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In 2004 all publications will carry a motif taken from the €100 banknote.

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Abstract:

The present paper analyses currency in circulation in the euro area since the beginning of the 1980s. After a comprehensive literature review on this topic we present some stylised facts on currency holdings in the euro area countries as well as at an aggregate euro area level. The next chapter develops a theoretical model, which extends traditional money demand models to also incorporate arguments for the informal economy and foreign demand for specific currencies. In the empirical sections we first estimate the demand for euro legacy currencies in total and for small and large denominations within a cointegration framework. We find significant differences between the determinants of holdings of small and large denominations as well as overall currency demand. While small-value banknotes are mainly driven by domestic transactions, the demand for large-value banknotes depends on a short-term interest rate, the exchange rate of the euro as a proxy for foreign demand and inflation variability. Large-value banknotes seem to be therefore used to an important extent as a store of value domestically and abroad. As monetary policy is mainly interested in getting information on the demand for currency used for domestic transactions we also try several approaches in this direction. All the methods applied result in rather low levels of transaction balances used within the euro area of around 25% to 35% of total currency. After this we deal with possibly changing cost-benefit-considerations of the use of cash due to the introduction of euro notes and coins. Overall, there seems no evidence so far of a substantial decline of the demand for currency in the euro area. The analysis of currency in circulation and in particular estimates on the share of currency which is likely to be used for domestic transactions therefore help to explain monetary developments and are informative for monetary policy.

Keywords: currency in circulation, cointegration, purposes of holding currency

JEL classification: E41, E52, E58

Non-technical summary

In this paper, after presenting some stylised facts on currency and a theoretical currency model, the demand for the currency as well as the demand for small and large-value banknotes in the euro area between 1980 and 2001 is analysed on the basis of various econometric techniques. In addition, the period surrounding the cash changeover is investigated in detail and some possible longer-term considerations of the introduction of the euro as a cash-payment instrument in the euro area are drawn.

Currency holdings in the euro area were very diverse in the last 20 years. Currency holdings per capita and in relation to private consumption were particularly high in Germany, Spain and Austria. While this is in part linked to the foreign demand for the currency (in particular for the Deutsche Mark), it is also connected with domestic hoarding and/or the use of currency in the informal economy. By contrast, currency holdings were particularly low in France and Finland, pointing to an advanced use of cashless payment instruments. With regard to the denomination structure of the euro legacy banknotes, mainly Germany and the Netherlands had national banknote values similar to the largest euro banknote value (€500). For most of the euro area countries, the physical introduction of the euro has thus been connected with a move to higher-value banknotes, which may have an impact on the demand for currency.

When estimating the demand for currency within a cointegration framework from 1980 until the second quarter of 2001, excluding the period directly surrounding the cash changeover, we find a stable long-run relationship between real currency, real private consumption, an opportunity cost variable and the real effective exchange rate of the euro, the latter capturing the non-resident demand. In addition, we find significant differences between the determinants of holdings of small and large banknote denominations. While small-value banknotes are mainly driven by domestic transactions, the demand for large-value banknotes depends on a short-term interest rate, the exchange rate of the euro as a proxy for foreign demand and inflation variability. Large-value banknotes seem to be therefore used to an important extent as a store of value domestically and abroad. In addition, an included linear time trend in the equation for small denominations and overall currency demand may signal that currency demand has decreased slowly over time related to a more intensive use of cashless payment instruments.

For monetary policy, the share of euro currency which is used for domestic transactions is particularly relevant as it is related to economic activity and price developments in the euro area. By contrast, currency which is hoarded or used abroad is less relevant for these domestic developments. According to our estimates, a share of only around 25% to 35% of all currency in

circulation is held for domestic transactions, i.e. neither hoarded nor held abroad. In order to derive these estimates, a number of indirect estimation techniques are applied: the seasonal method, a best-fit approach and an analysis of the evolution of currency in the course of a representative year. Moreover, an upper limit of the non-resident demand for euro legacy currencies, estimated on the basis of various seasonal methods using France and Canada as benchmarks, amounted to between €25 and €50 billion at the end of 2000, corresponding to between 7% and 15% of the stock of currency in circulation in the euro area at that time.

The estimates of the share of currency holdings for hoarding purposes or abroad allow a more accurate picture of the demand for currency that is relevant for monetary policy purposes. This is of particular relevance in periods in which the demand for currency not held for domestic transaction purposes changes considerably and could, if unknown, lead to a misinterpretation of currency developments.

Furthermore, the rapid increase of the number of large-value euro banknotes in circulation after the euro cash changeover indicated a resumption of the hoarding of banknotes in the euro area and demand for euro banknotes from abroad. In addition, as data on the shipment of euro banknotes to countries outside the euro area as well as survey information from central banks of euro area neighbouring countries reveal, there has been substantial demand for euro banknotes from abroad. Hence, hoarding and the demand from abroad seem to play an important role in the demand for euro (legacy) currency.

Finally it is too early to conclude, if the euro cash changeover has triggered a structural change in the demand for euro banknotes and coins. In 2003 Q4, the level of currency was broadly in line with the level forecast by the presented currency demand model estimated between 1980 and 2000. At the same time, further developments have to be closely monitored, as the recovery process of currency does not yet show clear signs of a slowdown.

1. Introduction and literature review

"It is a capital mistake to theorize before one has data.
Insensibly one begins to twist facts to suit theories,
instead of theories to fit facts."

(Sherlock Holmes)

The currency component of monetary aggregates is the narrowest definition of money analysed by central banks. It comprises notes and coins in circulation held by non-Monetary Financial Institutions. The total amount of currency in circulation is closely controlled by the monetary authorities, as central banks are, in principle, able to decide precisely about the amount of currency they put into circulation and know the exact amount of outstanding currency. In addition, central banks usually accommodate the total demand for currency regardless of its origin. This notwithstanding, central banks are not able to follow the way that currency takes once put into circulation. Consequently, there is little direct statistical information on where the currency circulates, who holds the currency (residents or non-residents) and on the reasons for which the currency is held (for transactions, hoarding and/or illegal purposes).

For monetary policy purposes, the amount of currency held for transactions within the domestic currency area is of particular interest, since this part is closely related to domestic spending and hence, to domestic price developments. By contrast, for hoarding as well as foreign holdings of banknotes this is probably not the case. Therefore, for monetary policy purposes it would be helpful to have information on the transactions cash demand by residents. This is the starting point of the present paper. Based on the demand for the euro legacy currencies at an aggregate level, currency in circulation in the euro area has been analysed from the beginning of the 1980s until at least the end of 2001. This enables us to compare the (determinants of the) past demand for euro legacy currencies with present and future demand for euro banknotes and coins.

Major changes in the demand for currency could influence monetary developments, although the share of currency in circulation in broad monetary aggregates is relatively limited.[1] In this context, the introduction of the euro banknotes and coins has raised the question of how the demand for the new currency will evolve. The move towards the single currency, including changes in the denomination structure of the banknotes compared with the legacy currencies of the euro may imply a change in the domestic demand for currency. In this vein, the demand for euro banknotes from abroad may also differ from the past foreign demand for euro legacy

[1] The share of currency in circulation in the broad monetary aggregate M3 in the euro area was around 7% at the end of 2000.

currencies, which mainly concentrated on the D-Mark. A strong and, in particular, a fluctuating demand for euro banknotes from abroad could have implications for the assessment of monetary developments in the euro area. In this respect, the US experience shows that the foreign demand for US currency is sizeable and important enough to be monitored on a regular basis (Porter/Judson, 1996, United States Treasury Department, 2000, Lambert/Stanton, 2001). At the same time, payment and hoarding behaviour only change slowly over time.

In order to assess the demand for euro banknotes and coins, information from the cash changeover at the beginning of 2002 has also been extracted. The cash changeover provides a unique opportunity to get a more detailed picture about two fundamental questions, for what purposes and by whom currency is held. For instance, the reduction of currency in circulation in the course of 2001 and the demand for currency in the first months of 2002 should give some indication about the amount of currency used for hoarding purposes on the one hand and transaction purposes on the other. Moreover, the amount of euro banknotes which has been frontloaded or shipped in the first months of 2002 to countries outside the euro area, should give a, albeit limited, picture of the demand for euro banknotes abroad.[2]

So far, there are several papers dealing with the situation of specific national legacy currencies of the euro.[3] The usual approach is to estimate a currency demand function within the context of a narrow definition of money. The traditional arguments – a transaction variable and opportunity cost variables[4] – are in some cases supplemented by factors narrowly related to special characteristics of currency, e.g. its anonymity and secrecy.[5] An international comparison of currency demand equations including socio-economic factors is presented by Kenny, 1991,

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2 For the first months of 2002, banknote shipment data, which only capture the shipments via the banking system, are likely to be a relatively reliable indicator of the demand for euro banknotes from abroad, as most banknotes are likely to be transferred to abroad via the banking system. In general, however, banknote shipment data are likely to present a distorted picture of the net export of banknotes as the individual transport (e.g. via tourism or for reasons of fiscal evasion) is not captured. In addition, the original geographical source or final destination of banknotes is not captured, but only the direct source or destination.

3 A case study for the Deutsche Mark covering many different aspects of currency holdings over a time span of more than 50 years from the currency reform in Germany in 1948 until the introduction of euro notes and coins can be found in Deutsche Bundesbank, 2002a. The Deutsche Mark is a good example of a currency where all different motives for holding a currency were present during its existence. For EU countries that are not part of the euro area, see the papers by Janssen, 1998, Breedon/Fischer, 1996, and Astley/Haldane, 1995, for the UK and Schneider, 1986, as well as Denmarks Nationalbank, 1996, for Denmark. For an analysis of currency in circulation in prospective EU member countries see Nenovsky and Hristov, 2000, and Cuthbertson and Bredin, 2001. Andrist, 1998, part III, and Fischer, Jordan and Lack, 2002, consider the Swiss situation. The former studies the different motivations for holding Swiss Francs whereas the latter investigate the large Swiss currency holdings against the background of joining the euro area.

4 See e.g. Bohl/Sell, 1998.

5 Anonymity, secrecy, general acceptability with low risks and self-clearing are characteristics which make cash a unique payment instrument. See e.g. Langfeldt, 1989, for Germany. In this respect, Feige, 1987, tries to measure the payment velocity of currency for the Netherlands.

Drehmann/Goodhart, 2000, and Drehmann et al., 2002. Some authors try to capture the amounts of currency hoarded in the respective country,[6] others analyse foreign holdings of specific currencies, both from the point of view of a currency exporting country[7] and of currency importing countries.[8] In some cases, a distinction is made between different denominations, especially large and small denomination bills, and different holding groups.[9]

The relation between currency holdings and underground economic activity is generally discussed by Schneider/Enste, 2000, and empirically estimated for several EU countries by Schneider/Osterkamp, 2000, and Caridi/Passerini, 2001. In this respect, Drehmann et al., 2002, find that the ratio of (direct and indirect) taxes to GDP (an indicator of the size of the underground economy) becomes insignificant if one looks only at the USA, Germany and Switzerland whose currencies are the main potential candidates for foreign holdings. By contrast, in the subset of the other countries considered in their study, the tax ratio has a much larger and significant effect, especially for high denomination notes.

There are also papers which investigate the influence of financial innovation on the demand for cash.[10] Humphrey et al., 1996, especially stress the importance of differences across countries in cash and non-cash transactions. Attanasio et al., 2002, model both the access to interest bearing assets and the choice of an ATM card together with the demand for currency for Italian households. They find substantial economies of scale in cash holdings over time and significant differences in cash holdings between ATM cardholders and non-ATM cardholders. Dutta and Weale, 2001, show theoretically how changes in the transaction technology affect the choice of cash versus other methods of payment for consumption. An implementation of their model to UK data resulted in a steady improvement of transaction technology from the 1970s until the end of the 1990s and a high value for the substitution elasticity. Similarly, De Grauwe et al., 2000, compare the costs of cash and cards of the payment system participants in Belgium and Iceland. Their investigation unambiguously yields the result that the cost efficiency of the cash payment

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6 See Boeschoten, 1992, for the Netherlands; van Hove, 1999, van Hove/Vuchelen, 1999, for Belgium and Krueger, 2000, for Germany.

7 See De Nederlandsche Bank, 1991, for the Netherlands; Seitz, 1995, Krueger, 2000, and Doyle, 2000, for Germany.

8 See e.g. Feige et al., 1998, Kipici, 1996, for the case of the Deutsche Mark, Stix, 2001a, 2001b, for a comparison of holdings of Deutsche Mark, Austrian Schillings and US dollars in Central and Eastern Europe and Feige, 2003, for holdings of US-dollars and euro legacy currencies in 25 transition countries.

9 On the first point, see De Nederlandsche Bank, 1994, and Boeschoten/Fase, 1992, for the Netherlands; Virén, 1993, for Finland and Drehmann et al., 2002, as well as Porter/Judson, 1996, appendix B, for several OECD countries. The latter topic is analysed by Hirvonen/Virén, 1996, for Finnish business firms and Boeschoten, 1992, ch. 2 for Dutch households.

10 See Rinaldi, 2001, for Belgium; Boeschoten, 1998, for the Netherlands; Virén, 1989, 1992, 1994, for Finland; Schneider, 1990, for Austria; Attanasio et al., 2002, for Italy and Goodhart/Krueger, 2001, as well as Snellman et al., 2000, for an international comparison including several EU countries.

system is low compared to a payment system based on cards. The endogeneity of the evolution of different payment methods in a cross-country study is analysed by Humphrey et al., 2001, who find that payment users are quite sensitive to relative prices that reflect relative user costs.[11] In this respect, van Hove, 2002, strongly argues in favour of correct (i.e. transaction-based and visible to users) prices for different payment methods on efficiency grounds. As regards cash, he tries to show that, in general, it is the least efficient way of making payments.

There are only a few papers dealing with the potential demand for euro notes and coins.[12] The ECB, 2003, discusses the main determinants of currency demand in the euro area with a specific focus on the impact of the introduction of euro banknotes and coins on currency demand. Oesterreichische Nationalbank, 2001, Vuc helen/van Hove, 2001, and Hebbink/Peeters, 1999, analyse the problems connected with the changeover from the legacy currencies of the euro to euro notes and coins. These problems mainly concerned the exact amounts of currency needed for transactions and other purposes and the frictions involved with only concentrating on a single motive for holding currency. Mathä, 2001, illustrates with the help of a survey that the euro cash changeover could have more than temporary real economic effects as it may take several years before people truly and fully accept the new currency and the new denomination of prices. Mathä attributes this phenomenon to bounded rationality combined with people using rules of thumb rather than converting accurately (e.g. 1€ = 2 DM instead of 1€ = 1.95583 DM). Thus, economic agents make systematic errors. Rogoff, 1998, and van Hove/Vuchelen, 1996, discuss the relation between the denominational structure of euro banknotes and future currency demand of the underground economy. They argue that the existence of the two large denomination bills of €200 and €500 will facilitate tax evasion and illegal activities in the euro area.[13]

There are also some papers analysing the euro cash changeover.[14] These deal primarily with logistical aspects within and outside the euro area and a possible inflationary impact of the introduction of euro notes and coins. Their general conclusions are that the logistical challenges have been managed quite well and that the switch to the physical euro currency should and did not lead to a significant change in the price level.

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[11] See on this point Markose and Loke, 2003, who look at the interdependencies between payments media use, network effects and interest rates.

[12] Bindseil and Seitz, 2001, analyse banknotes in circulation in the euro area within the operational framework of the Eurosystem.

[13] On the possible international role of the euro and the dollar, see for instance Cohen, 1996, Cohen, 1998, and Müller, 1999.

[14] See e.g. Wynne, 2002, ECB, 2001, 2002a, 2002b, 2003, Oesterreichische Nationalbank, 2001. For individual country studies, see for instance Deutsche Bundesbank, 2002b and Mathä, 2002.

The paper is structured as follows. Section 2 presents some stylised facts on currency in circulation in the euro area countries as well as at the aggregate euro area level. A theoretical model which tries to capture some non-common determinants of currency demand is presented in Section 3. In Section 4, a currency demand function for euro area currency is estimated for overall currency holdings as well as for small and large denomination notes. Section 5 then tries to extract information on how much currency is used for transactions purposes within the euro area as well as for hoarding purposes and abroad with the aid of direct and indirect methods. Section 6 discusses currency developments after the cash changeover and the implications of the introduction of euro notes and coins for the longer-term demand for euro area currency. Finally, Section 7 summarises and draws some monetary policy conclusions.

2. Some stylised facts on currency in circulation in the euro area

"…the demand for currency may have properties nothing like what one would expect from textbook models of money demand."

