as well as a double-log specification.[11]

Closely related to opportunity costs of holding cash are alternative means of payment and financial innovation. While cash is still the most important means of payment in France for everyday purchases (see Banque de France, 2019), the number and total value of transactions with cards have been trending upward for years. Moreover, cash (but also traditional cards) faces increasing competition in the last years from new payment instruments like contactless or mobile payments (see for France Bounie & Camara, 2020). In order to capture these

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[8] If we use the notion "hoarding" in this paper, we mean cash not used for immediate domestic transactions (active circulation in the country of issuance). In France and other euro area countries, small denominations are hardly used for these hoarding purposes. In more unstable countries with high inflation rates, this might differ. There, €10 and €20 banknotes may very well be considered as large banknotes.

[9] As alternatives we also tried the French or harmonized CPI and the GDP deflator. Those variants yield worse statistical and/or economic results.

[10] The cash payment limitation for real property purchases in France is fixed at €3,000. For goods and services, the cash payment threshold is fixed at €1,000.

[11] The log-log specification yields interest rate semi-elasticities which vary with the level of interest rates. The lower interest rates, the higher the interest rate semi-elasticity in absolute terms which introduces a non-linearity in the relationship. Theoretical considerations justify this formulation (Mulligan & Sala-i-Martin, 2000). Moreover, Chadha et al. (1998), have shown that in the case of well-behaved utility functions, such a functional form follows necessarily from the application of first principles.

cashless payments, several variables are considered: the volume and value of card transactions as well as the volume and value of contactless and mobile payments, the number of POS terminals as a proxy for acceptance of cards by retailers and the number and value of POS transactions. Due to the historical importance of cheques in France, we also take the volume and value of cheques into account.[12] According to the ECB's report on payments statistics, in 2019 cheques represented 6.4 % of the total number of transactions, whereas this share was below 2% in other euro area countries (except Malta). And finally, we model access to cash via the number of ATMs.

It is sometimes argued that, due to its anonymity, cash is used intensively in the shadow economy (see, e. g., Rogoff, 2016).[13] As the size of the shadow economy is not observable, it has either to be estimated or causal or indicator variables have to be used. As a direct measure of the size of the shadow economy, we take Schneider's estimates as a share of GDP based on the MIMIC approach (Medina & Schneider, 2018).[14] The potential causal variables included in the estimates are the unemployment rate, the corruption perception index for France provided by Transparency International and different tax variables (direct and indirect taxes, taxes of households and firms).

The cumulated net issuance of euro banknotes put into circulation by the Banque de France differ considerably from the domestic holdings of banknotes. Due to large inflows and outflows between countries, net issues may systematically differ from the demand for cash within the economy. The foreign demand for banknotes issued in France can be divided in two parts: first, there is the demand for these "French" banknotes resulting from residents of other euro area countries. Consequently, the demand for cash in one euro area country may be satisfied in part by inflows of cash coming from another member state. The situation of being a net exporter or net importer of banknotes within the euro area can even change in the course of time. As a rough proxy for this effect, we take the net issues of the euro area countries without France on board. The idea is that there is a negative relation between the net issues of France and that of the rest of the euro area. The second category of foreign demand is demand from outside the euro area. Politronacci et al. (2017) as well as official banknote shipments indicate that "French" banknotes also flow to these countries. Figure 1

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[12] It is worth noting that these data include all cheque transactions and not only POS transactions. Furthermore, they do not differentiate between business and private operations.

[13] A critical assessment of this proposition can be found in Krüger & Seitz (2017), ch. 7.1. Karoubi (2012) analyzes the effects of crime on merchants' use and willingness to accept cash in the case of France.

[14] We use an update of the estimates for France in Medina & Schneider (2018) provided kindly by F. Schneider.

shows the net shipments of France to countries outside the euro area. They increased from €2.5 bn. in 2002 to more than €47 bn. in 2019, which accounts for nearly one third of the total cumulated net issues.[15] In the absence of a variable which directly indicates this demand from many different foreign countries, we proxy it with the euro exchange rate (see also Assenmacher et al., 2019; Bartzsch & Seitz, 2016; Rua, 2020).[16] An appreciating euro should be associated with a higher attractiveness and thus a higher euro demand from non-euro-area countries. We use the real and nominal effective exchange rate of the euro vis-à-vis different country groupings as well as the bilateral (nominal and real) euro US-dollar exchange rate as possible candidates.

Figure 1: Net shipments of euro banknotes of France (€ bn.)
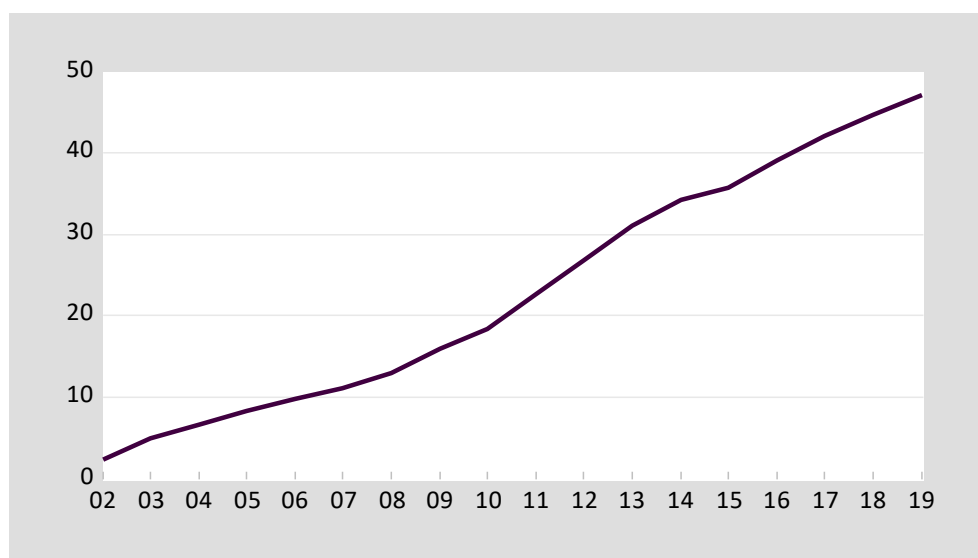
Source: Banque de France.

Precautionary and uncertainty related motives are further drivers of cash demand. The deeper reasons are financial, economic or geopolitical tensions. The variables with which we try to model this motive are consumer confidence for France, the volatility index of the CAC40, a geopolitical risk index (see Caldara & Iacoviello, 2019), a European news as well as a Finance news index for France and last, but not least, a measure of global financial uncertainty applied to France (see Caggiano & Castelnuovo, 2021).

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[15] The most important country with respect to these shipments is Germany, see, e. g., Bartzsch et al. (2011a, b), Deutsche Bundesbank (2018).

[16] An alternative would be a foreign demand indicator as in Lalouette (2021), ch. 2.2. This indicator is a weighted average of real GDP of the main destination countries of euro banknote shipments. However, in the case of France, such a country-specific division of the shipments is not available.

Finally, we include a step dummy (as deterministic regressor) for the financial crisis in 2008, i. e., the collapse of Lehman Brothers, to capture the drastic increase in the crisis-related demand for cash for precautionary and distrust reasons (see, e. g., Rösl & Seitz, 2021). It is 1 from 2008.q4 onwards, 0 before.[17]

The data are quarterly and not seasonally adjusted. They are taken from the Banque de France database, the ECB SDW, the OECD and DB·Nomics. Therefore, we include (centered) seasonal dummy variables in the equations, if necessary. Our sample covers the period from the first quarter of 2002 to the fourth quarter of 2019. When data are only available on an annual basis (as, e. g., the payments data and estimates of the shadow economy), we transform them to a quarterly frequency with simple interpolation methods.[18] The inclusion of data from 2020 onwards would distort the results due to the Covid-19 crisis and needs separate investigation. All variables are in natural logs unless otherwise stated. Total net issues, the three denominational groups and coins in real terms are shown in figure 2. While total, small, medium and coins are increasing steadily, especially the €50 bill ("medium"), the large denominations show a decreasing trend since the beginning of the sample. The latter is especially pronounced since 2014 and the net issues are even negative since 2018. The €200 and €500 taken together became already negative in mid-2013. Since then, France can be regarded as a net importer of specific large banknotes from other euro area countries.