(S. Sumner, 1994, 203)

In the past two decades, the demand for the legacy currencies of the euro was relatively heterogeneous across the euro area countries (see Tables 1 and 2). In part, this reflected differences in economic activity and opportunity costs of holding currency, related to interest rate and inflation differences across the euro area countries. It also mirrors differences in taxation, the importance of the informal economy[15] as well as heterogeneous payment habits, which are likely to be related to the different legacy banknote denominations[16] and cashless payment instruments. Moreover, differences in the demand for currency in the past resulted from the foreign demand for some of the euro legacy currencies.

Against this background, we present some stylised facts on currency in circulation at the national as well as the euro area level. Furthermore, with regard to international developments, currency demand in the euro area is compared with currency demand in the United States, the United Kingdom and Switzerland. This may provide some evidence on differences in the foreign demand for currency, in the payment behaviour as well as the size of the shadow economy. The development of small and large-value banknotes of the aggregate euro legacy currencies is also

[15] For estimates of the size of the informal economy, see Schneider and Enste, 2000.

[16] The definition of banknotes in circulation differs from that of currency in circulation in that currency in circulation includes coins, but excludes vault cash (i.e. cash held by Monetary Financial Institutions (MFIs)). Typically, the amount of outstanding banknotes exceeds the amount of currency in circulation by far.

analysed. Although banknote denominations differed markedly across the euro area countries, this aggregation may serve as a basis for a structural analysis of the demand for euro banknotes (see Section 6).

Table 1: Ratio of currency in circulation to private consumption (in percentages)

	1980	1985	1991	1995	1998	1999	2000	2001
Euro area	10.0	9.2	8.8	9.6	9.4	9.3	9.2	8.0
Belgium[1)]	16.9	12.5	10.0	8.5	8.3	8.6	8.5	7.4
Germany[2)]	9.6	9.6	9.8	11.2	11.1	10.8	10.6	8.8
Greece	14.2	11.9	9.8	8.1	8.0	8.3	8.1	7.7
Spain	10.4	10.3	14.1	16.4	15.6	15.2	14.8	13.1
France	9.0	7.6	6.8	6.0	5.7	5.6	5.7	4.8
Ireland	4.4	6.6	7.4	7.5	8.0	9.2	8.8	7.6
Italy	9.5	8.4	8.1	8.7	8.6	8.9	9.1	8.8
Luxembourg[1)]	..	..	..	..	..	6.9	5.9	4.4
Netherlands	11.6	12.6	12.8	11.3	9.6	8.8	8.2	6.5
Austria	12.1	10.4	9.8	9.9	9.4	9.4	9.7	8.9
Portugal	15.7	9.8	8.3	7.4	6.5	6.7	7.0	6.6
Finland	3.8	3.3	3.2	3.8	4.1	4.1	4.0	3.9
United Kingdom	6.3	5.6	4.2	4.0	4.0	4.0	4.1	4.2
United States	6.0	5.8	6.4	7.2	7.4	7.6	7.7	7.8
Switzerland	..	15.4	12.8	12.0	12.2	12.3	12.2	12.5

Source: ECB, NCBs, Eurostat, national accounts.
Note: Partly estimated for Ireland, Portugal and Luxembourg.

1) The figures for Luxembourg are included in the figures for Belgium before 1999.
2) West Germany before 1991.

Table 2: Currency holdings per capita[1] (in purchasing power parities)

	1980	1985	1991	1995	1998	2000	2001
Euro area	..	..	776	949	1060	1167	1073
Belgium	887	939	1036	1061	1109	1206	1080
Germany	..	..	974	1362	1518	1606	1396
Greece	481	548	693	762	858	927	900
Spain	400	531	1125	1489	1668	1754	1597
France	478	562	696	687	707	783	693
Ireland	306	361	561	737	923	1197	1093
Italy	458	581	818	1027	1174	1416	1401
Luxembourg[2]	97	129	205	249	255	1186	937
Netherlands	521	773	1096	1181	1208	1138	925
Austria	571	729	954	1193	1312	1526	1451
Portugal	451	414	567	642	655	778	747
Finland	160	205	274	368	454	509	508
United Kingdom	343	379	421	484	582	663	708
United States	485	681	1025	1392	1631	1897	1991
Switzerland	..	1506	1618	1827	2047	2157	2264

Source: ECB, NCBs, Eurostat, national accounts.

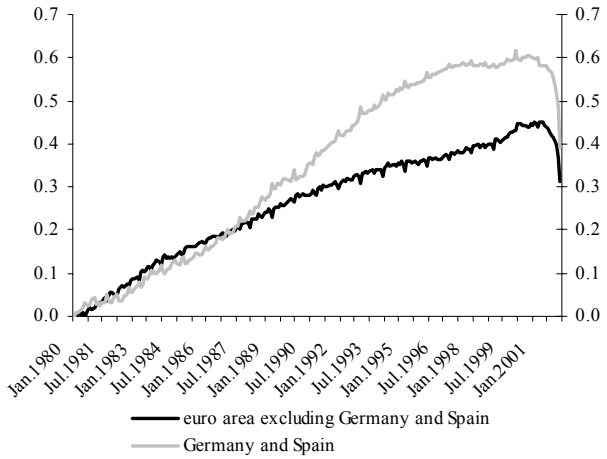
1) Based on purchasing power parities calculated by the OECD and Eurostat.

2) The figures for Luxembourg do not reflect the actual amount of currency in circulation due to the substantial circulation of foreign banknotes (mainly Belgian francs, German marks and Dutch guilders) in Luxembourg.

Despite considerable differences of currency holdings across the euro area countries, the ratio of currency in circulation to private consumption developed in a relatively stable manner at the aggregate euro area level between 1980 and 2000 (see *Table 1*).

The increase in the ratio of currency to private consumption in the first half of the 1990s mainly reflects the increase in the currency demand in Germany and Spain. Partly related to changes in national tax regulations, the average annual rate of change of currency in circulation between January 1986 and December 1994 was more than twice as high in Germany and Spain (10.6%) as in the euro area excluding these two countries (4.2%) (see ***Chart 1***), although in the case of Germany, this was also partly a result of the political and economic transformation in central and eastern Europe. In Germany, both the announcement of the introduction of a withholding tax on interest income from financial assets in 1987 and the decision by the Federal Constitutional Court on the taxation of capital gains in 1991 led to a substantial increase in currency holdings (Deutsche Bundesbank, 2002a). In Spain, currency in circulation rose considerably during that period owing to the introduction of a law in 1985 on a more homogeneous fiscal treatment of capital gains from financial assets, as well as the introduction of a value added tax in 1986 which led to tax evasion transactions (Banco de España, 1996). The slight decline of the ratio of currency to private consumption in the euro area in the second half of the 1990s until 2001 probably mirrors the somewhat lower currency demand from abroad owing to the economic stabilisation in central and eastern Europe, the more intensive use of cashless payment instruments, and, towards the end of the period, some preparations with regard to the euro cash changeover.

Chart 1: Currency in circulation developments in selected euro area countries (in logarithms)



Source: ECB.

Since the beginning of the 1980s, the increasing use of cashless payment instruments may have contributed towards reducing the demand for currency for transaction purposes. In particular, payment cards can substitute cash payments as they are mainly used for small and medium-value purchases. As can be seen from ***Table 3***, the use of payment cards has expanded considerably in the euro area in the second half of the 1990s. While there is an increasing trend in the use of payment cards in all euro area countries, the extent to which payment cards are actually used

across the euro area countries is very different. While some countries, such as Finland, are very advanced in the use of payments cards, in other countries, as for instance in Greece, Spain, Italy and Austria, the use of cards remained relatively modest so far.

The slightly declining ratio of currency in circulation to the monetary aggregates M3 or M1, respectively, observed since the beginning of the 1980s, may reflect the increased use of cashless payment instruments.

Table 3: Use of payment cards (total value in € of transactions with debit and credit cards per inhabitant)

	1996	1997	1998	1999	2000
Euro area	1096	1168	1403	1655	1875
Belgium	1431	1629	1934	2236	2564
Germany[1]	579	573	972	1170	1334
Greece	..	..	..	..	306
Spain	371	423	487	584	625
France	1688	1800	1797	2222	2534
Ireland	..	..	..	1189	1490
Italy	312	427	517	696	830
Luxembourg	2709	3062	3370	3533	4153
Netherlands	1316	1626	1913	2345	2714
Austria	418	475	586	776	997
Portugal	734	958	1315	1649	2079
Finland	2205	2399	2565	2799	3225

Source: ECB, Blue Book - Payment and Securities Settlement Systems in the European Union, Addendum incorporating 2000 figures, July 2002.

1) The sum of the number of accepting terminals for cards with a credit function is reported by the individual credit card institutions. This may result in double counting.

In this context, it is worth mentioning that in some countries, there are legal regulations in place which enforce the use of cashless payments. For instance, in France, the use of currency for large-value payments and for salary payments is limited by law. In Belgium, too, merchants are obliged to accept certain cashless payment instruments for large-value payments. In the Netherlands, ministries are required by law to promote the use of bank transfers for payments to the state. In Finland, there is a legal act in place for cashless rent payments.

The importance of high-value and low-value legacy banknotes in the euro area (converted into euro) is shown in ***Table 4***. Low-value banknotes were particularly important in Greece and Portugal, probably partly linked to their relatively low GDP per capita (in purchasing power parities) as compared with the EU-15 average. In addition, past high inflation, which led to a decline in the purchasing power of a banknote, also leads to a higher share of lower-value banknotes, when converted to euro, over time, if the denomination structure remained unchanged. High-value banknotes, by contrast, were particularly important in Germany, the

Netherlands, Belgium and Austria, in line with a relatively high denomination structure of their legacy banknotes, which is especially appropriate for hoarding and foreign demand.

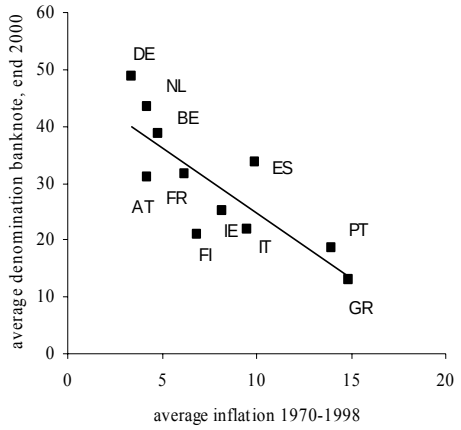
Table 4: Value of banknotes in circulation according to converted denominations in euro
(national banknotes in circulation in December 2000, in % of total national banknotes in circulation)

converted value in EUR	€ 200 and above	€ 100 to below € 200	€ 50 to below € 100	€ 20 to below € 50	€ 10 to below € 20	€ 5 to below € 10	below € 5
Belgium	51%	0%	0%	43%	3%	0%	3%
Germany	44%	3%	39%	8%	4%	2%	0%
Greece	0%	0%	0%	73%	22%	0%	5%
Spain	0%	0%	59%	33%	5%	3%	0%
France	0%	0%	47%	35%	15%	2%	0%
Ireland	0%	3%	33%	53%	7%	3%	0%
Italy	15%	0%	63%	16%	0%	3%	2%
Luxembourg	0%	79%	0%	17%	0%	0%	4%
Netherlands	35%	12%	0%	46%	6%	0%	2%
Austria	37%	0%	46%	6%	0%	8%	3%
Portugal	0%	0%	0%	86%	0%	6%	8%
Finland	0%	36%	16%	0%	42%	4%	3%

Source: ECB, NCBs.

In this context, as can be seen from ***CHART 2***, in countries with a high average inflation in the past (and high interest rates), the average legacy banknote value (i.e. the total value of banknotes in circulation divided by the number of banknotes in circulation) was relatively low at the end of 2000. Conversely, the average legacy banknote value was particularly high in countries with low inflation (and low interest rates), which may explain the importance attached to the use of currency, and particularly the use of large-value banknotes, for hoarding purposes in these countries.

Chart 2: Average-value banknotes and average inflation between 1970 and 1998
(in € at the end of 2000 and in percentages)



Source: ECB.

Furthermore, the demand for high-value banknotes was relatively strong by non-residents. From all euro legacy currencies, especially the Deutsche Mark, and, to a more limited extent, also the Austrian Schilling and the French Franc, were held abroad. Worker's remittances, tourism flows,

the political and economic transformation of central and eastern Europe at the end of the 1980s and the war in the former Yugoslavia were all factors contributing to a higher demand for the Deutsche Mark. According to a study published by the Deutsche Bundesbank, it was estimated that around 30% to 40% of Deutsche Mark banknotes were circulating abroad in the mid-1990s, probably mainly in central and eastern Europe, the western Balkans and Turkey, corresponding to around €35 to €45 billion at that time (Seitz, 1995). In the second half of the 1990s, by contrast, the stabilisation of the situation in eastern Europe probably led to a fall in the demand for euro legacy currencies in these countries. While there is no updated estimate for Deutsche Mark holdings abroad, more recent figures are available for the holdings of Austrian Schilling by non-residents. According to a survey by the Oesterreichische Nationalbank, non-resident holdings of Austrian Schilling banknotes in central and eastern Europe accounted for approximately 4% to 6.5% of the total circulation of Austrian Schilling banknotes in the first half of 2000 (around €0.5 billion) (Stix, 2001c).

In this context, it is important to notice that, because of the anonymity of currency, it is generally not possible to determine precisely the amount of currency circulating abroad and hoarded. There are only some direct indications based on statistics on cross-border shipments of banknotes via the banking system as well as on surveys and some indirect indications based on econometric estimations.

Compared with the US, where the increase in currency holdings in relation to private consumption during the past was mainly due to the foreign demand for US dollar, the development was more stable in the euro area (see *Table 1*). Related to the strong foreign demand for Swiss francs, currency holdings to private consumption (as well as per capita, as can be seen from *Tables 1 and 2* above) in Switzerland are considerably higher than in the euro area as a whole. By contrast, in the UK, where the use of cashless payment instruments is quite advanced and the foreign demand for Pound Sterling does not play a considerable role, currency holdings to private consumption are much lower than in the euro area.

In order to investigate total euro area developments over a longer historical period, it is of interest to construct a notional aggregate of small-value and of large-value banknotes for the euro area on the basis of the euro legacy banknotes. This may also form the basis for some preliminary comparisons with the euro banknotes. For this purpose, the euro legacy banknotes were converted into euro with the official irrevocable fixed conversion rates. The classification was based on considerations for each individual country with respect to the appropriateness of the legacy banknotes for transaction and hoarding purposes at home and abroad. It is assumed

that the large-value banknotes were to a considerable extent used for hoarding in the euro area as well as to some extent held abroad, whereas the small-value banknotes were probably predominantly used for domestic transactions. In addition, some banknotes were classified as neither large nor small, as these seem to have been used to a considerable extent for both hoarding and transaction purposes. At the same time, despite this case-by-case approach, the denominations with a converted value of more than €30 could generally be classified as "large", while the denominations with a value of less than €30 were generally classified as "small".[17] ***TABLE 5*** shows the chosen split into small and large-value banknotes by national denominations as well as converted into euro.[18] As can be seen from the table, in most countries, the value of the legacy banknotes has on average been lower than the value of the euro banknotes. Only in Germany and the Netherlands and, with some distance, in Austria there was a legacy banknote of a similar value as the €500 banknote. Accordingly, for most euro area countries the changeover to the euro banknotes meant a change to on average higher denominations which may have an impact on the demand for currency.

[17] Apart from the banknotes, which were neither classified as large nor small, this rule was followed with one exception, namely Greece, where the largest banknote (GRD 10000, corresponding to € 29.35) was counted as a large banknote denomination. Other studies classify denomination according to a specific converted value (see e.g. Drehmann et al., 2002, who use a separation value of 50 £).

[18] In the case of Portugal and Luxemburg, monthly data start in January 1991 and January 1996, respectively. All other national currency data start at the beginning of 1980.