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[17] Further additional potential dummy variables for specific events (introduction of negative interest rates for banks, decision to stop the production of the €500 banknote, euro sovereign debt crisis) are mostly insignificant.
[18] Specifically, the annual series are converted to the quarterly frequency using the Chow–Lin regression-based interpolation method. We match the last observation for stock variables and the sum of observations for flow variables.

Figure 2: Total cumulated net banknote issues, small, medium and large denominations, coins (€ bn.)
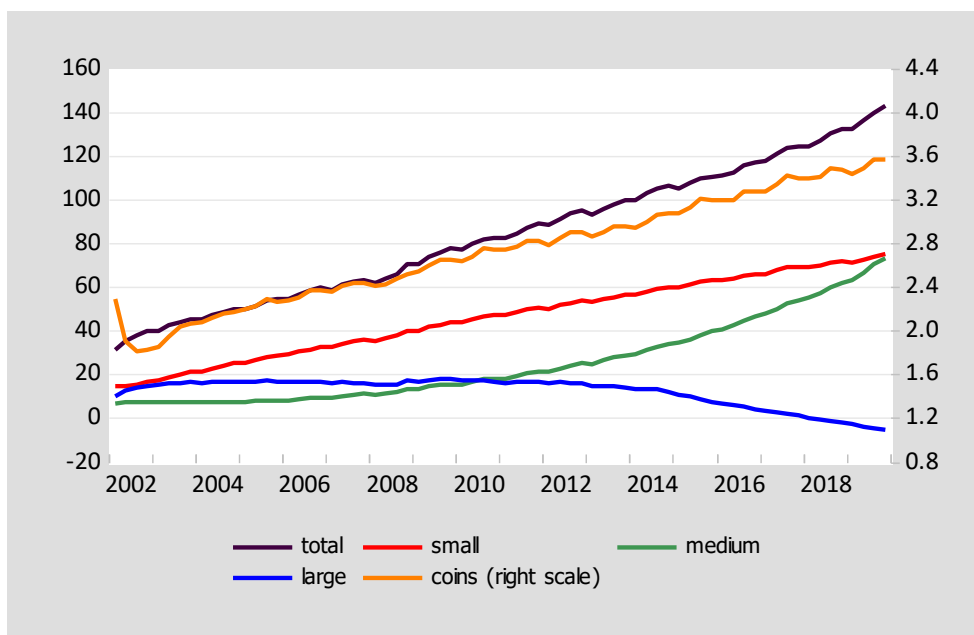
Source: Banque de France.

Notes: Deflated by the private consumption deflator; small: €5 - €20, medium: €50, large: €100 - €500.

2.2. Econometric framework

Our empirical approach is based single-equation cointegration regressions with Dynamic Ordinary Least Squares (DOLS). We prefer a single-equation method over a vector error correction system as we focus on a single long-run relation between the variables, i. e. a demand equation for the cumulated cash issues. With this approach we do not need to model the short-run dynamics, which may be unstable over time, along with the long-run coefficients. Furthermore, DOLS yields valid results also in the case of structural breaks (Campos et al., 1996). Both DOLS and Fully Modified OLS (FMOLS) are usually preferred to the OLS estimator (which is consistent) because they take care of the small sample bias (see Banerjee et al., 1986) and an endogeneity bias (second-order bias) by taking the leads and lags of the first-differenced regressors into account (Stock & Watson, 1993). The parametric DOLS is superior to the non-parametric FMOLS as the latter assumes that all variables should be integrated of the same order and that the regressors themselves should not be cointegrated.[19]

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[19] However, the FMOLS results (available upon request) do not differ too much from the DOLS results.

The number of leads and lags in the DOLS estimates are selected by the Hannan-Quinn information criterion (given a maximum length of 4, respectively).[20] For the computation of the coefficient covariance matrix, the method of re-scaling the OLS coefficient covariance using an estimator of the long-run variance of the DOLS residuals is chosen (with the Bartlett kernel and a Newey-West fixed bandwidth of 4). The cointegration framework necessitates the determination of the unit root characteristics of the variables included. We use different kind of tests, both for the null of a unit root and of stationarity, and also consider possible structural breaks. The tests suggest that most of the variables which, after pre-testing, enter at least one of our preferred models, are I(1) in levels and stationary in first differences (results available upon request). Finally, we also test for possible trend breaks in the cointegration equation.

2.3. Results

The following tables 1 and 2 display the finally selected long-run estimation equations for all three denominational groups and total cumulated net issues of the Banque de France together with some statistical diagnostics. As a benchmark, table 1 concentrates on total net issues. However, this specification does not adequately capture the fact that different denominations satisfy the cash holding motives to different extents. Therefore, table 2 focusses on the determinants of the three denominational groups. As already mentioned, we follow a rather eclectic approach in that we test the different empirical proxies for the motives of holding cash for their statistical and economic significance.

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[20] The purpose of including leads and lags is to remove long-run dependence by orthogonalizing the equation residual with respect to the history of stochastic regressor innovations. As the automatic selection by information criteria were not designed for this purpose, we also estimate the equations with a fixed lead-lag structure of one. The results do not differ significantly and are available upon request.

Table 1: DOLS estimates: Total cumulated net issues

Variable	(1)	(2)	(3)
PC	4.07***		2.04***
	(0.47)		(0.24)
RS		2.17***	
		(0.13)	
Exchange rate	0.96***	1.63***	
	(0.35)	(0.15)	
Interest rate	-0.04***		-0.02*
	(0.01)		(0.01)
UN	0.08***	0.09***	
	(0.02)	(0.01)	
CC			0.22***
			(0.03)
POS			-4.82**
			(0.56)
GFU		0.02**	
		(0.01)	
DUM_FIN		0.05*	0.03***
		(0.03)	(0.01)
R²	0.99	0.99	0.99
SE	0.02	0.02	0.00
JB	0.80	0.44	0.41
VIF	x	x	
Leads/lags	3/4	3/4	4/4
Phillips-Ouliaris τ	-6.23***	-6.80***	-6.03***
Hansen	0.02	0.02	0.06

Notes: The dependent variable is the log of the real value of total cumulated French net cash issues. Explanatory variables are the logs of real private consumption (PC) or retail sales (RS), the log of the interest rate on short-term bank time deposits from households in (3) or the level of the 1-month money market interest rate in (1), the log of the nominal effective exchange rate of the euro against 42 currencies, the unemployment rate in France (UN), the indicator of global financial uncertainty for France (GFU), consumer confidence for France (CC), the number of POS terminals (POS) and a step dummy for the financial and economic crisis of 2008/09 (DUM_FIN). Regressions include a constant; in (3) we allow for a deterministic trend. R²: adjusted R²; SE: standard error of regression; JB: p-value of Jarque-Bera normality test; VIF: (centered) variance inflation factor with "x": all VIFs < 10; Phillips-Ouliaris τ-test of cointegration with the null of no cointegration; Hansen test: cointegration test with the null of cointegration. Unadjusted sample: 2002.q1 to 2019.q4. Standard errors in parentheses; *, ** and *** indicate significance on the 10, 5 and 1 percent level.

We present three alternatives for the total net issues which all describe the data rather well.[21] In all specifications, we find a positive and significant transactions elasticity, in (1) and (3) proxied by private consumption, in (2) by retail sales. Also common in all variants is the positive influence of the effective exchange rate, in (1) and (2) captured by an exchange rate term, in (3) by a deterministic trend (see also figure 1). These are two possibilities to proxy

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[21] Taking additionally coins into account would not change the results qualitatively.

the foreign demand for banknotes from outside the euro area. An appreciation of the euro, as expected, increases cash demand abroad which is partly satisfied by the Banque de France.[22] But (1) and (2) also differ in important aspects: First, (1) and (3) include an opportunity cost term, measured by an interest rate on bank deposits or a money market interest rate, respectively. In case it is measured in logs, it is a true elasticity. In contrast, (2) and (3) reveal a positive influence of financial market turbulences. It is captured by the financial crisis dummy variable and, additionally, by a measure of global financial uncertainty for France in (2). All these crisis variables increase cash holdings. Third, in (1) and (2) there is a positive impact of the unemployment rate. This might indicate cash use in the shadow economy. Fourth, (3) exhibits that the number of POS terminals as a proxy for the acceptance of cashless payments is important. Fifth, trust of consumers measured by consumer confidence is an additional regressor in (3). The lower consumer confidence as a measure of uncertainty, the higher cash holdings in France.

As usual in DOLS estimates, the adjusted R^2 is high. There are no problems with the normality of the residuals according to the Jarque-Bera test. The variance inflation factors show that multicollinearity seems to be not too serious in (1) and (2), but problematic in (3).[23] Finally, cointegration tests for all three specifications yield unambiguous results with both the Hansen and the Phillips-Ouliaris τ -test indicating cointegration.

To find optimal specifications for the different denominations, table 2 presents results on three denominational groups, small, medium and large banknotes. We present two alternatives for "small" and "large", respectively, and one for "medium". The group the hardest to model was the "medium" one which only comprises the €50 note. Obviously, the "optimal" determinants of cash use are not the same for the different denominations. There are some important and interesting findings.

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[22] Most net shipments of banknotes to countries outside the euro area originate from the Deutsche Bundesbank, see, e. g., Bartzsch et al. (2013).

[23] The DOLS estimator solves the issue of endogeneity but not multicollinearity. Therefore, the VIFs are taken on board. As often suggested, we have chosen a cut-off rate of 10 (see Kutner et al., 2004). Månsson et al. (2017) present an alternative estimator to deal with this issue.

**Table 2: DOLS estimates: Small, medium and large banknotes**

Variable	Large (1)	Large (2)	Medium	Small (1)	Small (2)
PC				6.06*** (0.32)	
RS			10.28*** (2.17)		2.11*** (0.14)
House	29.49*** (2.02)	11.24*** (3.30)			
Exchange rate		12.29*** (5.03)		1.22*** (0.20)	1.26*** (0.16)
Other_euro		-12.10*** (2.02)			
UN	2.15*** (0.26)			0.12*** (0.01)	
ATM			0.79*** (0.22)		1.01*** (0.10)
Cards	-24.87*** (1.65)		-2.18*** (0.75)		
Mobile				-0.00*** (0.00)	
GPR			0.32*** (0.05)		
DUM_FIN	3.23*** (0.79)	2.57*** (0.41)	0.29*** (0.03)		
R²	0.99	0.99	0.99	0.99	0.99
SE	0.60	0.27	0.04	0.02	0.03
JB	0.83	0.53	0.06	0.57	0.88
VIF	x	x		x	x
Leads/lags	4/4	4/4	3/4	2/4	3/4
Phillips-Ouliaris τ	-5.10***	-4.70**	-4.07	-8.45***	-7.04***
Hansen	0.03	0.03	0.03	0.02	0.01

Notes: The dependent variable is the log of the real value of large, medium and small denomination banknotes, with small: €5 - €20, medium: €50, large: €100 - €500. Explanatory variables are the logs of real private consumption (PC) or retail sales (RS), the log of real house prices (house), the log of the nominal effective exchange rate of the euro, the net issues of other euro area central banks (other_euro), the unemployment rate in France (UN), the log of number of ATMs, the log of the volume of card payments, the log of the volume of mobile payments (mobile), the log of the geopolitical risk index (GPR) and a step dummy for the financial and economic crisis of 2008/09 (DUM_FIN). Regressions include a constant. R²: adjusted R²; SE: standard error of regression; JB: p-value of Jarque-Bera normality test; VIF: (centered) variance inflation factor with "x": all VIFs < 10; Phillips-Ouliaris τ-test of cointegration with the null of no cointegration; Hansen test: cointegration test with the null of cointegration. In "large" (2) we allow for a break in the trend in 2014 to account for the effect of a strongly declining trend in the respective cumulated net issues. Unadjusted sample: 2002.q1 to 2019.q4. Standard errors in parentheses; *, ** and *** indicate significance on the 10, 5 and 1 percent level.

First, the transactions motive seems to be of little importance for the large denominations.

Besides house prices, no other transactions variable appears in the equations. Second, in

contrast to total cash issues, opportunity costs in the form of interest rates do not play a role in explaining the evolution of the denominational groups, given the relevance of the other motives for holding cash. Third, foreign demand from outside the euro area is concentrated at the small and large denominations (see the exchange rate argument). With respect to the small denominations, this seems plausible against the background of the steadily increasing trend (see figure 3). For the large denominations, this influence should be present mainly until 2011 as afterwards the cumulated net issues declined and became even negative in 2018 (see figure 3), with the €200 and €500 banknote already negative in 2013. This observation is supported by the fact that we have a significant negative trend break in "large" (2) in 2014. The increase in "large" until 2011 is entirely due to the €100 banknote.

Figure 3: Large and small banknotes (net cumulated issues, € bn.)
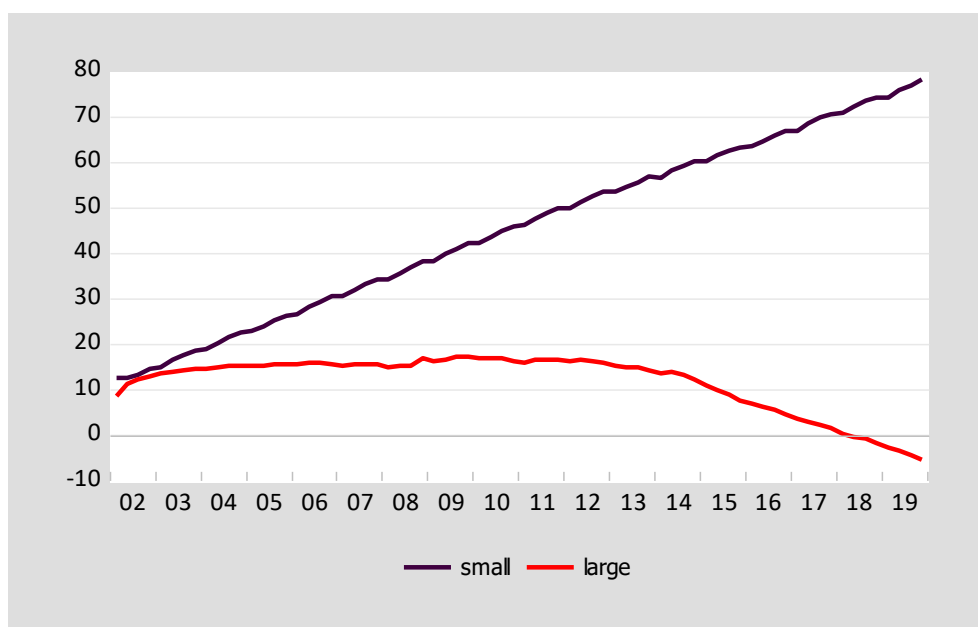
Source: Banque de France.

Notes: Small: €5 - €20, large: €100 - €500.

Fourth, within the euro area, France is a net importer of two largest banknotes since mid-2013. However, a declining trend in these two denominations was already present since 2003. In the estimates, this is reflected in the negative coefficient of "other_euro" which captures the effect of increasing net issues of other euro area central banks to compensate for the decreasing French net issues. Therefore, France seems to be a net importer of large banknotes within the euro area (at least of the €200 and €500 banknote), but a net exporter of small as well as large banknotes to countries outside the euro area. This is a kind of puzzle. Fifth, access to cash is important for the small and medium bills distributed via ATMs.