Table 5: Small and large-value euro area banknotes

Country	Small	Large
in national denominations		
Belgium	BEF 500; 200; 100; *50; 20*	BEF 10,000; 5,000; 2,000
Germany	DEM 50; 20; 10; 5	DEM 1,000; 500; 200
Greece	GRD 500; 200; 100; 50	GRD 10,000
Spain	ESP 2,000; 1,000; less than 1,000	ESP 10,000; 5,000
France	FF 100; 50; 20	FF 500; 200
Ireland	IRP 20; 10; 5; *2; 1*	IRP 100; 50
Italy	ITL 50,000; *20,000*; 10,000; 5,000; 2,000; 1,000	ITL 500,000; 100,000
Luxemburg	LUF 100	LUF 5,000
Netherlands	NLG 50; 25; 10; *5*	NLG 1,000; 250
Austria	ATS 100; 50; 20	ATS 5,000; 1,000
Portugal	PTE 2,000; 1,000; 500; *100*	PTE 10,000
Finland	FIM 50; 20; 10; *5; 1*	FIM 1,000; 500
converted in euro (using the official irrevocable fixed conversion rates)		
Belgium	€ 12.39; 4.96; 2.48; *1.24; 0.50*	€ 247.89; 123.95; 49.58
Germany	€ 25.56; 10.23; 5.11; 2.56	€ 511.29; 255.65; 102.26
Greece	€ 1.47; 0.59; 0.29; 0.15	€ 29.35
Spain	€ 12.02; 6.01; less than 6.01	€ 60.10; 30.05
France	€ 15.24; 7.62; 3.05	€ 76.22; 30.49
Ireland	€ 25.39; 12.70; 6.35; *2.54; 1.27*	€ 126.97; 63.49
Italy	€ 25.82; *10.33*; 5.16; 2.58; 1.03; 0.52	€ 258.23; 51.65
Luxemburg	€ 2.48	€ 123.95
Netherlands	€ 22.69; 11.34; 4.54; *2.27*	€ 453.78; 113.45
Austria	€ 7.27; 3.63; 1.45	€ 363.36; 72.67
Portugal	€ 9.98; 4.99; 2.49; *0.50*	€ 49.88
Finland	€ 8.41; 3.36; *1.68; 0.84; 0.17*	€ 168.19; 84.09

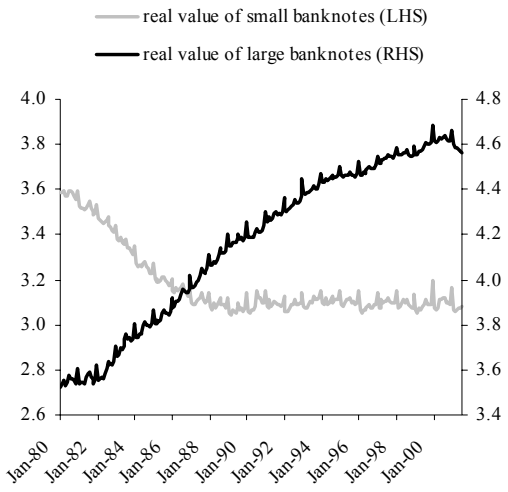
Notes: The table includes all denominations since 1980 even if they do no longer exist or did not exist the whole time period. Denominations in italics indicate notes which were not any more issued before the end of 2001. The following banknote denominations were classified as neither large nor small as they are likely to be used for both transactions and hoarding to a considerable extent: BEF 1000 (€ 24.79); DEM 100 (€ 51.13); GRD 5000 (€ 14.67), GRD 1000 (€ 2.93); LUF 1000 (€ 24.79); NLG 100 (€ 45.38); PTE 5000 (€ 24.94); FIM 100 (€ 16.82).

In real terms, the value of small banknotes declined in the first half of the 1980s (see *Chart 3*). In the second half of the 1980s and in particular during the 1990s, small-value banknotes have been relatively stable in real terms, in line with relatively low inflation during most of this period.

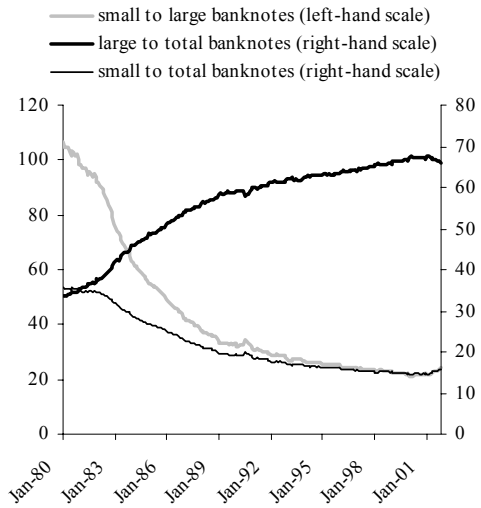
In contrast to the small-value banknotes, the large-value banknotes increased steadily, in nominal as well as in real value terms, between 1980 and 2000, before declining in 2001 related to the upcoming cash changeover.

Chart 3: Small-value and large-value legacy banknotes in the euro area

a) deflated by the private consumption deflator, in logarithms



b) ratios in percentages



Source: ECB, NCBs.
Note: Small (large)-value banknotes are defined as in Table 5.

In sum, the ratio of small to large-value banknotes of the euro legacy currencies therefore declined during the past two decades. In line with this, in a number of euro area countries new banknote denominations were issued and existing banknote denominations withdrawn during the period under review. The issued denominations were mostly large-value banknotes, i.e. with a converted value of above €30, while the withdrawn denominations were mostly small-value banknotes, i.e. with a value of below €30.

3. A theoretical model of currency demand

"paper currency is worth virtually nothing to an individual unless he knows that it is valued by others."
(M. Obstfeld/K. Rogoff, 1996, 513)

This section presents a theoretical model of currency demand in the presence of tax evasion or underground economic activities and foreign demand for the home currency. As, at present, there is no universally accepted theoretical approach to modelling the microfoundations of money, we concentrate on one specific model, the so-called money-in-the-utility-function model.[19] It captures the role of money as a store of value as well as a medium of exchange. The model combines and extends the models of Rogoff, 1998 (appendix), and Obstfeld/Rogoff, 1996, ch.

[19] Holman (1998) postulates that this kind of models allows for transactions as well as precautionary and store-of-value motives for holding money. For a textbook version of introducing money in a Walrasian framework see Handa, 2000, parts 2 and 8. One of the latest theoretical attempts to rationalise holdings of fiat money is presented in Schröder, 2001.

8.3. The main aim of this section is to derive which variables should theoretically be incorporated in an empirical currency demand model relevant for the euro area. Although the empirical literature on currency demand has long recognised the importance of currency use in the underground economy (Gutman, 1977) and the potential of foreign demand for major currencies (Kimball, 1981), standard theoretical treatments of money demand have remained curiously oblivious to this possibility.[20]

Consider a two-country model with two currencies. Both economies produce and consume one perishable good.[21] Imagine "home" as being the euro area and "foreign" any country in the world with a potential demand for euro. An individual's lifetime utility $U(*)$ is given by the discounted sum of the per period utility functions of the representative agent at home and abroad, as in (1) and (2), respectively:

$$(1) \qquad U_s = \sum_{t=s}^{\infty} ß^{t-s} u(c_t, \frac{cu_t}{p_t}),$$

$$(2) \qquad U_s^* = \sum_{t=s}^{\infty} ß^{*t-s} u*(c_t^*, \frac{cu_{t,f}^*}{p_t^*}, \frac{e_t cu_t^*}{p_t^*}),$$

where $c(*)$ is consumption at home (abroad) per period t, cu (cu_f) denotes the home (foreign) nominal currency stock, $ß^{(*)} < 1$ is the discount factor and $p(*)$ is the home (foreign) price level. Residents of the foreign country demand their own currency cu_f and the (stable and widely accepted) currency cu. The variable cu_f^* represents foreign demand for the foreign currency, cu^* the foreign holdings of home money, which have a real value for the foreigner of $e \cdot cu^*/p^*$.[22] The exchange rate e is expressed as the foreign currency price of domestic currency (1€ = e foreign currency units). It is assumed that $u^{(*)}$ is strictly concave with $u^{(*)\prime} > 0$ and $u^{(*)\prime\prime} < 0$.

Let us first consider the home country. Each period, the individual is endowed with gross real income y, but also faces a proportional tax on earned income at a notional rate τ. The tax rate is notional in that the agent can reduce his effective tax rate by holding a higher level of real currency levels cu/p. This modelling feature should capture the idea that using currency helps

[20] One exception with respect to the first argument is Rogoff, 1998. However, there are theoretical papers on the situation in parallel-currency ("dollarised" or "euroised") countries, see e.g. Lane, 1992, Guidotti/Rodriguez, 1992, Seitz, 1995, ch. IV, Uribe, 1995, Peiers/Wrase, 1997, Alami, 2001, and Cooper/Kempf, 2001. In this respect Bogetić, 2000, distinguishes between official and unofficial dollarisation. A recent paper which considers the endogenous choice of a currency depending on national money growth rates is Martin, 2002.

[21] All foreign variables are marked with an asterisk.

[22] In chapter 8.3.8, Obstfeld/Rogoff, 1996, also consider tax evasion costs in the sense that legal restrictions on foreign currency use are easier to evade in some transactions than in others.

avoiding the detection of income by the tax authorities. Thus, net real taxes paid by the individual are $\tau g(cu_t/p_t y)$ with $g(0) = 1$, $g'(.) < 0$, $g''(.) > 0$.

Our assumptions on the tax avoiding technology imply that the home individual's budget constraint in money terms may be written as

$$(3) \qquad p_t b_{t+1}^i + cu_t^i = p_t(1+r)b_t^i + cu_{t-1}^i + p_t y(1-\tau g(\frac{cu_t^i}{p_t y})) - p_t c_t$$

In (3) b_{t+1} are the holdings of real bonds, r is the real interest rate and cu_t are currency holdings at the end of period t.

Let us now turn to the foreign country. Residents of this country hold both the home currency cu and their legal tender cu_f. In order not to over-complicate issues we do not take into account possible tax evasion in the foreign country and only consider the case of a lump-sum tax T. Therefore, the foreign budget constraint reads as[23]

$$(4) \qquad p_t^* b_{t+1}^* + cu_{f,t}^* + e_t cu_t^* = p_t^*(1+r^*)b_t^* + cu_{f,t-1}^* + e_t cu_{t-1}^* + p_t^* y^* - p_t^* c_t^* - p_t^* T_t^*$$

The individual holds foreign bonds as well as domestic and foreign monies. Gross real income is y^* and the real interest rate abroad is r^*.

To close the model we need the budget constraints of the two respective government sectors, (including the central bank). To concentrate on the main issue of currency and to simplify the analysis, let us abstract from home and foreign government spending, asset holdings and debt issues. Then, the two government budget constraints are

$$(5) \qquad \begin{aligned} \tau g\left(\frac{cu_t}{p_t y}\right) &= \frac{cu_t + cu_t^* - cu_{t-1} - cu_{t-1}^*}{p_t} \\ T_t^* &= \frac{cu_{f,t}^* - cu_{f,t-1}^*}{p_t^*} \end{aligned}$$

Thus, the home country earns seigniorage from the demand by residents and non-residents. This lowers the domestic tax burden. By contrast, the foreign country may have to increase taxes more and more if the domestic currency is no longer accepted in transactions or as a store of value. This is the typical situation in unstable and hyperinflationary countries.

The first order conditions of maximisation of (1) and (2) with respect to the budget constraints (3) and (4) imply

[23] We drop the superscripts i in order not to use too many of them.

(6) $$u_c(c_t, \frac{cu_t}{p_t}) = (1+r)\,ß u_c(c_{t+1}, \frac{cu_{t+1}}{p_{t+1}})$$

(7) $$\frac{1}{p_t} u_c(c_t, \frac{cu_t}{p_t})\left[1 + \tau g'(\frac{cu_t}{p_t y})\right] = \frac{1}{p_t} u_{cu/p}(c_t, \frac{cu_t}{p_t}) + \frac{1}{p_{t+1}} ß u_c(c_{t+1}, \frac{cu_{t+1}}{p_{t+1}})$$

(8) $$u^*_{c^*}(c^*_t, \frac{cu^*_{f,t}}{p^*_t}, \frac{e_t cu^*_t}{p^*_t}) = (1+r^*)\, ß^* u^*_c(c^*_{t+1}, \frac{cu^*_{f,t+1}}{p^*_{t+1}}, \frac{e_{t+1} cu^*_{t+1}}{p^*_{t+1}})$$

(9) $$\frac{1}{p^*_t} u^*_{c^*}(c^*_t, \frac{cu^*_{f,t}}{p^*_t}, \frac{e_t cu^*_t}{p^*_t}) = \frac{1}{p^*_t} u^*_{cu^*_f / p^*}(c^*_t, \frac{cu^*_{f,t}}{p^*_t}, \frac{e_t cu^*_t}{p^*_t}) + \frac{1}{p^*_{t+1}} ß^* u^*_{c^*}(c^*_{t+1}, \frac{cu^*_{f,t+1}}{p^*_{t+1}}, \frac{e_{t+1} cu^*_{t+1}}{p^*_{t+1}})$$

(10) $$\frac{1}{p^*_t} u^*_{c^*}(c^*_t, \frac{cu^*_{f,t}}{p^*_t}, \frac{e_t cu^*_t}{p^*_t}) = \frac{1}{p^*_t} u^*_{cu^*/p^*}(c^*_t, \frac{cu^*_{f,t}}{p^*_t}, \frac{e_t cu^*_t}{p^*_t}) + \frac{1}{p^*_{t+1}} ß^* u^*_{c^*}(c^*_{t+1}, \frac{cu^*_{f,t+1}}{p^*_{t+1}}, \frac{e_{t+1} cu^*_{t+1}}{p^*_{t+1}})$$

Conditions (6) and (7) refer to home optimisation, (8) – (10) to foreign optimisation. (6) and (8) are the standard consumption-Euler equations. These state that at a utility maximum the consumer cannot gain from shifts of consumption between periods. (7) and (9) determine the allocation of income between money and consumption. For the sake of interpretation let us concentrate on equation (7): $1/p_t$ is the quantity of current consumption a home-person must forgo to raise real balances by one unit, and $u_c(.)$ is the marginal utility of that consumption. On the right-hand side, the first term is the marginal utility the agent gets from having one extra currency unit to conduct transactions. Breaking down the second term on the right-hand side, $1/p_{t+1}$ is the quantity of consumption the individual will be able to pursue in period $t+1$ with an extra currency unit, and $ß u_c(.)$ is the marginal utility of date $t+1$ consumption, discounted to date t. An analogous interpretation holds for (9). Finally, (10) states that an optimising foreign agent must be indifferent at the margin between spending a unit of the other country's currency on date t consumption or holding it for one period and then spending it on date $t+1$ consumption.

Combining equations (6) – (10) and given our assumptions on $g(.)$ yields a standard demand for money function increasing in y and decreasing in the nominal interest rate i.[24] The important differences are that currency demand also depends positively on the marginal tax rate τ, the exchange rate of the euro e and on the consumption level c as well as on several foreign variables like i^* and y^*. Taking into account a stochastic version of the model would imply including volatility (e.g. inflation variability) and risk parameters (e.g. risk premia, crime

variables). Furthermore, incorporation of a further payment medium may allow the treatment of the evolution of potential cash substitution processes which may have repercussions on the currency demand function in the sense of a financial innovation influence (see e.g. Kabelac, 1999).

4. Estimating the demand for cash for euro area currencies

"…there are essentially two, largely separate, markets for currency; these are, first, a market for large value notes to facilitate `bad behaviour`, and, second, a market for small bills for ordinary, every-day consumption payments' purposes."

(Drehmann et al., 2002)

This section estimates currency demand in the euro area within a cointegration framework. Until the end of year 2000 the data refer to the initial 11 euro area member states, afterwards to the current 12 euro area countries. Variables expressed in euro were converted from the euro legacy currencies into euro with the irrevocably fixed conversion rates.

4.1 The data: Description and motivation

The variable to be explained are real currency holdings (*cur*) of euro area currencies. This means we assume long-run price homogeneity to hold. We analyse overall currency in circulation as well as small (*smallr*) and large (*bigr*) denomination bills.

In general and according to the arguments put forward in Sections 2 and 3 there are four potential influences on the evolution of real cash balances which may differ in importance depending on whether small or large denominations are considered. These determinants reflect the various purposes of holding currency. They are 1) the traditional transactions, precautionary and speculative motives, 2) advances in payments technology (financial innovation), 3) demand by non-residents and 4) informal economy activities including the illegal underground economy. In what follows we will shortly explain how these items are proxied in the empirical analysis.

- Transaction, precautionary and speculative motives

The transaction and speculative motives of holding cash are captured via a transaction variable and via an opportunity cost term. In order to calculate real cash holdings we deflate nominal balances with the private consumption deflator. This is due to the fact that we treat real private

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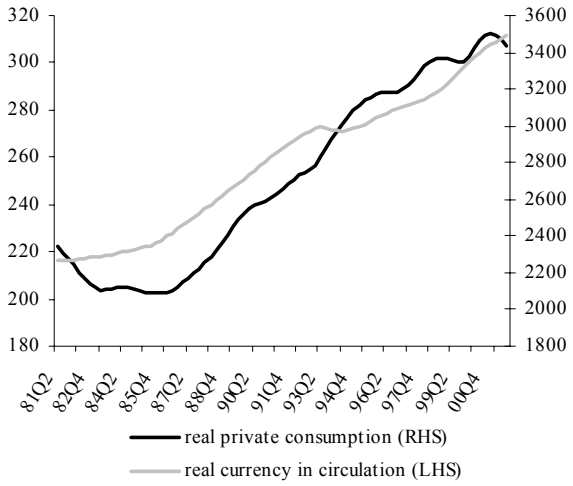
[24] Remember that according to the Fisher identity $1+i=\frac{P_{t+1}}{P_t}(1+r)$.

consumption expenditures (c) as the relevant transactions variable.[25] The two variables are shown in *Chart 4*.