Consequently, a reduction in the number of ATMs that is observed in France in recent years, despite some initiatives of private cash dispensing services at retailers as a substitute of removed ATMs at banks, can result in a supply-driven forced decline in cash demand in France. However, this declining trend might also be due to the reduced use of cash for transaction purposes. Sixth, alternative cashless payment media exert a negative influence on the use of all three denominational groups. The higher the volume of (debit and credit) card transactions, the lower the demand for large ("large" 1) and medium denominations. As low value purchases were usually not paid by cards, they do not exert a significant influence on the small denominations. However, and although the levels are very low, the increasing use of mobile payments in the very last years has reduced the use of small denominations ("small" 1). Moreover, contactless payments have surged, too. Nevertheless, in 2019, the shares of contactless and mobile payments at the POS are around 5.8 % and only 0.1 %, respectively. Figure A1 in the appendix shows the evolution of mobile and contactless payments over time.

Seventh, uncertainty and crisis-related as well as precautionary motives are present with the large and medium denominations. The financial market crisis of 2008 increased the demand for both groups (*dum_fin*), whereas the indicator of geopolitical risk only affects the medium denomination (*gpr*). This index (see Caldara & Iacoviello, 2019) is based on newspaper articles covering geopolitical tensions like the 9/11 terrorist attacks or the 2003 Iraq invasion. Since 2012, this index is trending upwards. And finally, the unemployment rate (un) as an indicator of the shadow economy stimulates the demand for small and large banknotes. Depending on the concrete activity (car repair, house building, baby sitting etc.), both denominations may be suited for such purposes.[24]

The statistical properties of the equations are quite good, especially with respect to "large" and "small". There are some problems with the normality of the residuals and multicollinearity in "medium". In this case, the cointegration tests also yield ambiguous results with the Hansen test indicating cointegration while the Phillips-Ouliaris τ -test does not. However, the 10 % level of significance is only marginally exceeded (p-value: 0.15). All these problems might be due to the fact that "medium" only consists of the one denomination, the €50 banknote. As a matter of fact, the €50 banknote embodies a dual role

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[24] There is one specification (large (1)) in which a step dummy variable with respect to the decision to no longer produce the €500 banknote (which is 1 from the *first* quarter of 2016 onwards when the decision was announced) is additionally significant. However, its short-term negative impact leaves the interpretation of the other variables in the equation unchanged.

in France as it is used for transactions as well as hoarding (non-transactional) motives. Figure A2 in the appendix exhibits the (well-behaved) residuals for one variant of each denominational group together with the one standard error bands.

The cash demand equations reveal that transactions as well as non-transactional motives for holding cash are present in the case of France, both domestically as well as abroad. The next section tries to estimate these shares.

3. The different motives: estimating the shares

3.1. Some general remarks

The outstanding volume of euro banknotes issued by the Banque de France has increased permanently since the introduction of euro cash. As we have seen in the last chapter, this growth cannot be explained by domestic transaction balances alone. As a central bank only knows the amounts of cash issued, but not by whom and where it is held, there is a huge information problem. To shed light on this black box, usually indirect methods are applied (see, e. g., Bartzsch et al., 2011b) which make use of different characteristics of domestic transactions balances compared to cash balances held for other purposes (at home and abroad).[25] Thus, these indirect approaches incorporate behavioural assumptions about the characteristics of banknotes held in a specific country for transactions purposes, in our case France, and for other uses. As any demand for banknotes is met by the central bank, the characteristics reflect demand behaviour. The general problem can be formulated more precisely as follows (Feige, 1997, 184). For simplicity and presentation reasons, we distinguish only between two uses of cash.

The shares $ß_1$ and $ß_2$ 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. Consequently, the average feature X is a weighted average of both characteristics, with the weights being the unknown shares $ß_1$ and $ß_2$.

(1) $$X = ß_1 X_1 + ß_2 X_2$$

As $ß_1 = 1 - ß_2$, the shares can be estimated by means of the observed and measured properties.

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[25] The share of lost banknotes is considered as negligible in value terms and therefore disregarded in our study. See on this topic Finlay et al. (2019), ch. 4.

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

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

A sensible solution to this problem exists if the characteristics of the two parts (e. g., transactional and non-transactional demand or domestic and foreign demand) X_1 and X_2 differ $(X_1 \neq X_2)$ and the calculated shares vary between 0 and 1. Therefore, to implement this approach for our purpose of the calculation of French banknotes held for transaction motives in France, the characteristics of the banknotes used for non-transactional purposes (X^n) must differ sufficiently from those of the transaction balances in France (X^d) so that the non-transactional share can be identified by observing the overall behaviour. This may involve the age, quality, velocity of circulation or seasonal pattern of the banknotes, for example. At the same time, information is required about how the demand for banknotes would have developed if there had been no non-transactional demand. The domestic transactional share is given by

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

and the corresponding non-transactional share by

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

In what follows, we concentrate on the different seasonal structures of the two shares. The aim of the seasonal method is to filter out information about banknotes used for domestic transactions from the "seasonal structure of banknotes" pattern. This method was first applied by Sumner (1990) to the calculation of domestic hoardings. Bartzsch et al. (2013) adopted the approach for calculating the domestic transactional and non-transactions as well as the foreign part for a member country of the euro area, namely Germany. The seasonal factor of the total cumulated net issues (X) can be calculated using standard seasonal adjustment methods. To approximate the domestic transactional share (X^d), use will be made of comparisons with other euro area currencies, a transactions variable (private consumption, retail sales) and vault cash. An alternative approach analyzes the banknote to coin ratios in France and abroad. As the volume of domestic coins in circulation abroad is negligible and

the total banknote to coin ratio is known, only the domestic ratio still needs to be identified. A reference country can again be used to this end.

The fundamental assumption of the seasonal approach is that the non-transactional shares have little or no seasonality, as the motives behind have little to do with domestic seasonal developments. Hence, the transactional and non-transactional demand differ in terms of the seasonal fluctuation and the total net issues display a dampened seasonal factor.

The underlying seasonal model assumes that the time series of French banknote issuance consists of three terms: a trend component T_t, a seasonal term S_t and an irregular or noise component. These are multiplicatively interlinked (multiplicative seasonal model). Attributing the noise term to the trend for simplicity and taking into account that French banknotes are not only used for transaction purposes but also for other reasons at home and abroad (o) yields the following equation (where t represents the time index and d stands for "domestic", i. e. France)

(4) $$T_t S_t = T_t^d S_t^d + T_t^o S_t^o.$$

Let β_t denote the fraction of the overall trend held for domestic transactions and, consequently, $(1-\beta_t)$ the other (non-transactional) share:

(5) $$T_t S_t = \beta_t T_t S_t^d + (1 - \beta_t) T_t S_t^o \text{ or}$$

(5') $$S_t = \beta_t S_t^d + (1 - \beta_t) S_t^o.$$

(5') is a specific example of the general equation (1), with the seasonal component taking on the role of the measured characteristic X. Assuming that the non-transactional share does not vary seasonally, i. e. $S^o = 1 \; \forall \; t$, (5') can be simplified to

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

Given the seasonal terms S and S^d yields an equation for the unknown value β_t, the share of banknotes held for domestic transactions:

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

The non-transactional share, in turn, is $(1-\beta_t)$. S_t corresponds to the seasonal component of total French cumulated net banknote issues and can be calculated quite easily. By contrast, S^d, the seasonal term for the share of banknotes circulating in France for transaction

purposes, is unknown. It must be estimated and various methods for this are presented below. However, equation (7) does not always produce meaningful results. If, for example, there is no seasonal fluctuation in any given period, i. e. $S_t = S_t^d = 1$, equation (7) is indeterminate. Moreover, if the seasonality of all outstanding banknotes is not less pronounced in all periods than that of the banknotes held for domestic transactions, interpretation problems occur. This method thus produces plausible results for some, but not for all frequencies.

Therefore, further modifications are needed to allow for these eventualities and to enable this method to be implemented. Fairly accurate estimation results can often be obtained only for a certain frequency within a given year. We therefore take the fact into account that seasonal fluctuations are usually greatest around Christmas owing to domestic transactions. For example, in the case of French banknote issuance, the seasonal high is in December, while there is often a seasonal low in February (in this case, there is accordingly a two-month frequency). In order to factor this into (7), we replace the time index t by m,j, where m denotes the mth month and j stands for the jth year. If equation (6) for February is subtracted from the corresponding equation for the preceding December, the domestic share β_j reads as:

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

The essential question then is, what is the best way of modelling S^d, the unknown domestic part in equation (8)? As mentioned, we try three variants which might proxy the seasonal component of the euro banknotes held in France. These include

a) Selection of a reference country,

b) Inclusion of a transactions variable,

c) Analysis of banks' vault cash.

Since all three variants include different assumptions and hypotheses concerning what share of domestic and foreign demand is captured, the calculated $\beta's$ will also assume differing values. In our case and as will be explained below, they allow to calculate the shares of the cumulated net issues of banknotes of the Banque de France

- used for transactions balances in France,
- held for non-transactions purposes in France (hoarding, store of value, precautionary demand etc.),

- used for net exports to other euro area countries and
- held outside the euro area.

a) The reference country

The idea behind selecting a reference country is to find a country that is ideally similar to France in its payments behaviour and especially in its use of cash, except non-transactional demand. The idea is that in this case the different seasonal fluctuations are solely due to non-transactional demand. Therefore, we insert this country's seasonal factor of small banknotes (mainly transaction banknotes) for S^d in (8). After careful investigation of many different euro area countries, we decided on Belgium and Finland as adequate reference countries.[26] Both are euro area countries and thus have the same denominational structure.[27] They also have a similar standard of living as France. Additionally, the overall cashless payments behaviour of non-banks relative to cash transactions in the countries and the supply (access) of (to) cash do not seem to be too dissimilar. There is also empirical evidence of a high and increasing degree of synchronisation of business cycles in the euro area, in particular of private consumption expenditure between France and other euro area countries (Aguiar-Conraria and Soares, 2011; Campos et al., 2019). The seasonal component of transaction demand should therefore be comparable. And the size and evolution of the shadow economy, in which transactions are often settled in cash, is not too different in the three countries (Medina & Schneider, 2018). Moreover, and as France, both countries are net exporters of banknotes (in total and of small denominations) within the euro area. To this extent, France, Belgium and Finland could be treated similarly with regard to migration within the euro area as an initial approximation. As, additionally, small banknotes are not used for store-of-value purposes, using this approach, we identify the share of French euro banknotes used for hoarding and outside the euro area (see figure 4). Therefore, β in this case is the share of banknotes in active circulation (for transactions) in France and held in other euro-area countries.

b) Seasonal of a transactions variable

An alternative is to compare the seasonal variation of French euro banknote issues (S) with the seasonal variation of a transactions variable (S^d). In our case, private consumption is used. Private consumption mirrors transactions, whereas S reflects transactional and non-

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[26] In the case of Finland €5 - €20, for Belgium only €20.
[27] In the case of the US dollar, usually Canada is taken as the reference country, inter alia for this reason, see, e.g., Judson (2017).

transactional cash demand within France and abroad. Therefore, and in general, this method yields hoarding balances in France together with the total share of the French net issues which is outside France, i. e., in other euro area countries and outside the euro area (see figure 4). To take hoardings and the fact that private consumption is only available at a quarterly frequency into account, (8) has to be modified to

$$(8') \qquad \beta_j = \frac{S_{q4,j} - S_{q1,j+1}}{\eta \cdot \Delta_{q4,j;q1,j+1} S(tr)},$$

where η is the domestic income elasticity (transactions elasticity) of the demand for banknotes, which, inter alia, captures the level of hoardings. Therefore, we assume $\eta = 1$.[28] $\Delta S(tr)$ is the difference between the seasonal highs and lows of the transactions variable, in this case the last quarter of the year and the first quarter of the following year. Thus, and finally, this approach yields an estimate of total foreign holdings.

c) Banks' vault cash

Banks incur opportunity costs for cash balances held. They therefore keep them to a minimum and those held stem almost exclusively from regular domestic transactions. Domestic hoarding and foreign demand have virtually no impact on banks' cash balances.[29] The seasonal component of vault cash is therefore more pronounced than that of French banknotes in circulation. Consequently, this approach delivers an estimate of hoarding plus total foreign holdings of French banknotes (see figure 4).

In figure 4, all three estimates are below the total cumulated net issues of the Banque de France, as it should be. The estimates based on the seasonal of vault cash are always consistently above those based on the seasonal of the reference country as the former also include the net exports to other euro area countries. The difference between the black and the blue line are due to hoarding and banknote flows within the euro area. Figure 5 illustrates that the estimated amounts outside the euro area are consistently above the official net shipments.

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[28] See for the case of Belgium Rinaldi (2001).
[29] If this assumption does not hold true, the transaction balances would be ver-estimated. Since 2003, vault cash increased by around 3.5 % per year, whereas nominal private consumption or retail sales only increased by 2.5-3 %. However, the increase in vault cash in the last years, especially since the introduction of the negative deposit rate, is not exceptional.

Figure 4: The seasonal methods' estimates over time (€ bn.)
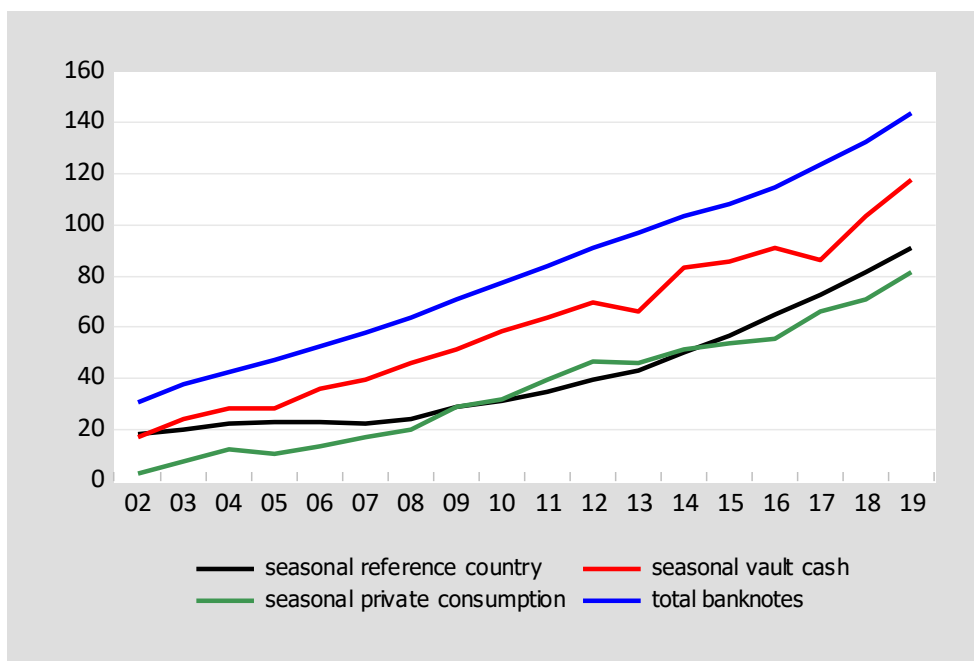
Source: own estimates.

Notes: seasonal reference country: small denominations (€5 - €20) of Finland, estimate of domestic hoarding plus holdings outside the euro area; seasonal vault cash: estimate of domestic hoarding balances plus total foreign holdings; seasonal private consumption: estimate of total banknotes abroad.