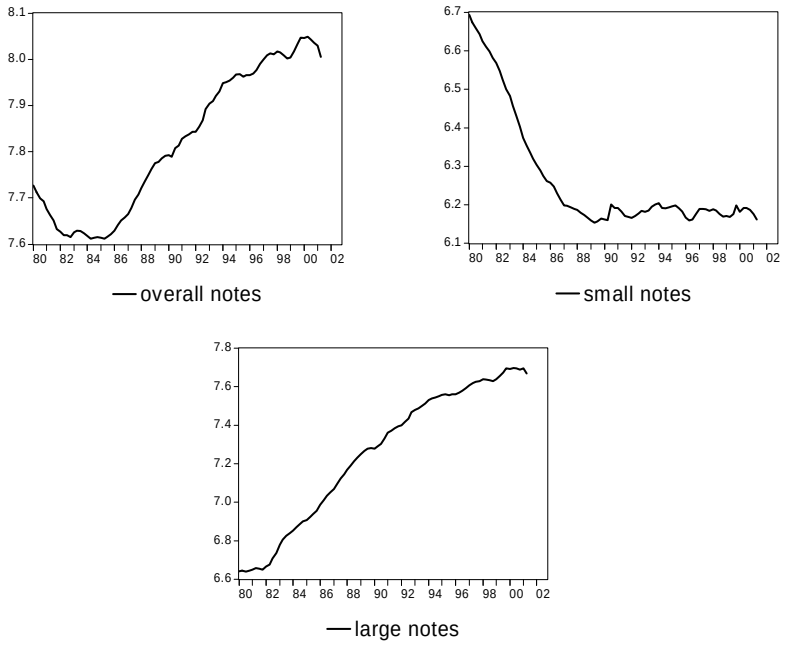
Chart 4: Real currency and real private consumption in the euro area (€ billions)
(deflated by the private consumption deflator, in annual terms)



Source: ECB.

The growth rate of private consumption should proxy cyclical influences on the use of cash (Hoggarth/Pill, 1992, Drehmann/Goodhart, 2000). The three cash variables *cur*, *smallr* and *bigr* (in logarithms) are shown in the following Chart 7 (see also Section 2).

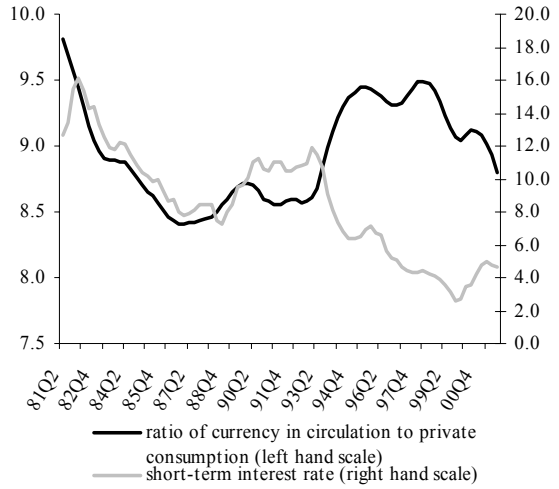
Chart 5: The real cash variables (in logarithms)



[25] An alternative would be retail sales (Janssen, 1998, Seitz, 1995). As, for the euro area as a whole, these are only available since 1996, this possibility has to be discarded. With GDP we get poorer empirical results and problems

As cash is non-remunerated, the opportunity costs should be made up of a short-term interest rate. Specifically, we tried a measure of the own rate of return of overnight deposits (see Calza et al., 2001, for details), the three-month money market rate (*i3*) and the yield on 10-year government bonds (*il*) to capture the return on a long-term alternative to currency holdings (all in percentage terms). In the two latter cases, because of the high and volatile money and capital market rates in some euro area countries before 1999, we did not only calculate weighted euro area interest rates, but also used the 3-month German Fibor (Frankfurt Interbank Offered Rate) and the yield on German government bonds, respectively, instead.[26] CHART 6 shows currency in circulation in relation to private consumption and the three-month money market rate.

Chart 6: Ratio of currency to private consumption and opportunity cost of holding currency (in %)



Source: ECB.
Note: The short-term interest rate is a GDP weighted average of the short-term interest rates in the euro area countries.

We also experimented with the term spread (*sp*), i.e. (*il* – *i3*), as a potential determinant of cash holdings where we have no priors as regards the sign of this variable. According to the expectations theory of the term structure the current spread may forecast the future course of short-term rates (see e.g. Anker and Wasmund, 1998) and may thus approximate speculative motives for cash holdings. This would imply a positive sign. However, a high spread may also reveal, that the long bond has a higher return over its life than a series of short bonds (Campbell, 1995, 141). Friedman, 1977, within an optimising framework under uncertainty, showed that a demand-for-currency equation should include the key characteristics of the whole structure of yields: the "general" level, the "tilt" of the term structure to maturity and the difference between

with the domestic opportunity cost variable. An attempt to approximate the volume of cash transactions in the economy may be found in Snellman/Vesala, 1999, and Snellman et al., 2000.

real and nominal yields. A steepening of the tilt of the term spread with an unchanged mean, for example, which implies higher long-term rates and lower short-term rates, will tend to reduce cash balances, and conversely (Friedman, 1977, 408).[27] Finally, a high yield spread may sign inflation expectations which would also imply a negative relationship. Empirically implementing this idea implies using the term spread instead of interest rate levels to capture the opportunity costs of currency holdings adequately.

- Financial innovation

It is often argued that advances in payments technology have resulted in a substitution of non-cash payments for cash (see e.g. Snellman et al., 2000 and Section 2). The influence of this financial-innovation-effect may be captured by including a linear time trend (*time*) in the regressions. Some authors use more direct measures of financial innovation such as the number of ATM's, bankcards or EFTPOS terminals (see e.g. Rinaldi, 2001, Drehmann/Goodhart, 2000). While these figures are informative for a structural analysis of the demand for currency, for an econometric analysis they have the disadvantage to be only available on an annual basis. Others stress that financial innovation is an endogenous process. Therefore, they try to explain (the incentives for) the innovation process. This idea may be captured by a cumulative interest rate term (*icum*) (Janssen, 1998) as this might be a good proxy for the level of transactions technology (Hall et al., 1990).[28] In our case, it is calculated as the cumulative sum of the three-month money market rate.

- Foreign demand

In addition, currency developments in the euro area reflect the foreign demand. Economic agents in currency areas with less stable monetary regimes may have tended to hold euro area currencies, notably those which had a tendency to appreciate in the past. It is very difficult to find an empirical proxy for the incentives for non-residents to hold foreign currencies. One possibility is via the introduction of an exchange rate argument e (see the theoretical model above as well as Bohl/Sell, 1998, Drehmann/Goodhart, 2000, Gross, 1989, Holtham et al., 1990,

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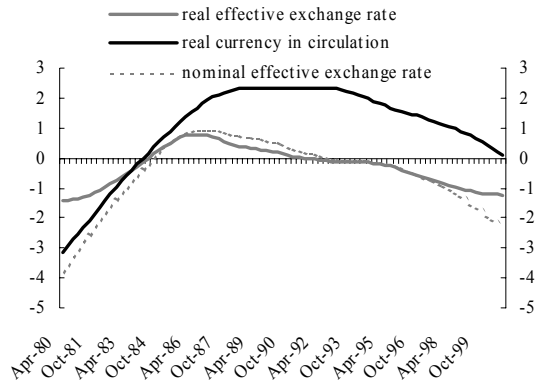
[26] This may be rationalised by the fact that within the former (asymmetric) European Exchange Rate Mechanism (ERM) the Bundesbank pursued an independent monetary policy aimed at price stability while the other ERM countries tried to maintain a stable exchange rate vis-à-vis the Deutsche Mark (De Grauwe, 2000, ch. 5, Wellink/Knot, 1996). If uncovered interest parity holds, it seems natural to consider German rates.

[27] An empirical implementation of Friedman's proposal may be found in Friedman/Schwartz, 1982, for the US and in Seitz, 1998, for Germany.

[28] Drehmann and Goodhart, 2002, for instance, argue that there are essentially two, largely separate, markets for currency (see the citation at the beginning of chapter 4). The evidence presented in their paper suggests that non-cash electronic payments mechanisms, or at least those so far available, should mainly compete in the market for small bills. Markose and Loke, 2000, find that the high interest rates of the late 1980's and the early 1990's were a spur to the development of EFTPOS cash substitutes.

and Seitz, 1995).[29] The external value should indicate the relative strength and attractiveness of the euro legacy currencies compared to others. As candidate series we take into account the nominal and real euro-dollar exchange rate as well as nominal and real effective exchange rates of the euro against the 12 major trading partners of the euro area (UK, Sweden, Denmark, US, Canada, Japan, Australia, Switzerland, Norway, Hong Kong, Singapore, Korea).[30] For the time prior to the beginning of Stage 3 of Economic and Monetary Union "synthetic" historical time series were constructed by aggregating the data of the euro area countries (see e.g. Maeso-Fernandez/Osbat/Schnatz, 2001, for a detailed description and analysis). ***CHART 7*** shows real currency together with two of these exchange rate measures.

*Chart 7: Currency in circulation, real and nominal effective exchange rate of the euro**
(quarterly changes in currency in € billions and quarterly changes in the effective exchange rate in index points)



Source: ECB.

** In order to reduce noise, all series were smoothed with a Hodrick-Prescott filter with λ= 1600.*

- Shadow economy, hoarding

It is common to estimate the size of the shadow economy via a currency approach (see e.g. Schneider/Enste, 2000). In these approaches, it is usually assumed that the majority of payments in the shadow economy is settled with cash (see also the theoretical model above). This would mean that the development of the size of the shadow economy or of the most important causes of these activities over time should be considered as determinants of cash holdings (Dotsey, 1988).[31] The taxation of labour and capital income as well as fiscal controls of tax payments should be decisive factors in this respect (see also Section 2). Therefore we included the share of

[29] If the period in which foreign demand started is known, another possibility would be the introduction of a special dummy variable, see e.g. Hong Kong Monetary Authority, 1997, 4.

[30] Due to price rigidities the developments of the nominal and real exchange rates do not differ too much.

[31] In Switzerland, even the two-year tax assessment periods exerted a significant influence on the evolution of cash (Ettlin/Fluri, 1986). In Germany, the volatility of currency demand, inter alia due to uncertainties regarding the introduction of a withholding tax on interest income, led to the demise of the central bank money stock and its replacement as intermediate target variable by M3 in 1988.

taxes in GDP (*TY*) as a further potential determinant of currency demand (see e.g. Boeschoten, 1992, 127).[32]

These "bad behaviour" variables (Drehmann/Goodhart, 2000) may also include crime variables which unfortunately are, if at all, only available on an annual basis. The influence of the latter is theoretically ambiguous since criminals will probably use cash intensively, but the threat of mugging will deter cash holdings among law-abiding individuals. Furthermore, currency kept as a store of value may be expected to be interest rate sensitive. Possible multi-collinearity problems and the fact that a short-term interest rate already enters to capture the transactions and speculative motives recommends not to include a further interest rate variable.

- Further influences

Besides socio-economic factors, e.g. age, sex, education, urbanisation etc., which are studied in cross-sectional analyses (e.g. Boeschoten, 1998), there are also further economic variables worth mentioning. Trundle, 1982, suggests that unemployment should have an important negative influence on currency demand as the lower level of unemployment benefits as compared with past income might reduce the average demand for cash.[33] At the same time, this might already be captured in the transaction variable. However, the unemployment situation in connection with high total labour costs is quite often seen as a cause for the increase in the shadow economy (Schneider/Enste, 2000, 87). This would indicate a positive relation. Therefore we test the euro area unemployment rate (u) as an additional variable.

In addition to the nominal interest rate, which might be broken down into a real interest rate and expected inflation, actual inflation also reflects the cost of holding currency, as this reduces the value of financial assets in contrast with real assets (see Section 2). In line with Janssen, 1996, we try to solve the problem that it is not easy to identify the effects of inflation and interest rates on the demand for cash separately in including inflation variability (σ). Inflation variability is calculated as the standard deviation of CPI inflation over a rolling window of 4 years. Data availability constraints prevent us from evaluating and including other proposals, e.g. a financial wealth variable as a proxy for the precautionary demand for cash (Janssen, 1998) or the food spending share of total expenditures (Hoggart/Pill, 1992).

[32] We also experimented with splitting TY into the share of indirect and direct taxes in GDP.

[33] Using micro-data on British households, Benito's, 2002, results support the proposition that an increase in unemployment risk reduces consumption (and thus currency demand) significantly.

4.2 A cointegration analysis

We use a *VAR* approach to ultimately estimate a structural model of the demand for currency. First, this approach involves running stationarity tests (Augmented-Dickey-Fuller (*ADF*) and Phillips-Perron (*PP*) tests for the null of a unit root, the Kwiatkowski-Phillips-Schmidt-Shin (*KPSS*) test for the null of stationarity) to determine the order of integration of all variables. Second, we run unrestricted *VAR*s to select the lag order.[34] Finally, we estimate a Vector Error Correction model (*VECM*) where we use Johansen's maximum likelihood procedure (Johansen, 1995, 2000; Johansen/Juselius, 1990) to determine the number of cointegration vectors and to distinguish between the long-run relationships and the short-run dynamics. In order to identify the long-run relationships, tests on weak exogeneity are carried out.

We use quarterly data over the sample 1980.1 - 2001.2. The beginning of this sample is due to data availability. We stop our analysis in the middle of 2001 as currency figures for the second half of 2001 are more and more distorted by the approaching cash changeover (see on this point section 6). Except interest rates and exchange rates all series are seasonally adjusted.[35] Furthermore, all variables except the term spread and inflation variability are in logarithms.[36] The difference operator Δ refers to first (quarterly) differences. It is not necessary to introduce dummy variables for the beginning of Stage 3 of Economic and Monetary Union or the Y2K problem.

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[34] Cheung and Lai, 1993, show that in finite samples the standard model selection procedures are useful for choosing the right lag length for Johansen's tests in the presence of autoregressive processes. However, in the case of moving-average dependence, these criteria perform poorly in selecting the appropriate lag length. This is especially true in the case of under-parameterisation of the lag length.

[35] Inter alia, this implies that we disregard seasonal cointegration (see for this in the context of currency demand Bohl/Sell, 1998). But we checked whether the results are sensitive to the specific seasonal adjustment method used. Davidson/MacKinnon, 1993, 714, prove that unit root test statistics are biased against rejecting the null hypothesis when working with seasonally adjusted data. As nearly all our variables are clearly *I(1)* (see Annex 1) this reduces the severity of this problem. Furthermore, Ericsson/Hendry/Tran, 1994, show theoretically and empirically within the Johansen framework that the number of cointegrating vectors and the cointegrating vectors themselves are invariant to the use of seasonally adjusted or unadjusted data.

[36] Therefore, all coefficients are true elasticities. Regarding interest rates, this is not standard in empirical money demand models, which usually estimate interest rate semi-elasticities. However, the log-log specification enables us to derive interest rate semi-elasticities, which vary with the level of interest rates. Especially, the lower interest rates the higher the interest rate semi-elasticity in absolute terms. The change to a low inflation regime in some euro area countries during the nineties may as well as theoretical considerations justify this formulation (Janssen, 1998, 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. For the US, a double log specification exhibits sufficient curvature to track M1 velocity over the full range of observed nominal interest rates in the post war period (Hoffmann and Rasche, 1996).

Annex 1 shows the results of the three unit root tests.[37] For the *ADF* and *PP* tests, the lag, trend and constant selection followed the general-to-specific approach and visual inspection of the time series. Initially, we set the maximum lag number equal to four. The number of lags was reduced as long as the coefficient for the highest lag was significant at the 10 % level given that the residuals were still white noise. Neither the *ADF* nor the *PP* test is capable of distinguishing a stationary process around a linear trend from a process with a unit root and drift. A rejection of the unit root null is very unlikely in this case. In these instances we applied the strategy proposed by Dolado et al., 1990, for testing for unit roots in the presence of possible trends. The characterisations in the "*T*" cases are made after the imposition of this procedure. For the *KPSS* test we used the Bartlett kernel with the Newey-West bandwidth selection procedure.