Figure 5: Estimated shares outside the euro area and official net shipments (€ bn.)
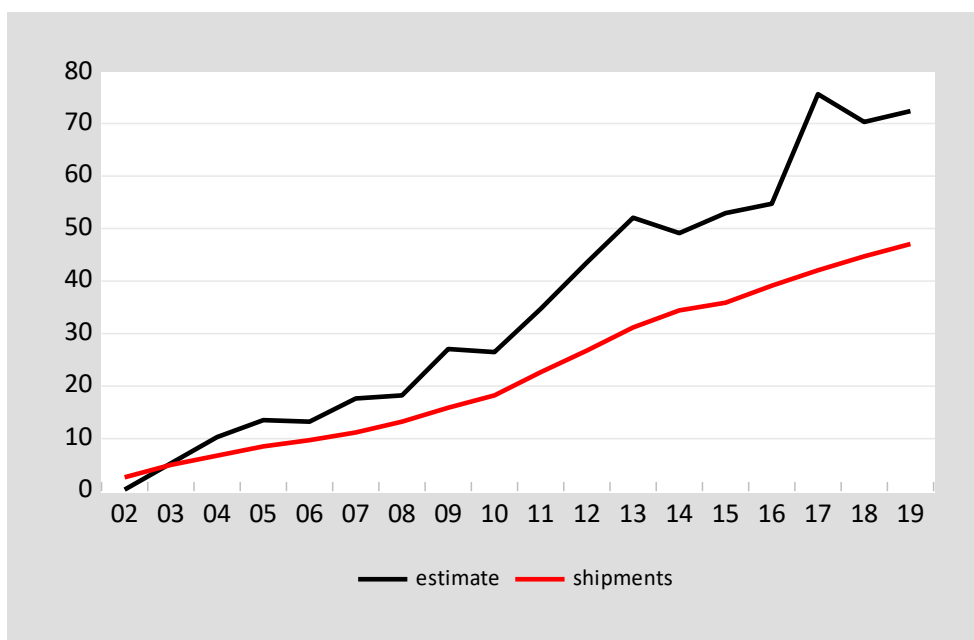

Source: Banque de France and own estimates.

Given these three methods (and the different variants), we can calculate the four shares mentioned above: domestic transaction and non-transaction share (the latter named "hoarding" in figure 6) and the two parts of foreign holdings (see figure 6). In 2019, only around 15 % of the cumulated net issues of around €145 bn. (average value for 2019) are used for domestic transactions. This number is lower than that in Politronacci et al. (2017) for 2015 if the shadow economy is included (around 20 %), and also lower than the euro area average of around 20 % (Zamora-Pérez, 2021). The cash holdings within France amount to around €60 bn. which is significantly lower than the estimates in Politronacci et al. (2017) of €80 bn. in 2015. 50 – 70 % are used outside France, either in other euro area countries (i. e., France is a net exporter of banknotes within the euro area) or outside the euro area. Around 25 % are used for store of value purposes (hoarding) within France. €60 - €70 bn. of the net issues of the Banque de France are held in non-euro-area countries. Deutsche Bundesbank (2018) estimates that almost 50 % of its net issues are outside the euro area (about €350 bn.). Consequently, the vast majority of the 40 % of total euro banknotes held outside the euro area, about €500 bn. (Zamora-Pérez, 2021), stem from the Deutsche Bundesbank and the Banque de France.[30]

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[30] Working with Belgium as reference country would yield higher estimates for holdings outside the euro area, but lower exports to other euro rea countries. The domestic shares would be unchanged.

Figure 6: Different motives for holding cash: The case of France 2019
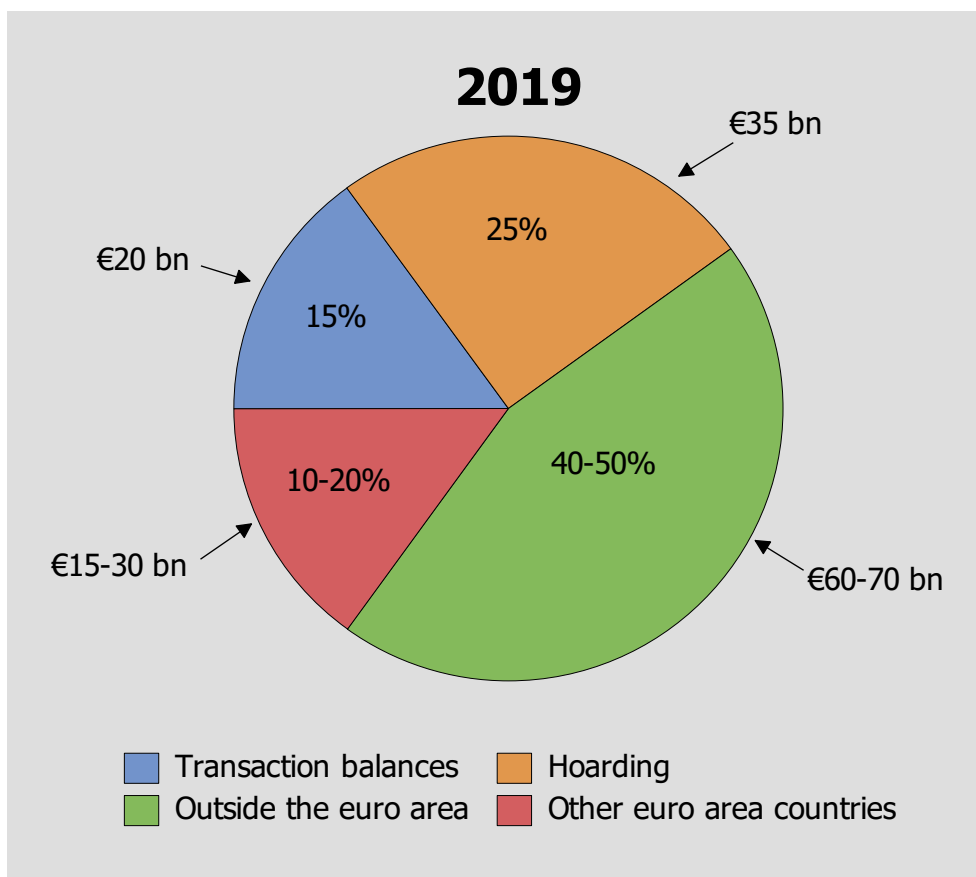
Source: own calculations.

Notes: rounded figures.

In principle, the approach with the reference country can also be applied to individual denominations.[31] In the case of France, it works for every denomination except the €50 banknote due to strange seasonal fluctuations which are probably related to the dual (transaction and non-transaction) role of this denomination in France. For the other denominations the respective amounts outside the euro area in 2019 are 8 bn. (€10), 30 bn. (€20), 7 bn. (€100), -0.6 bn. (€5), -1.6 bn. (€200) and -12 bn. (€500). The negative signs for €5, €200 and €500 mean that France is not exporting, but importing these banknotes from countries outside the euro area (negative net shipments). This is consistent with the fact that France is also a net importer of these denomination within the euro area for years. The seasonal method indicates exactly the same pattern. From the estimates of the total holdings

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[31] This is due to the fact that we have the denominational breakdown for France and the reference countries. Consequently, these calculations cannot be made for the other two variants as we do not have the denominational structure of private consumption and vault cash.

outside the euro area and the estimates for the different denominations, we can infer that about €30-35 bn. of the €50 banknote are abroad.[32]

We robustified (and confirmed) our results, especially with respect to holdings outside the euro area, with the help of another indirect method, an analysis of French coin issues (see annex A3).

4. Summary and conclusion

The idea of the present paper was to shed light into the different motives for holding cash in case of the cumulated net cash or banknote issues of the Banque de France. For that purpose, we first established cash demand equations and tried to estimate the domestic transactions and hoarding shares as well as the foreign shares (within and outside the euro area) by means of an indirect approach, the so-called seasonal method, in a second step. The cash demand equations revealed that different domestic and foreign motives for holding cash play an important role in the case of French net issues. The second part found low and decreasing transaction balances; in contrast, internal hoardings as well as holdings outside the euro area increased. There is also a net demand from countries within the euro area. Interestingly, it seems that the two foreign parts are mainly driven by the small and medium denominations, at least in the last years. We did not analyze, which sector, i. e. private households or firms, are responsible for the increased hoardings. Usually, the majority of these cash holdings is attributed to households. However, there might also be an increasing demand by firms.[33]

The decreasing transaction shares are not unique to France, but a worldwide phenomenon (see, e. g., Bartzsch et al., 2013; European Central Bank, 2020b; Rösl & Seitz, 2021). It implies that the active circulation of cash in France is on a declining trend. However, in particular the foreign parts over-compensate this decrease and lead to a rise in the cumulated net issues of the Banque de France over time. Even the cash to GDP ratio has increased permanently since 2002 (see figure 7).