Most of the variables appear to be *I(1)*, at least at the 5% significance level. One exception is the unemployment rate *u* (in percentage terms) which, according to the *ADF* test, is a borderline *I(0)* or *I(1)* variable. In the final specification below, we included the change in the unemployment rate as an exogenous unmodeled variable in the *VECM*.[38] Moreover, according to the *ADF* test, the small banknote series is *I(0)* in levels. For comparison purposes and as the other two tests reveal non-stationarity, we treat this variable as *I(1)* in the following estimations. And finally the *ADF*- and the *KPSS*-test indicate that the term spread *sp* is stationary. As it should be so theoretically, we included sp as a possible exogenous *I(0)*-variable in the short-run dynamics.

Given the non-stationarity of most variables, cointegration techniques as suggested by Johansen, 1995, are employed. This approach enables the detection of long-run equilibrium relationships between variables. The starting point of this methodology is a vector error correction model of the following type

$$(11) \qquad \Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + B x_t + \mu + \varepsilon_t ,$$

where y_t is a *(nx1)* vector of the *n I(1)* variables considered, x_t is a *(mx1)* vector of exogenous variables, μ is a *(nx1)* vector of constants, Γ_i represents *(nxn)* matrices of short-run coefficients, Π is a *(nxn)* coefficient matrix, *B* is a matrix of the exogenous parameters, *k* is the lag order of the VAR and ε_t is a vector of white noise residuals. Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r < n$, then there exist *(nxr)* matrices α (the loading

[37] The table also reveals the fact that the checking of the null hypothesis with this test has low power against the alternative. For a discussion of different unit root tests and their problems see Mills, 1999, 64-99.

[38] Elliott, 1998, demonstrates that whilst point estimates of cointegrating vectors remain consistent, commonly applied hypothesis tests no longer have the usual distribution when roots are near but not one. By constrast, hypothesis tests on general restrictions on the cointegration relationship are unaffected by the presence of near unit root variables not included in the restriction.

coefficients or adjustment parameters) and ß (the cointegrating vectors) each with rank *r* (the number of cointegration relations or the cointegrating rank) such that $\Pi = \alpha ß'$ and $ß' y_t$ is *I(0)*.

The final aim of this procedure is to identify a statistically significant currency demand equation. The coefficients of this equation should individually be significant and should have the theoretically expected signs.

4.2.1 Overall Currency Demand

The chosen cointegration specification for the overall demand for euro legacy currencies assumes a linear trend in the data in that an unrestricted constant is included.[39] This specification may also have an economic meaning as it may capture the effects of financial innovation on currency holdings (via the trend in all the variables included). After pretesting according to the requirements mentioned in the last paragraph of the previous subsection, we selected four variables to enter the cointegrating space: real currency holdings (*cur*), real private consumption expenditures (*c*), the 3-month money market rate (calculated with the German money market rate before 1999) (*i3*) and the real effective exchange rate of the euro (*e*).[40] Furthermore, as mentioned above, we included the change in the unemployment rate (*u*) as an exogenous unmodeled variable in the system of equations.

The first step is then to test the number of lags to be included in the *VECM*. We did this according to five lag order selection criteria: the sequential modified LR test (*LR*), the final prediction error (*FPE*), the Akaike (*AIC*), the Schwarz (*SC*) and the Hannan-Quinn (*HQ*) criterion (Lütkepohl, 1993, ch. 4.3). The criteria yield ambiguous results (see ***TABLE 6***). The first three select a lag length of 3 while the two others indicate 2 lags. Mills, 1999, 36, shows that although theoretically the *SC* has advantages over the *AIC*, it would seem that the latter selects the preferred model on more general grounds. Finally, χ^2(Wald)-lag exclusion tests in the *VECM*, the multivariate Portmanteau test for autocorrelation and the multivariate residual autocorrelation *LM* test suggest that 3 lags in levels (2 lags in first differences) should be included. This lag length is enough to ensure uncorrelated residuals.[41]

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[39] Snellman et al., 2000, find that approximating financial innovation for European countries via a linear trend captures almost the same effect as using more direct measures like the number of EFTPOS terminals.

[40] Somewhat surprisingly, we get slightly poorer statistical results with the own rate of return of overnight deposits instead of the 3-month money market rate. This might be due to the specific construction of the series, especially in the 1980s (see for details Calza et al., 2001).

[41] This latter selection criterion is also suggested and applied in Johansen, 1995. Both underestimating and overestimating the number of lags in higher dimensional systems and short samples within the Johansen framework seem to lead to underestimation of the number of unit roots (Ho/Sørensen, 1996).

Table 6: VAR lag order selection for overall currency holdings

Sample: 1980:1 2001:2
Included observations: 82

Lag	LogL	LR	FPE	AIC	SC	HQ
0	292.08	NA	1.27E-08	-6.831227	-6.479024	-6.689823
1	881.75	1078.660	1.07E-14	-20.82312	-20.00131	-20.49317
2	917.45	61.82468	6.62E-15	-21.30364	-20.01223*	-20.78516*
3	936.02	30.34843*	6.28E-15*	-21.36636*	-19.60535	-20.65934
4	946.40	15.94897	7.33E-15	-21.22928	-18.99866	-20.33372

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic; *FPE*: Final prediction error; *AIC*: Akaike information criterion; *SC*: Schwarz information criterion; *HQ*: Hannan-Quinn information criterion.

As a next step the number of cointegration relations has to be determined. This is decided on the basis of Johansen's lambda and trace statistics (see *Table 7*). These test statistics suffer from a small sample bias tending to reject the null of no cointegration too often. Therefore, we corrected the test statistics by the factor *(n-mk)/n*, where n is the number of observations, m the number of variables and k the number of lags, as suggested by Reimers, 1991.[42] Both test statistics strongly suggest the existence of only one cointegrating vector among the variables. This fact is taken into account when specifying and estimating the *VECM*.[43]

Table 7: Johansen's cointegration tests for overall currency holdings

Hypothesized no. of CE(s)	Eigenvalue	Adj. trace statistic	5 percent critical value	1 percent critical value	Adj. max. eigenvalue statistic	5 percent critical value	1 percent critical value
None **	0.43	55.43	47.21	54.46	39.58	27.07	32.24
At most 1	0.12	15.85	29.68	35.65	9.18	20.97	25.52
At most 2	0.07	6.67	15.41	20.04	5.47	14.07	18.63
At most 3	0.02	1.20	3.76	6.65	1.20	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level.
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels.
Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels.

The system of equations resulting from the *VECM* (with the cointegrating vector normalized on real currency holdings) reads as (absolute t-values in brackets below the coefficients)[44]

[42] An alternative would be to adjust the critical values, see Cheung/Lai, 1993. As they use an analogous correction to that of Reimers, 1991, the results are in any case qualitatively the same.

[43] The cointegration relation would break down if we only look at the set (*cur, c*) or (*cur, c, i3*).

[44] Including the *level* of the unemployment rate in the *cointegration* relationship would result in an insignificant long-run coefficient. If, on the other hand, the *level* of the unemployment rate is included as an *exogenous* variable in the dynamic part, a long-run currency demand equation could not be identified. Instead a theoretically rather implausible consumption equation would result. Therefore, we prefer the chosen specification.

$$\Delta cur_t = \underset{(5.7)}{-0.10}(cur - \underset{(26.8)}{1.05}\,c + \underset{(2.2)}{0.04}\,i3 - \underset{(6.0)}{0.41}\,e + 8.06)_{t-1} + \underset{(3.6)}{0.40}\,\Delta cur_{t-1} + \underset{(0.8)}{0.08}\,\Delta cur_{t-2}$$

$$(12) \qquad - \underset{(3.2)}{0.39}\,\Delta c_{t-1} - \underset{(2.0)}{0.26}\,\Delta c_{t-2} - \underset{(1.7)}{0.01}\,\Delta i3_{t-1} - \underset{(0.6)}{0.00}\,\Delta i3_{t-2} - \underset{(0.6)}{0.02}\,\Delta e_{t-1} - \underset{(1.6)}{0.04}\,\Delta e_{t-2}$$

$$- \underset{(3.8)}{0.02}\,\Delta u_t + \underset{(2.0)}{0.01}\,\Delta u_{t-1} + \underset{(3.7)}{0.01} + \varepsilon_{cur,t}$$

$$\Delta c_t = \underset{(2.9)}{-0.05}(cur - \underset{(26.8)}{1.05}\,c + \underset{(2.2)}{0.04}\,i3 - \underset{(6.0)}{0.41}\,e + 8.06)_{t-1} - \underset{(0.3)}{0.03}\,\Delta cur_{t-1} - \underset{(0.8)}{0.07}\,\Delta cur_{t-2}$$

$$(13) \qquad - \underset{(3.1)}{0.36}\,\Delta c_{t-1} - \underset{(2.5)}{0.32}\,\Delta c_{t-2} + \underset{(0.8)}{0.01}\,\Delta i3_{t-1} + \underset{(0.1)}{0.00}\,\Delta i3_{t-2} + \underset{(2.1)}{0.05}\,\Delta e_{t-1} - \underset{(2.8)}{0.07}\,\Delta e_{t-2}$$

$$- \underset{(2.9)}{0.01}\,\Delta u_t + \underset{(1.3)}{0.01}\,\Delta u_{t-1} + \underset{(7.4)}{0.01} + \varepsilon_{c,t}$$

$$\Delta i3_t = \underset{(0.9)}{-0.27}(cur - \underset{(26.8)}{1.05}\,c + \underset{(2.2)}{0.04}\,i3 - \underset{(6.0)}{0.41}\,e + 8.06)_{t-1} - \underset{(0.4)}{0.67}\,\Delta cur_{t-1} + \underset{(0.8)}{1.29}\,\Delta cur_{t-2}$$

$$(14) \qquad - \underset{(0.1)}{0.11}\,\Delta c_{t-1} + \underset{(0.1)}{0.17}\,\Delta c_{t-2} + \underset{(1.4)}{0.16}\,\Delta i3_{t-1} - \underset{(0.6)}{0.06}\,\Delta i3_{t-2} - \underset{(2.5)}{0.98}\,\Delta e_{t-1} - \underset{(1.6)}{0.71}\,\Delta e_{t-2}$$

$$- \underset{(0.4)}{0.03}\,\Delta u_t - \underset{(1.9)}{0.13}\,\Delta u_{t-1} - \underset{(0.5)}{0.01} + \varepsilon_{i,t}$$

$$\Delta e_t = \underset{(1.0)}{0.10}(cur - \underset{(26.8)}{1.05}\,c + \underset{(2.2)}{0.04}\,i3 - \underset{(6.0)}{0.41}\,e + 8.06)_{t-1} + \underset{(0.2)}{0.11}\,\Delta cur_{t-1} + \underset{(0.2)}{0.09}\,\Delta cur_{t-2}$$

$$(15) \qquad + \underset{(0.1)}{0.09}\,\Delta c_{t-1} + \underset{(1.3)}{0.95}\,\Delta c_{t-2} + \underset{(1.1)}{0.04}\,\Delta i3_{t-1} - \underset{(0.2)}{0.01}\,\Delta i3_{t-2} + \underset{(2.8)}{0.38}\,\Delta e_{t-1} + \underset{(0.5)}{0.07}\,\Delta e_{t-2}$$

$$- \underset{(0.6)}{0.03}\,\Delta u_t - \underset{(0.3)}{0.01}\,\Delta u_{t-1} - \underset{(1.0)}{0.01} + \varepsilon_{e,t}$$

Some general and equation specific test statistics may be found in ***TABLE 8***.

Table 8: Test statistics for the system (12) – (15)

General		Equation specific	Eq 12	Eq 13	Eq 14	Eq 15
White	0.42	R^2	0.66	0.30	0.26	0.02
JB	0.004	SE	0.005	0.005	0.08	0.03
Lag exclusion (1,2,3)	0.00	SSR	0.002	0.002	0.50	0.06
LM(4)	0.45					
Port(12)	0.75					
W.E. (cur)	0.00					
W.E. (c)	0.004					
W.E. (i3)	0.36					
W.E. (e)	0.32					

Notes: In "General" the numbers indicate the p-values of the respective null hypothesis. White: White's test for heteroskedasticity for systems (using cross terms); JB: Multivariate extension of the Jarque Bera residual normality test with the factorisation chosen according to the inverse square root of the residual correlation matrix; Lag exclusion: χ^2-statistic for the joint significance of all endogenous variables at the specified lags in the whole system; LM(4): Multivariate LM test statistic for residual serial correlation at lag 4; Port(12): Multivariate Box-Pierce/Ljung-Box Q-statistic for residual serial correlation up to lag 12 with small sample correction (Portmanteau Autocorrelation Test); W.E. (x): Test of weak exogeneity of variable x. R^2: Adjusted coefficient of determination; SE: Standard error of regression; SSR: Sum of squared residuals.

The derived cointegration relationship is

$$(16) \qquad cur_t = -8.06 + 1.05c_t - 0.04i3_t + 0.41e_t$$

All coefficients show the theoretically expected signs. The transactions elasticity is above unity. This may be rationalised by other motives besides transactions motives influencing currency demand. However, the restriction that it is 1 cannot be rejected at conventional significance levels as indicated by a Likelihood Ratio test ($\chi^2(1)=1.11$, p-value = 0.29).[45] Increased domestic opportunity costs lead to a reduction in real currency holdings. The coefficient of –0.04 is a true elasticity. Consequently, the semi-elasticity increases with lower interest rates.[46] An appreciation of the real effective exchange rate of the euro by 1 percent leads to an increase in real currency holdings by 0.4 percent. This should reflect foreign influences on the demand for euro area currencies in the form of "currency substitution" or "euroisation". The highly significant error correction term (compared with the non-standard critical values tabulated in Banerjee et al., 1998) in equation (12) reassures that the long-run relation may be interpreted as a currency demand equation. But the adjustment to the long-run equilibrium is rather slow: only 10 percent of the disequilibrium is corrected in one quarter. Weak exogeneity tests present further evidence on the nature of the cointegrating vector (see ***TABLE 8***). The exchange rate and the interest rate are clearly weakly exogenous, but real currency holdings and real private consumption are not. Theoretically, the latter could make sense if above equilibrium currency holdings do not only lead to a reduction in currency demand but also to increased consumption. But the empirical evidence invalidates this interpretation as the error correction coefficient in (13) is negative. Moreover, it is not significant according to the critical values in Banerjee et al., 1998. Therefore it seems that there is enough evidence as to interpret the cointegrating vector as a currency demand equation. This is why we concentrate on this equation in what follows.

Overall, the statistical fit of the system of equations is rather satisfactory. There are no hints of heteroskedasticity and serial correlation. In contrast, the Jarque Bera test statistic indicates a possible non-normality of the residuals. As cointegration theory is asymptotically valid under the *i.i.d.* assumption of the innovations this result should not be too serious a problem. In the currency equation (12) about two thirds of the variance of real currency holdings is explained. The cointegration vector is shown in ***CHART 8***:

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[45] In his analysis of euro area M1, Stracca, 2001, found an income elasticity clearly below unity. Together with our results for currency this would imply that overnight deposits are primarily held for transactions purposes while cash balances also satisfy other motives.

[46] See Stracca, 2001, for alternative ways to model an interest rate elasticity for M1 that decreases in size with the level of the interest rates.

Chart 8: The cointegration relation

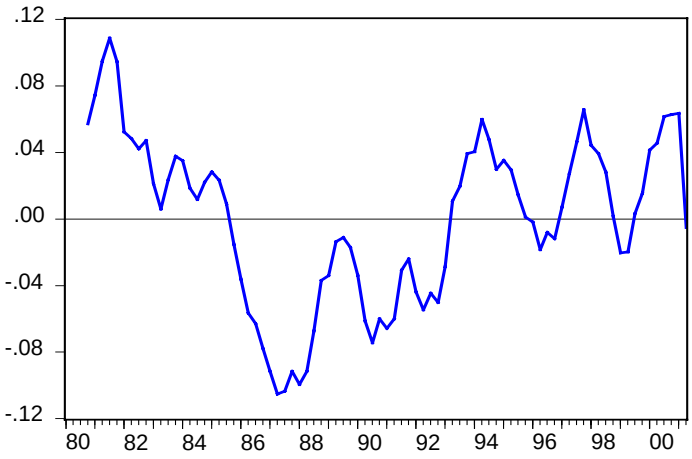


CHART 9 presents the recursive error correction term of equation 12 (*ECT*) and the recursive long-run coefficients with the 2 standard error bands from 1995 to 2001. All the coefficients exhibit a reasonably stable development with the exchange rate coefficient slightly increasing in the last years of the sample. Moreover, ***CHART 10*** shows that according to the recursive residuals and a *CUSUM* test the identified cointegrating vector is well behaved. At the end of the sample the recursive residuals reveal signs of instability.[47] This is not surprising against the background of the approaching cash changeover of the euro legacy currencies against the euro at the beginning of 2002. Having this in mind and taking into account the highly significant error correction term, the evolution of currency does not seem to be suggestive to permanent instabilities. If the decrease in currency holdings in 2001 is reversed, only a temporary instability would result. If, however, the currency relations concerning the euro differ permanently from those of the sum of the national euro area currencies due to the introduction of euro notes and coins, a clear structural break would be detected. This may occur, for instance, if foreign demand for euro evolves only slowly or if the demand for domestic cash transaction balances changes.