These developments have repercussions on cash logistics, cash distribution, withdrawal and depositing behaviour which occur probably less intensively. All this is already taken into account by the Banque de France, the commercial banks and retailers as well as cash in transit

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[32] Using Portugal as reference country would approximately yield the same amounts.
[33] See for firms' cash holdings Swiss National Bank (2022).

firms. It may build the ground for new cooperation, e. g., between banks and retailers, and business models. In France, the National Cash Management Policy (NCMP) aims to address all issues raised by the decline of cash transactions with a view to manage this decline in an orderly manner. This requires the involvement of public authorities, commercial banks and cash-in-transit companies, as well as other stakeholders in the French cash industry, particularly the retail sector. The decline in cash payments raises five challenges that are tackled collectively by the NCMP. These are: acceptability of cash, access to cash, quality of cash, robustness and efficiency of the cash cycle (Banque de France, 2021a). To address these challenges, a Cash Industry Steering Committee was established.

Figure 7: The Cash to GDP ratio for France (in %)
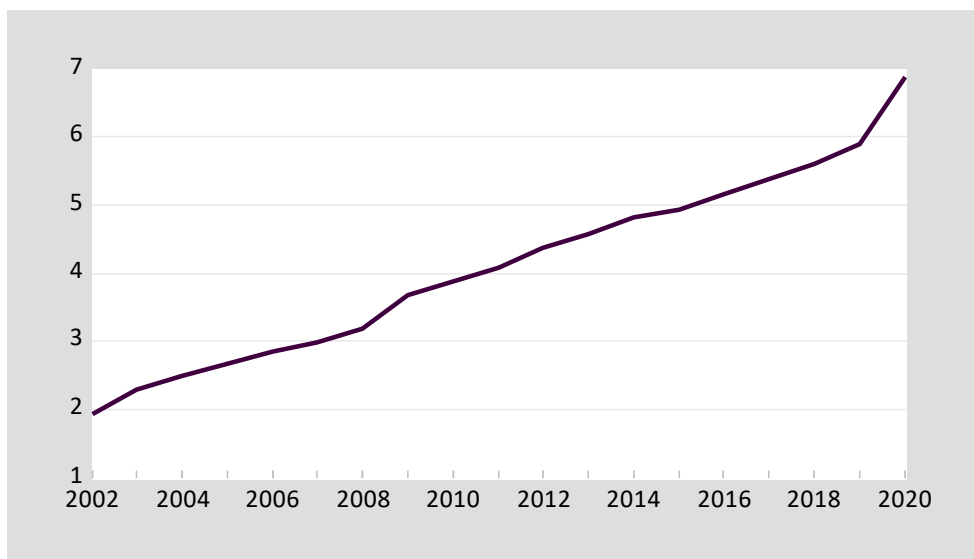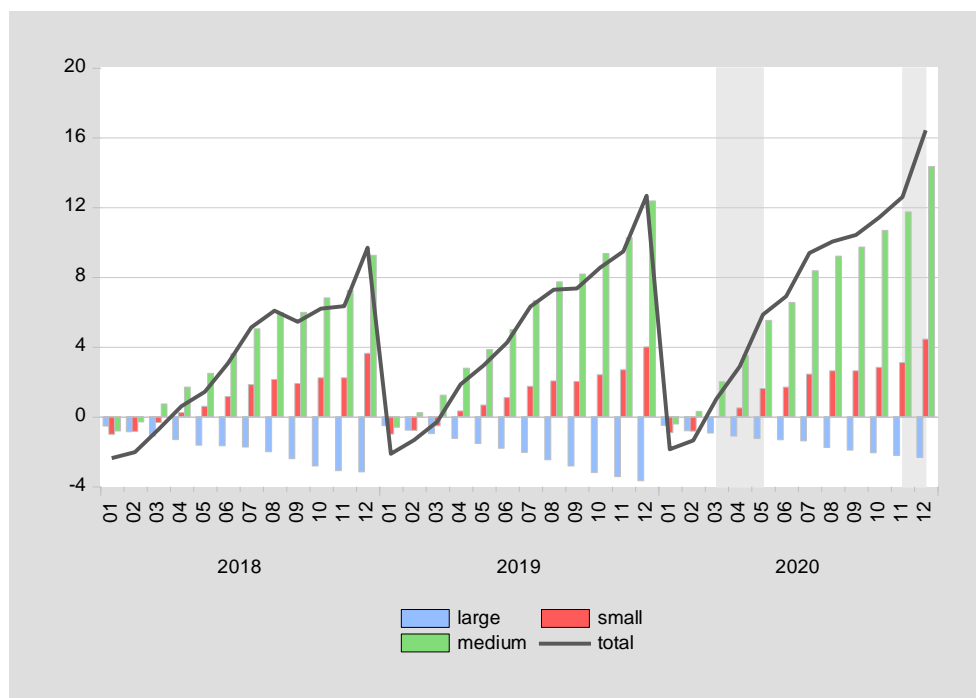

Source: Banque de France.

Due to the decreasing number of ATMs since 2014, the Steering Committee already tackled the question of public access to cash in 2018 (Banque de France, 2021b). Indeed, in order to monitor the level of cash access, an annual assessment is conducted by the Banque de France to put emphasis on this issue. Store of value considerations and precautionary as well as crisis-related cash demand might even play a bigger role in the future than in the past. The current pandemic has shown that cash seems to play an important role in successful crisis management, especially as central banks provide cash in a perfectly elastic way. In any case, it is certainly important to ensure access to cash (via different channels) for those who want to use it.

For the interpretation of the cumulated net issues, it is essential to understand the motives behind the cash holdings. Given the developments described, the indicator properties of

cash with respect to the business cycle might deteriorate as this is mainly due to transactions balances. However, the longer-term crisis, or more generally uncertainty and risk, related indicator functions will improve. A deeper analysis of these topics is left to future research. This would necessitate a more thorough investigation of the cash cycle and of specific individual denominations.

The Corona pandemic starting at the beginning of 2020 has once again proven the importance of cash. In the course of the crisis, cash holdings have increased worldwide (see figure 8 for the case of France as well as Ashworth & Goodhart, 2021, and Rösl & Seitz, 2021, for an international perspective). Interestingly, this is not only true for large, but also for small denominations. As illustrated in figure 8, the French annually cumulated net issues in 2020 increased by €16 billion. This value is 30 % higher as in 2019. The €50 banknote was the most impacted denomination as it grew by 16 % on an annual basis. The large denominations decreased, but to a lower extent than in previous years. This illustrates the important impact of the pandemic on cash demand, essentially for precautionary and uncertainty reasons.

Figure 8: Annually cumulated net issuance of banknotes for France (€ bn.)

Source: Banque de France.

Notes: Shaded areas indicate the lockdown periods in France. First lockdown from March 17 to May 11, 2020; second lockdown from October 30 to December 15, 2020.

No matter whether the corona crisis has only led to a temporary or a permanent change in the relationships, it has shown the significant role of cash in such a situation (this is also true in the context of the current war in Ukraine). The special role of the years 2020/21 for the concrete situation in France is beyond the scope of the present study. However, the results presented should be taken as a kind of benchmark of such a further analysis. The covid-19 crisis has also once again demonstrated the outstanding role of the €50 note in France. Against the background of the problems we encountered with this denomination in both parts of the study, an analysis of its special role, both for transactions as well as non-transactional purposes, necessitates further research and is left to another paper.