[47] Inclusion of a dummy variable in the short-run dynamics which is zero until the end of 1999 and one afterwards would show up with a significant negative sign without changing the other conclusions qualitatively.

Chart 9: Recursive coefficients of the long-run currency demand equation

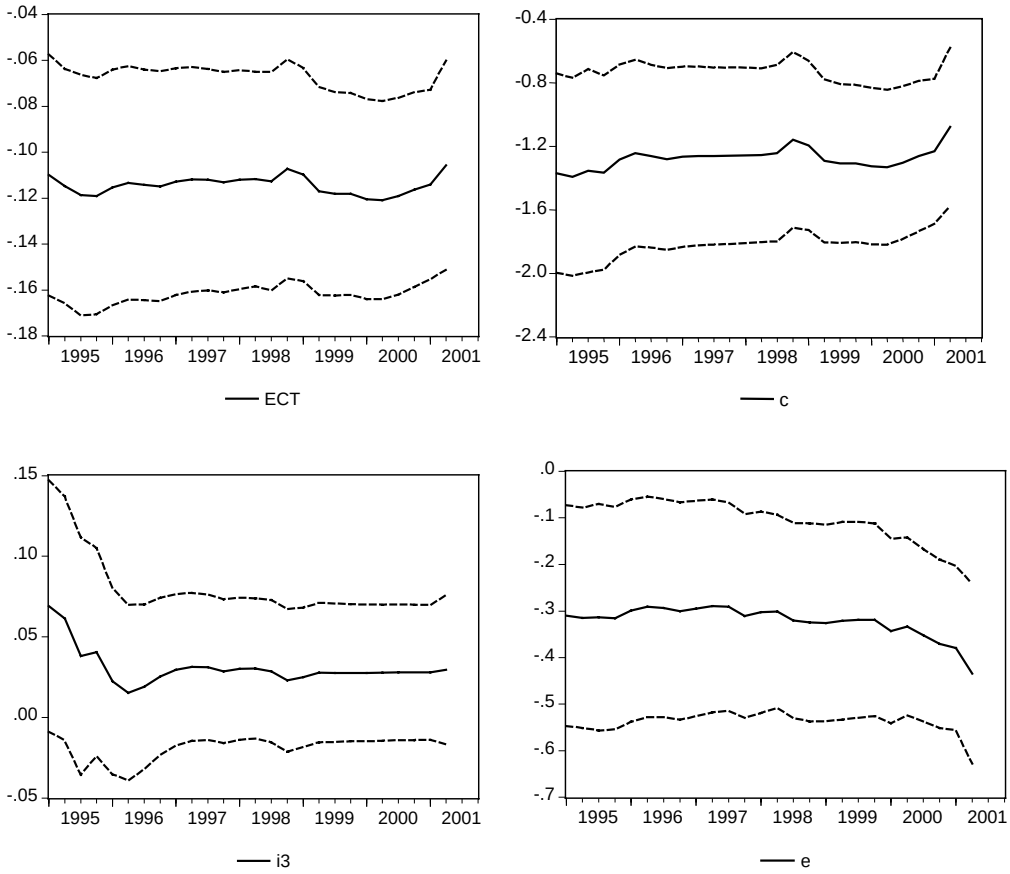
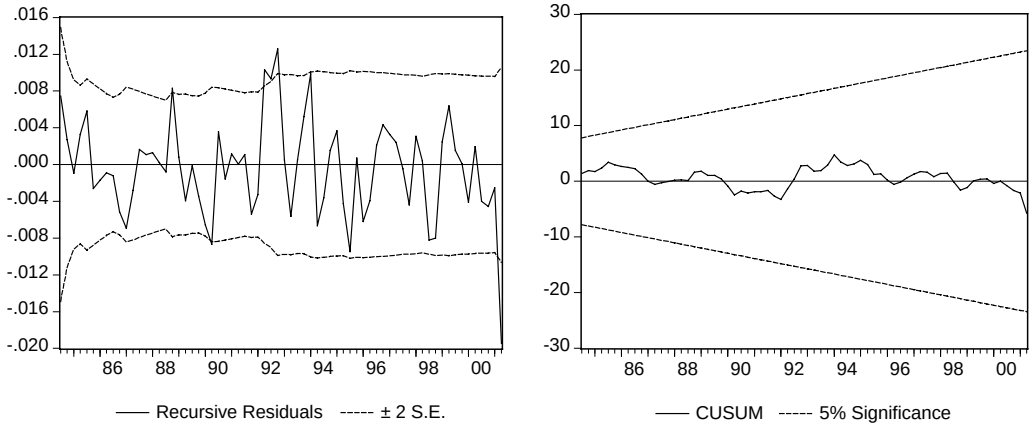


Chart 10: Stability tests



We do not intend to go too much into the details of the short-run dynamics. Just some remarks. In the dynamic currency equation (12) currency holdings depend negatively on real private consumption. The sum of the 2 coefficients is –0.65. Such a negative dependence is not uncommon in empirical analyses of narrow monetary aggregates (see e.g. Seitz, 1998, Stracca, 2001). It may be interpreted as a kind of buffer in the sense of a precautionary motive for holding cash. Hoarding and foreign demand, if not fully captured by our approach, may also rationalise the negative coefficient if in situations with rising private consumption real balances used for

hoarding and abroad decrease. It is also well known that consumption is closely related to permanent income. In the case of temporary income shocks, savings, which usually do not include cash holdings, would vary in the same direction. Furthermore, it may be the case that (unexpected) fluctuations in transactions are more absorbed by variations in demand deposits than by currency. The much larger standard deviation of quarterly changes in demand deposits compared to that of cash points in this direction. The observation of a counter-cyclical element in currency holdings which may be related to changes in expenditure patterns (Hoggarth/Pill, 1992) may also rationalise the negative short-term relationship between currency and real private consumption. In particular, during downturns, non-essential, larger value expenditures (mainly financed by non-cash payments) tend to be reduced the most, whereas necessary, typically smaller-value purchases (mainly financed by cash) are maintained.[48]

The second remark refers to unemployment. Taking the coefficients on the two terms together, an increase in the unemployment rate causes currency holdings to decrease (a Wald test rejects the null that the sum of the 2 coefficients is zero). This means that the shadow economy explanation of the inclusion of the unemployment rate in currency demand equations has to be discarded and that rather the lower income resulting from unemployment probably plays a role in the demand for currency.

As all other variables discussed above do not help to explain the evolution of currency in the euro area, do not change the long-run currency demand equation or the number of cointegration relations, there is only weak evidence of a relation between the size of the shadow economy and currency holdings in the euro area as a whole.[49] But keep in mind that an influence of financial innovation cannot be ruled out due to the specification of the *VECM* with a linear trend in the data. As the constant enters the long run equation with a negative sign, this interpretation of financial innovation would imply a downward trend in currency in circulation.

4.2.2 The demand for small-value and large-value banknotes

In what follows we present the results of the estimation of the demand for small and large-value banknotes. We apply the same procedure as with overall currency demand. The denominational split was chosen according to a country-by-country investigation as described in Section 2. As

[48] Hoggarth and Pill, 1992, test this hypothesis explicitly by incorporating the ratio of food spending to total expenditures in the currency demand equation.

[49] The fact that the tax ratio exerts no significant influence on overall currency holdings may be due to an aggregation bias, the poor indicator properties of this series for the size of the underground economy or the inclusion of Germany whose currency is known to be heavily demanded abroad (see for an analogous result Drehmann et al., 2002).

we classified some denominations as "neutral" which were not included in the estimations, the results cannot be directly compared with those for overall currency demand. If the demand for large value notes is different from the demand for the small denominations this should be reflected in either different coefficients on the same variables or different variables determining the demand functions.

Let us first concentrate on the small denominations (*smallr*). As for the whole currency holdings the cointegration space assumes a linear trend in the data in that an unrestricted constant is included. After pre-testing there are only two variables which seem to explain the evolution of small denominations over time: the transactions variable real private consumption (*c*) and the term spread (*sp*) which enters the short-run dynamic specification.[50] Thus it seems that the opportunity costs for the small denominations are best captured by the whole term structure, as suggested by Friedman (1977). All other potential determinants discussed above either have the wrong sign, are not significant or their inclusion deteriorates the statistical properties of the model.

The five lag length criteria unanimously suggest a lag order of one in levels (see ***TABLE 9***). This lag length is therefore assumed in the following cointegration analysis. Together with the fact that only 3 variables enter the system this results in a very parsimonious model.

Table 9: Lag order selection for small denominations

Included observations: 82						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-286.46	NA	3.90	7.04	7.09	7.06
1	581.37	1672.17*	2.76E-09*	-14.03*	-13.86*	-13.96*
2	584.36	5.61	2.83E-09	-14.01	-13.72	-13.89
3	584.80	0.81	3.08E-09	-13.92	-13.51	-13.76
4	585.66	1.53	3.33E-09	-13.85	-13.32	-13.63

* indicates lag order selected by the criterion (each test at 5% level)
LR: sequential modified LR test statistic; *FPE*: Final prediction error; *AIC*: Akaike information criterion;
SC: Schwarz information criterion; *HQ*: Hannan-Quinn information criterion.

The number of cointegration relations is again determined according to Johansen's lambda and trace statistics (see ***TABLE 10***) where the small sample adjustment of the test statistics according to Reimers (1991) has been applied. Both adjusted test statistics suggest one cointegration equation at the 1%- and 5%-level.

[50] Including the change in the unemployment rate as a further (and significant) exogenous variable would drastically deteriorate the statistical fit of the model.

Table 10: Johansen's cointegration tests for small denominations

Hypothesized no. of CE(s)	Eigenvalue	Adj. trace statistic	5 percent critical value	1 percent critical value	Adj. max. eigenvalue statistic	5 percent critical value	1 percent critical value
None **	0.49	58.19	15.41	20.04	55.56	38.80	18.63
At most 1	0.03	2.64	3.76	6.65	2.64	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5% (1%) level.
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels.
Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels.

The Vector Error Correction Model with the cointegrating vector normalised on real holdings of small denomination bills reads as (absolute t-values in brackets below the coefficients):

$$(17) \qquad \Delta smallr_t = \underset{(8.5)}{-0.04}(smallr - \underset{(2.7)}{0.44}c + 0.42)_{t-1} - \underset{(2.8)}{0.002}\, sp_t - \underset{(4.0)}{0.001} + \varepsilon_{smallr,t}$$

$$(18) \qquad \Delta c_t = \underset{(2.2)}{-0.01}(cur - \underset{(2.7)}{0.44}c + 0.42)_{t-1} + \underset{(0.9)}{0.00}\, sp_t + \underset{(6.4)}{0.00} + \varepsilon_{c,t}$$

Some test statistics for this two-equation system are shown in *Table 11*.

Table 11: Test statistics for the system (17) – (18)

General		Equation specific	Eq 17	Eq 18
White	0.71	R^2	0.45	0.06
JB	0.00	SE	0.009	0.006
Lag exclusion (1)	0.00	SSR	0.006	0.003
LM(4)	0.002			
Port(12)	0.14			
W.E. (smallr)	0.00			
W.E. (c)	0.03			

Notes: In "General" the numbers indicate the p-values of the respective null hypothesis. White: White's test for heteroskedasticity for systems (using cross terms); JB: Multivariate extension of the Jarque Bera residual normality test with the factorisation chosen according to the inverse square root of the residual correlation matrix; Lag exclusion: χ^2-statistic for the joint significance of all endogenous variables at the specified lags in the whole system; LM(4): Multivariate LM test statistic for residual serial correlation at lag 4; Port(12): Multivariate Box-Pierce/Ljung-Box Q-statistic for residual serial correlation up to lag 12 with small sample correction (Portmanteau Autocorrelation Test); W.E. (x): Test of weak exogeneity of variable x. R^2: Adjusted coefficient of determination; SE: Standard error of regression; SSR: Sum of squared residuals.

The derived cointegration relationship is

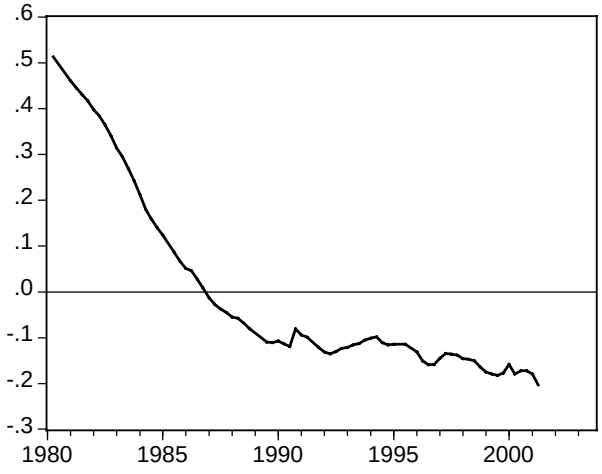
$$(19) \qquad smallr_t = -0.42 + 0.44c_t$$

All coefficients show the theoretically expected signs. The transaction elasticity is 0.44. This is in line with the famous "square root law" in the Baumol-Tobin model, which implies a

transaction elasticity of 0.5.[51] But the *VEC* restriction that this elasticity is 1 cannot be rejected according to a Likelihood Ratio test ($\chi^2(1)=1.44$, p-value = 0.23). An increase in the term spread leads to a reduction in the demand for small denominations. Thus, Friedman's, 1977, result that higher long-term rates together with lower short-term rates, i.e. a steepening of the yield curve (with an unchanged mean), reduces cash balances seems to be relevant for the euro area. An increase in the spread by one percentage point reduces these holdings by 0.002 percentages. The highly significant error correction term (compared with the non-standard critical values tabulated in Banerjee et al., 1998) in equation (17) reassures that the long-run relation may be interpreted as a currency demand equation. But the adjustment to long-run equilibrium is even slower than for overall currency holdings: only 4 percent of disequilibria are corrected in one quarter. Weak exogeneity tests present further evidence on the nature of the cointegrating vector (see *Table 11*). Real holdings of small denominations are unambiguously endogenous, but real private consumption is weakly exogenous only at the 1 % level of significance. As, once again, a meaningful economic interpretation of the long-run consumption equation is not possible and the error correction coefficient in equation (18) is not significant, it seems that there is enough evidence as to interpret the cointegrating vector as a demand equation for small denomination bills. Overall, the statistical fit of the system of equations is not too bad. In the cash equation (17) about one half of the variance of real holdings of small denominations is explained.

The resulting cointegration vector is shown in ***CHART 11***. It shows the difficulties of establishing a long-run relation for a variable, which decreases sharply for a certain time period and then fluctuates around a low level. Estimating a model with such a time series over the whole time span introduces a "bias" via a low adjustment to disequilibria, a tendency to work more and more with a near-stationary variable and the danger to reach the long-run solution only once.

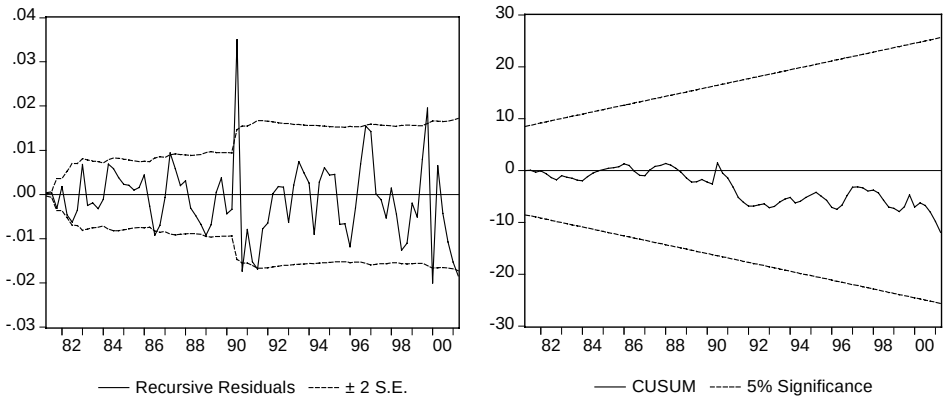
Chart 11: The cointegration relation for small denominations



[51] See for a recent extension of this model in the context of currency demand Attanasio et al., 2002, ch. III.

Nonetheless, ***CHART 12*** shows that according to the recursive residuals and a *CUSUM* test the identified cointegrating vector is well behaved. The stabilisation of holdings of small denominations at the end of the 80s shows up as a one-time breakpoint in the recursive residuals. There are no such clear-cut signs of instability at the end of the sample as in the case of overall currency demand.

Chart 12: Stability tests for small denominations



Let us now turn to the large-value banknotes. After pretesting, we selected four variables to enter the cointegrating space: real holdings of large denomination bills (*bigr*), the interest rate on overnight deposits (*iod*), the real effective euro exchange rate (*e*) and the volatility of inflation (σ) calculated as the standard deviation of the consumer price index in euro area countries over a 4 year rolling window (all in logarithms). The inclusion of the latter variable leads to an adjustment of the sample which now starts in 1985 Q1. This specification implies that a transactions variable does not influence the holdings of large denominations. This influence stems mainly from the small denominations.[52]

Table 12 shows the results of the five lag order selection criteria. Four criteria suggest a lag order of 2 in levels, the *AIC* a lag order of 3. As, according to a multivariate *LM* test, there is no residual correlation with lag 2, we decided to work with this lag specification.

Table 12: VAR lag order selection for large denominations

Included observations: 62

Lag	LogL	LR	FPE	AIC	SC	HQ
0	117.19	NA	3.05E-07	-3.65	-3.51	-3.60
1	526.36	752.35	9.48E-13	-16.33	-15.65	-16.06
2	571.94	77.92*	3.68E-13*	-17.29	-16.05*	-16.80*
3	588.12	25.57	3.72E-13	-17.29*	-15.51	-16.59
4	602.36	20.67	4.06E-13	-17.24	-14.90	-16.32

* indicates lag order selected by the criterion (each test at 5% level)
LR: sequential modified LR test statistic; *FPE*: Final prediction error; *AIC*: Akaike information criterion; *SC*: Schwarz information criterion; *HQ*: Hannan-Quinn information criterion.

[52] But keep in mind that we excluded in the classification of the banknotes into small and large-value notes those banknotes, which are likely to be used for both transactions and hoarding purposes (see Section 2).

The determination of the number of cointegration relations is pursued in *Table 13*. The Reimers-adjusted trace and max. eigenvalue statistics both suggest one cointegrating equation at the 5%- and 1%- level. As in the other two cases, the cointegration tests assume an intercept in the cointegration equation and the test *VAR*, i.e. they allow for a linear deterministic trend in the data.

Table 13: Johansen's cointegration tests for holdings of large denominations

Hypothesized no. of CE(s)	Eigenvalue	Adj. trace statistic	5 percent critical value	1 percent critical value	Adj. max. eigenvalue statistic	5 percent critical value	1 percent critical value
None **	0.40	57.07	47.21	54.46	28.90	27.07	32.24
At most 1	0.24	15.85	29.68	35.65	15.01	20.97	25.52
At most 2	0.18	6.67	15.41	20.04	10.93	14.07	18.63
At most 3	0.04	1.20	3.76	6.65	1.20	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5% (1%) level.
Trace test and max-eigenvalue test indicate 1 cointegrating equation(s) at both 5% and 1% levels.

Equations (20) – (23) summarise the *VECM*. The cointegrating vector is normalised on holdings of large denominations. T-values appear in absolute form in brackets below the coefficients. Further test statistics are shown in *Table 14*.

$$\Delta bigr_t = \underset{(4.3)}{-0.06}(bigr + \underset{(3.5)}{0.11}iod - \underset{(1.6)}{0.32}e + \underset{(7.3)}{0.21}\sigma - 6.20)_{t-1} + \underset{(2.6)}{0.34}\Delta bigr_{t-1} - \underset{(0.4)}{0.01}\Delta iod_{t-1} - \underset{(1.6)}{0.06}\Delta e_{t-1} - \underset{(0.2)}{0.00}\Delta\sigma_{t-1} + \underset{(3.9)}{0.01} + \varepsilon_{bigr,t} \quad (20)$$

$$\Delta iod_t = \underset{(0.3)}{0.03}(bigr + \underset{(3.5)}{0.11}iod - \underset{(1.6)}{0.32}e + \underset{(7.3)}{0.21}\sigma - 6.20)_{t-1} + \underset{(1.0)}{1.22}\Delta bigr_{t-1} + \underset{(4.3)}{0.53}\Delta iod_{t-1} - \underset{(1.0)}{0.40}\Delta e_{t-1} + \underset{(0.6)}{0.08}\Delta\sigma_{t-1} - \underset{(1.2)}{0.02} + \varepsilon_{iod,t} \quad (21)$$

$$\Delta e_t = \underset{(3.2)}{-0.15}(bigr + \underset{(3.5)}{0.11}iod - \underset{(1.6)}{0.32}e + \underset{(7.3)}{0.21}\sigma - 6.20)_{t-1} - \underset{(2.6)}{1.19}\Delta bigr_{t-1} + \underset{(0.7)}{0.03}\Delta iod_{t-1} + \underset{(0.2)}{0.03}\Delta e_{t-1} + \underset{(0.5)}{0.03}\Delta\sigma_{t-1} + \underset{(2.3)}{0.02} + \varepsilon_{e,t} \quad (22)$$

$$\Delta\sigma_t = \underset{(0.0)}{-0.00}(bigr + \underset{(3.5)}{0.11}iod - \underset{(1.6)}{0.32}e + \underset{(7.3)}{0.21}\sigma - 6.20)_{t-1} - \underset{(1.5)}{1.17}\Delta bigr_{t-1} - \underset{(1.5)}{0.11}\Delta iod_{t-1} + \underset{(1.2)}{0.29}\Delta e_{t-1} + \underset{(7.2)}{0.66}\Delta\sigma_{t-1} + \underset{(0.5)}{0.01} + \varepsilon_{\sigma,t} \quad (23)$$

Table 14: Test statistics for the system (20) – (23)

General		Equation specific	Eq 20	Eq 21	Eq 22	Eq 23
White	0.00	R^2	0.51	0.22	0.16	0.58
JB	0.00	SE	0.007	0.07	0.03	0.04
Lag exclusion (1,2)	0.00	SSR	0.003	0.29	0.04	0.11
LM(4)	0.20					
Port(12)	0.22					
W.E. (bigr)	0.00					
W.E. (iod)	0.79					
W.E. (e)	0.02					
W.E. (σ)	0.98					

Notes: In "General" the numbers indicate the p-values of the respective null hypothesis. White: White's test for heteroskedasticity for systems (using cross terms); JB: Multivariate extension of the Jarque Bera residual normality test with the factorisation chosen according to the inverse square root of the residual correlation matrix; Lag exclusion: χ^2-statistic for the joint significance of all endogenous variables at the specified lags in the whole system; LM(4): Multivariate LM test statistic for residual serial correlation at lag 4; Port(12): Multivariate Box-Pierce/Ljung-Box Q-statistic for residual serial correlation up to lag 12 with small sample correction (Portmanteau Autocorrelation Test); W.E. (x): Test of weak exogeneity of variable x. R^2: Adjusted coefficient of determination; SE: Standard error of regression; SSR: Sum of squared residuals.

The cointegration relation reads as

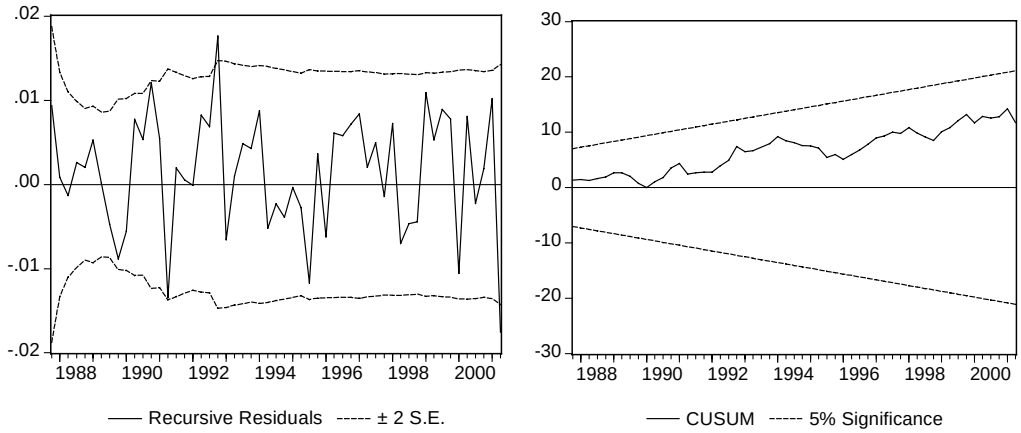
$$(24) \qquad bigr_t = 6.20 - 0.11 iod_t + 0.32 e_t - 0.21 \sigma_t$$

Once again, all the long-run coefficients have the theoretically expected signs. An appreciation of the euro legacy currencies causes the demand for large denominations to rise. An increase in the volatility of inflation by one percentage point decreases this demand by 0.2 percentages. And an increase in domestic opportunity costs, measured by the own rate of return of overnight deposits, reduces holdings of large denomination notes by 0.1 percentages. Again, this is a true elasticity which means that the semi-elasticity increases with lower interest rates.

The significant error correction term in equation (20) reassures that the long-run relation may be interpreted as a demand equation for large denomination bills. As for overall currency demand and the demand for small denominations the adjustment to long-run equilibrium is rather slow: only 6 percent of disequilibria are corrected in one quarter. The exogeneity tests presented in *Table 14* show that σ and *iod* are obviously weakly exogenous; *bigr* is clearly not and *e* only so at the 1% level of significance. Together with a meaningful economic interpretation this leads us to interpret the cointegrating vector as a demand equation for large denomination bills. Overall, the statistical fit of the system of equations is rather good. In the cash equation (20) slightly more than half of the variance of real holdings of large denominations is explained.

CHART 13 shows that according to the recursive residuals and a *CUSUM* test the identified cointegrating vector is well behaved. There are some signs of instability at the end of the sample as in the case of overall currency demand. But this is not too surprising against the background of the cash changeover.

Chart 13: Stability tests for large denominations



Overall, the results of the estimation of currency demand within a *VECM* show that there seems to be a foreign influence stemming mainly from the large denominations. Furthermore, domestic transactions predominantly influence the demand for small denominations. Thus, there are obviously differences in the motives for holding large and small denomination notes. Although there are no direct variables representing financial innovation, the specification of the *VECM* with a linear time trend in the data suggests that there may be such an influence on overall currency holdings and holdings of small denominations.

5. Estimating currency used for domestic transactions and the demand by non-residents

"In agricultural countries where peasants readily hoard money, an inflation, especially in its early stages, does not raise prices proportionately, because when, as a result of a certain rise in the price of agricultural products, more money flows into the pockets of the peasants, it tends to stick there;-deeming themselves that much richer, the peasants increase the proportion of their receipts that they hoard." (J.M. Keynes, 1924, 81)

The stock of currency used for domestic transactions is not directly known as some portion is held for hoarding purposes or outside the euro area (e.g. Seitz, 1995, Rogoff, 1998, Snellman et al., 2000). In this section, we therefore use several indirect methods in order to capture the stock of currency held for domestic transactions purposes, separating it from other motives of holding cash (hoarding, demand by non-residents). This is of interest as domestic aggregate demand and price developments might be closely related to the development of currency used for domestic transactions.

In addition, we try to distinguish between domestic hoarding and foreign demand (see for such a separation e.g. United States Treasury Department, 2000, appendix B.1.1, or Markose/Loke, 2000), although it is extremely difficult to estimate the division of those notes, which are not held for domestic transactions purposes, into those held externally and those held in the underground economy (Rogoff, 1998, 165ff.). For the euro area, such a separation is of interest as euro legacy currencies were probably both held abroad (e.g. Deutsche Mark as well as, to some extent, Austrian Schilling and French Franc) and hoarded in large amounts (e.g. Dutch Guilder, Spanish Peseta, Belgian Francs).

This section contains three different types of indirect methods to derive estimates for the share of currency used for transaction purposes and abroad. First, a seasonal method is applied that is based on the assumption that the part of currency that is not related to transaction demand does not exhibit a strong seasonal pattern and therefore dampens the seasonal variability of currency. This method, dependent on the choice of a reference series, allows estimating the transaction related share of currency as well as the non-resident demand for currency. A second indirect source of evidence concerning the use of currency for domestic transactions combines data on currency flows and their composition with their seasonal pattern in the course of a year. Finally, a third method for estimating the share of currency used for transaction purposes is presented that tries to find the share of currency within M1 that optimises a simple bivariate inflation equation for forecasting inflation one year ahead.

5.1 The use of seasonality

5.1.1 Background and description of the methods[53]

The idea of using the seasonal variation to distinguish between different holding motives for cash was first established by Sumner, 1990, for an estimation of the domestic hoarding of US dollar. Porter, 1993, and Seitz, 1995, extended this idea to the estimation of non-resident holdings of US dollars and Deutsche Mark respectively.

The principle of this estimation method is based on the assumption that the use of currency for transaction purposes is influenced by a number of events that regularly occur during a calendar year, like Christmas shopping, summer holidays, bonus payments etc. At the same time, the use of currency for domestic hoarding purposes and the non-resident demand is not or only to a small extent driven by such domestic seasonal influences.

The seasonal method basically assumes that in a country with important domestic currency hoarding or important non-resident holdings, the percentage variation of the outstanding amounts of currency due to seasonal effects is dampened at time t by x percent. This unknown percentage can be estimated by a comparison with a reference series. A number of reference series were proposed in the literature, three of which will be discussed here, as they have led to the most plausible results:

a) a comparison of the monthly seasonal variation of currency in circulation of one country with the seasonal variation of currency in circulation of a benchmark country.

b) A comparison of the daily seasonal pattern of banknotes in circulation of one country with the seasonal variation of banknotes in circulation of a benchmark country.

c) The use of the relation between seasonal variations of currency and a transaction related variable (e.g. retail trade or private consumption) of a benchmark country in order to infer transaction related amounts in the country of interest.

a) The use of currency in circulation of a benchmark country

It is assumed that the currency stock cu_t is a weighted average of a currency stock used for transactions and a currency stock used for domestic hoarding/non-resident holdings:

(25) $$cu_t = \alpha_t cu_t^{tr} + (1-\alpha_t) cu_t^{hoard},$$

[53] See Porter (1993).

where α is the share of currency used for internal transaction purposes and *(1-α)* the share used for hoarding/non-resident holdings. The abbreviation "*tr*" stands for transaction purposes and "*hoard*" for domestic hoarding purposes and demand from abroad.

Let us assume that the time series cu_t can be decomposed into unobserved components like a trend-cycle capturing the medium-term to long-term developments, a seasonal component incorporating the effects that more or less regularly repeat every year and an irregular component capturing the noise and the unexplained rest. Let us further assume that these components are linked in a multiplicative way (this is the most commonly used approach, as in general, especially for nominal variables, the variation of a time series is dependent on its level in a close to proportional way). With these assumptions, one can extend equation (25), with cu_t being decomposed into the above-mentioned unobserved components. The product of the trend-cycle TC_t and the seasonal factors SC_t can then be split into

$$TC_t SC_t = TC_t^{tr} SC_t^{tr} + TC_t^{hoard} SC_t^{hoard}. \tag{26}$$

Let the term α_t now be the share of the trend level that is held for domestic transaction purposes and *1-*α_t the share of the trend level held for other purposes. Cancelling out the trend on both sides of (26) leads to

$$SC_t = \alpha_t SC_t^{tr} + (1-\alpha_t) SC_t^{hoard}. \tag{27}$$

Given the assumption that currency held for hoarding purposes and currency held abroad is not influenced by seasonal factors, equation (27) and can be solved for α_t, the share of the trend of currency used for domestic transactions

$$\alpha_t = \frac{SC_t - 1}{SC_t^{tr} - 1} \tag{28}$$

The seasonal factors for currency can be derived from standard seasonal adjustment packages. The seasonal factors of currency that are due to transaction related motives (SC^{tr}), however, are unknown and can only be approximated with a benchmark series, in this case by the seasonal variation of the currency of a benchmark country that is either mainly used for internal transaction purposes or is used in addition for internal hoarding purposes but not demanded by non-residents, dependent on the issue of interest.[54] Such a series must exhibit the same seasonal

[54] It becomes apparent from equation 28 that the choice of the benchmark series as well as the choice of the seasonal figures is crucial for this estimation method. In case, seasonal variation of the benchmark series is lower, this may lead to an estimate of a negative share held for transaction purposes. Furthermore, the estimate goes to infinity in case the seasonal factor of the benchmark series for month t goes to 1.

pattern for every month and the trend should not be influenced by domestic hoarding/foreign demand for the respective currency. Such a situation, however, is unlikely to occur in practice. Some assumptions of the indirect estimation method must therefore be relaxed. After some experiments, we choose to only take into account the range of the seasonal factors within one year instead of using the monthly seasonal patterns.[55] Specifically, we use the range of the seasonal factors between December and February instead of the maximum range due to the following reasons:

- A seasonal peak in December is generally visible in the currency time series of all countries under investigation.
- In February, currency series show a seasonal trough or at least values close to it for most countries under investigation.
- The underlying cause for both, seasonal peaks (e.g. Christmas shopping, annual bonuses) and troughs, remain basically unchanged over time, whereas other seasonal patterns (e.g. around the summer holiday period) have undergone substantial changes not related to changes in the share of currency used for transactions. One main reason for the fact that in several euro area countries the seasonal peak around the summer holidays decreased substantially is probably driven by the increase in the flexibility of the production processes during the 1980s and 1990s leading to more flexible holiday patterns of employees. As the reduction of the summer holiday peak mainly was compensated by increases around Easter and Autumn, pattern in seasonality in these months might give misleading signals when being used to derive information on the share of currency used for transaction purposes.