Another important aspect is the sustainability of cash demand for transaction purposes. If cash is no longer demanded for transaction motives, what would be the effect on the non-transactional demand for cash? This also raises two other questions: the first is about the payment preferences of economic agents in times of further and increasing digitalization of payments. The second relates to the existence of a lower threshold of cash used for transaction purposes below which it is no longer profitable for banks to guarantee access to cash and for retailers to accept cash. All these questions can be summarized by the hypothesis of a cashless society where cash is no longer used for transaction purposes. Is this a sustainable and desirable development for society?

Against the background of steeply rising inflation rates and also increasing interest rates in the future, the question is, how will cash demand react. This depends on how the motives for holding cash are influenced. If inflation only increases temporarily and only to one-digit numbers, the repercussions on cash demand will probably be restrained. If the process will last longer, the transactional demand will need higher denominations than currently. In the econometric estimates, we found no statistical significant influence of interest rates on the three denominations. Therefore, if there is no structural break, and given that it was the foreign and hoarding parts which drove the real net cash issues in France in the last decade, the effects of increased nominal interest rates should be subdued.

A further question refers to the repercussions of a future Central Bank Digital Currency (CBDC), the digital euro, on cash in circulation. Due to the special characteristics of cash, it is very difficult for such a CBDC to be a perfect substitute of cash. Consequently, it seems plausible to assume a co-circulation of cash and CBDC. Moreover, it remains to be seen whether there will be a strong demand for a CBDC. All these considerations are left to a further paper.

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Appendix A1
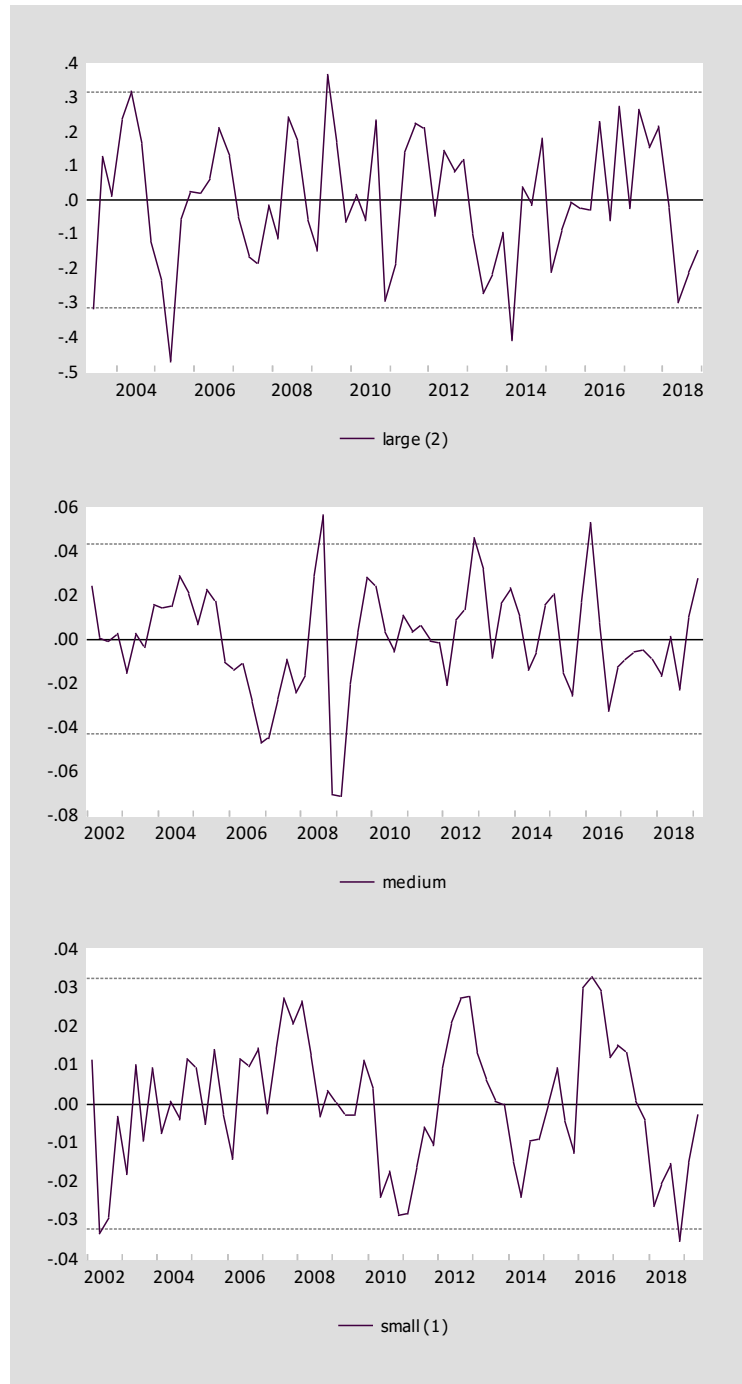
Figure A1: Contactless and mobile payments in France
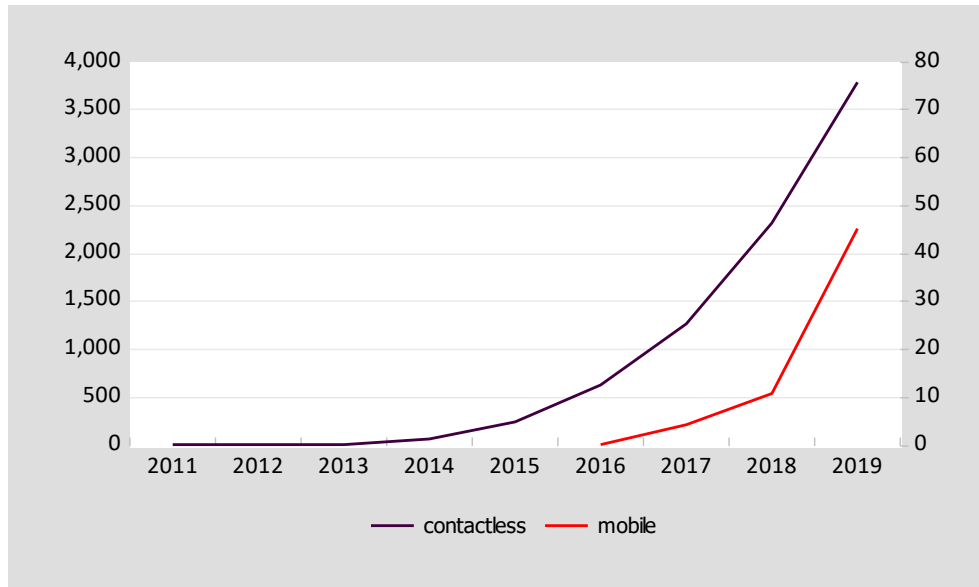
Source: Banque de France.

Notes: in volume terms, million.

Appendix A2

Figure A2: Residuals of the denominational groups' estimates

Source: own calculations.

Appendix A3

Coins to banknote ratio method

This method also makes use of a reference country (in this case Belgium) and assumes that the euro coin to banknote ratio for non-euro-area countries is zero as euro coins are not in circulation outside the euro area or only to a negligible extent.

The specifics of the model are as follows (see, e. g., Bartzsch et al., 2012). It is easy to calculate the coin to notes ratio for the entire French issuance *(c/n)*. However, the corresponding domestic and foreign shares are unknown. We approximate the domestic share $(c/n)^d$ by using Belgium (*B*) as the reference country. The coin to banknote ratio for non-euro-area countries, $(c/n)^a$, is likely to be zero, as mentioned above. Equation (1) thus reads as

(1')
$$\frac{c}{n} = \beta^d \left(\frac{c}{n}\right)^d + (1 - \beta^d)\left(\frac{c}{n}\right)^a.$$

As it is assumed that $(c/n)^d \approx (c/n)^B$ and $(c/n)^a \approx 0$, the following relationship holds for β^d:

(9)
$$\beta^d = \frac{\dfrac{c}{n}}{\left(\dfrac{c}{n}\right)^B}$$

and $\beta^a = (1 - \beta^d)$. This method yields an estimate of the foreign holdings of around €60 bn.