Due to these reasons, equation (28) was modified to

$$\alpha_r = \frac{\Delta^{Dec_r - Feb_r} SC_r}{\Delta^{Dec_r - Feb_r} SC_r^{tr}}. \tag{29}$$

The subscript r now describes the relevant years and not the monthly observations any more. In order to estimate the share of currency used for internal transaction purposes (the coefficient α), the unknown range of the seasonal factors of the currency used for transaction purposes is replaced by the estimated range of the seasonal factors of the benchmark series as described above.

[55] Some other methods are discussed in Seitz (1995).

b) The use of daily seasonal pattern of currency

The same method as described above can be applied to daily banknotes in circulation. Such a series contains three unobserved seasonal components, namely an intra-weekly seasonal component, an intra-monthly seasonal component and an intra-yearly seasonal component. The intra-weekly seasonal pattern might be considered as the best signal for seasonal variations linked to transaction purposes. In fact, the daily variation should be a rather pure signal for transaction related demand for cash. By contrast, anecdotal evidence shows that domestic hoarding and the demand of non-residents for currency might not be assumed to be free of seasonality in the intra-monthly and the intra-yearly case.[56] The share of transaction related currency can be estimated using again equation (29), except that the series cu_t now represents banknotes in circulation adjusted for the intra-monthly and intra-annual seasonality and SC_t refers to the intra-weekly seasonality. Instead of the range between seasonal factors of December and February, the subscript r in equation (29) now represents the range between the seasonal factors for Fridays (peak) and (normally) Wednesdays (trough).

c) The use of the relation between seasonal variations in currency and seasonal variations in transaction related series

A third application of the seasonal method is the use of the relation in a benchmark country between the seasonal variations in currency and seasonal variations of transaction related variables, e.g. retail trade, to infer to the share of currency held for transaction purposes in the country of interest. Let us assume that the population of country x and the benchmark country have similar habits in using cash for transactions. However, banknotes from country x are demanded strongly by non-residents, without showing a specific seasonal pattern and in addition, in country x currency hoarding is more common. Under these assumptions, the share of the currency not used for transactions can be derived similarly to the standard method described above. Instead of using the seasonal range of a reference country in the denominator, one uses the regression coefficient between the seasonal range of currency in circulation and retail trade of the benchmark country ($\hat{\gamma}$) and applies it to the seasonal range of retail trade in the country of interest:

(30) $$\alpha_r = \frac{\Delta^{Dec_r - Feb_r} S_r(cu_x)}{\hat{\gamma}\Delta^{Dec_r - Feb_r} S_r(\mathrm{Re}tailTrade_x)},$$

[56] In the case of Germany, think for example about the demand for cash by Turkish immigrants that return in summer to Turkey for holiday reasons taking often a considerable amount of banknotes with them.

where cu_x is the currency of country x and $RetailTrade_x$ is retail trade of country x. For purposes of comparing seasonal patterns of currency and retail trade, the focus on the range between the seasonal factors between December and February seems recommendable, as the low February seasonal as observed in currency and the seasonal peak in December corresponds for most countries to a similar pattern in retail trade, whereas the summer peak in seasonality in currency is in general not mirrored by corresponding developments in retail trade.

5.1.2 Benchmarking the indirect estimation method

Whereas the general concept of the analysis of seasonal patterns sounds appealing, its empirical performance is hard to prove. In order to verify the empirical appropriateness in a case where a substitute model is available, two different variants of this method are applied to the currency in circulation in Spain.

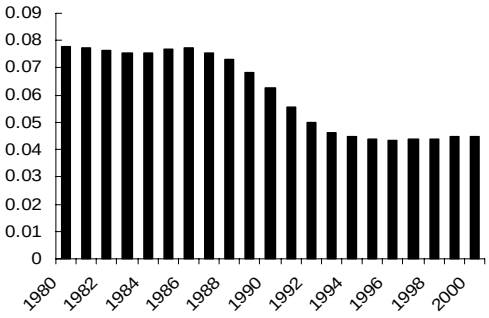
In fact, due to changes in the fiscal treatment of interest rate payments and the introduction of VAT in 1986, domestic hoarding increased substantially in the following years in Spain (see Section 2), heavily influencing the stability of the currency demand model. As described in Banco de España, 1996, by forecasting currency demand from 1986 to 1995, using the available currency demand model up to end-1985, the gap between the projected currency demand and the actual currency demand increased substantially within this period of time. By using the forecasts of the currency demand model, the Banco de España estimated that around 42% of the amount of currency was linked to hoarding purposes at the end of 1995 motivated by the change in the fiscal treatment of interest rate returns and the introduction of the VAT.[57]

Using this estimation as a reference, two variants of the seasonal method are applied to the Spanish case.

First, the seasonal pattern of currency in circulation in Spain is examined on its own. In order to reduce the impact of "noise" caused by holidays on the developments of the seasonal factors, the range between the December and February seasonal factors is derived for every calendar year (see explanation above). *Chart 14* shows the result from 1980 to 2000.

[57] In the case of Spain, as the Spanish Peseta circulated mainly domestically, the non-transaction demand corresponds to domestic hoarding alone.

Chart 14: The range of the seasonal factors for the Spanish currency in circulation

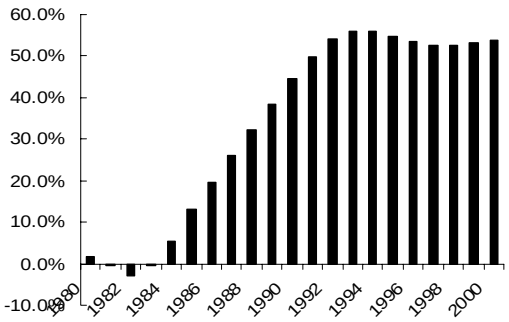


The chart reveals how stable the range of seasonal factors was until 1986, just to shrink substantially until 1995 and stabilising afterwards. The seasonality thus shows exactly the expected pattern as the increased hoarding should lead to a dampening in the seasonal variation that is mainly influenced by the amount of currency used for transaction purposes. Using the average range of seasonal factors between 1980 and 1985 as basis, the range of seasonal figures declined by 43% until 1995, increasing slightly afterwards. This result is fully in line with the results of the econometric analysis by Banco de España, 1996, that estimated an amount of 42% of currency used for hoarding in 1995. Even the pattern of the increased hoarding share is similar.

Similar results can be reached when using a benchmark seasonal range from another euro area country. In general, in this study, France is used as a benchmark country due to several reasons. First, the share of the different banknote denominations in France was rather stable over the estimation period 1980 to 2000 and, in addition, was distributed in no extreme way (see ***Table 4***). Moreover, there are no indications from institutional analysis that domestic currency hoarding in France is more substantial than in the rest of the euro area. Finally, the demand for French Francs by non-residents can be assumed to be rather low.

The results of using France as a benchmark country are shown in *Chart 15*. As can be seen, slightly negative percentages are derived for periods up to 1985 for the share of currency used for purposes other than transactions. In fact, these results can be explained by rather high historical inflation in Spain and a largest denomination that was below €70, which leads to the situation in the early 1980s where the percentage of currency hoarding in Spain had been extremely low, probably below that of France. By contrast, from 1986 until the beginning of the 90s currency used for hoarding and illegal purposes increased to over 50% in Spain and remained relatively stable until the end of the sample.

Chart 15: Share of non-transaction related currency in Spain using French currency as benchmark series



The example above shows that there is sometimes a need to calibrate somewhat the results. This point will be discussed later when deriving methods for the euro area, as in this case a calibration might be based on empirical evidence on hoarding and non-resident demand gained during the euro cash changeover.

The estimates derived from the approach of using the regression of the range of seasonality of currency against the range of seasonality of retail trade cannot be presented, as for Spain no longer-term series on retail trade is available. Time series for daily currency in circulation are unfortunately not available before 1994, so that this alternative could not be tested either.

5.1.3 Application of the use of a benchmark series for currency in circulation

After having seen that in principle, the seasonal method is able to deliver reasonable results in practice, one might consider its analysis for the euro area. A first and important step is a brief analysis of seasonal patterns for different countries between 1980 and 2000. *Chart 16* and *Chart 17* show the monthly seasonal factors for currency in circulation for 17 countries and the euro area as a whole.[58] The figures show the seasonal factors by month and by deviation from the average of this month. A positive seasonal factor of 110 for month x means that within a year, the seasonal fluctuation in month x amounts to +10%.

[58] Seasonal factors were estimated by using X-12 ARIMA of the US Bureau of Census and by applying stock trading day pattern to end-of-month figures including an Easter effect.

Chart 16: Monthly seasonal factors by country in the euro area between 1980 and 2000

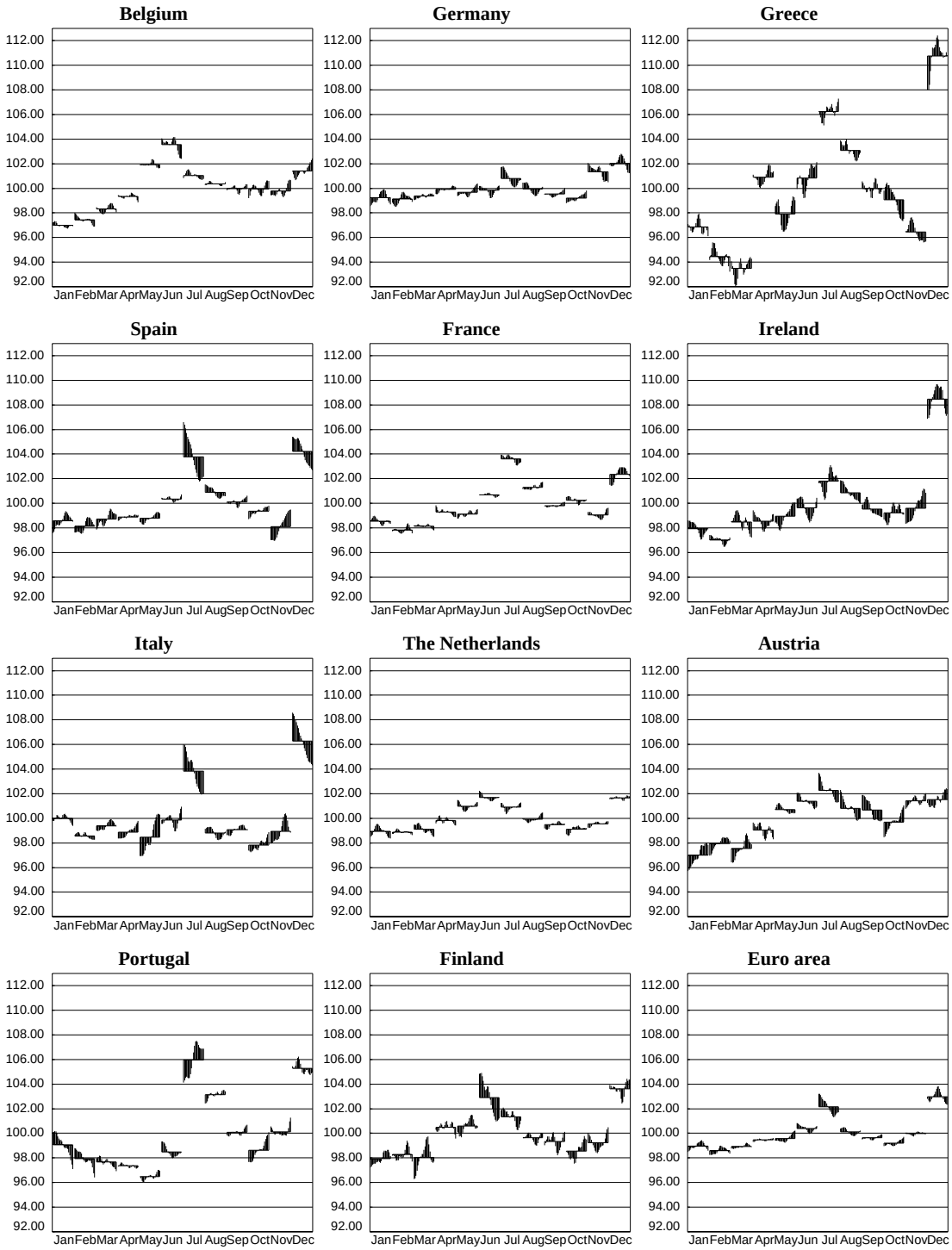
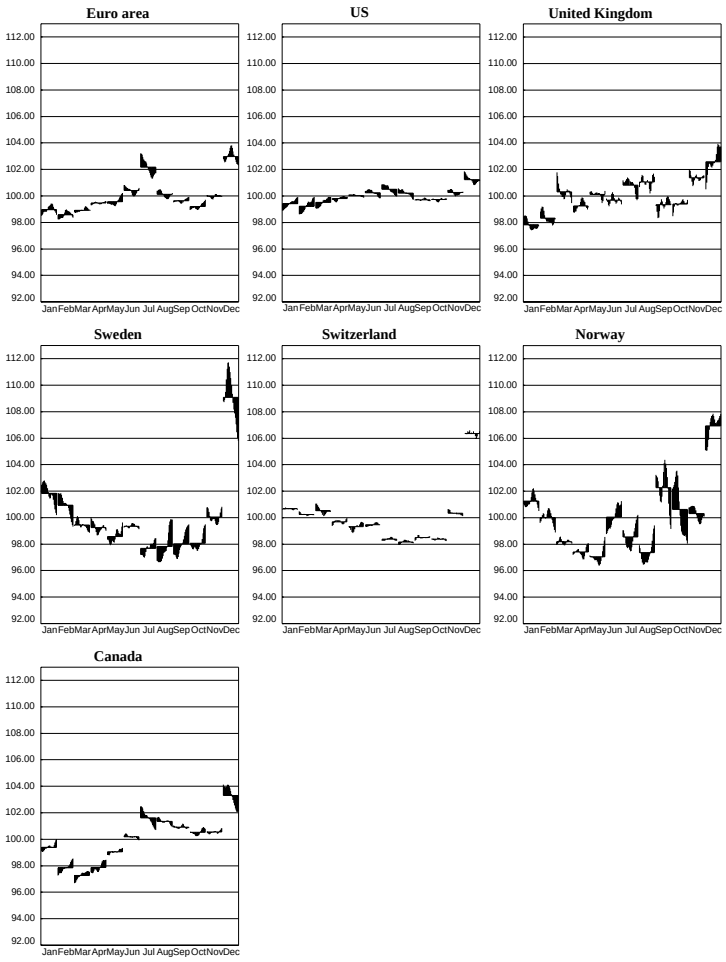


Chart 17: Monthly seasonal factors of selected countries in Europe and North America between 1980 and 2000



The stylised facts when analysing the above-shown seasonal pattern are amazingly in line with the analysis of the stylised facts of currency holdings as presented in Section 2. They can be summarised as follows:

Euro area

- Most of the countries show a seasonal peak in December, which is linked to Christmas shopping, holidays and the payment of annual bonuses. In addition, very often a seasonal peak in summer is observed, which is triggered by the relatively intensive use of cash during the summer holiday period. This summer peak is observed especially in the southern European countries.
- Currency in circulation in Germany and in the Netherlands show the most dampened seasonal fluctuations in line with the expectation that in Germany the sizeable demand of

non-residents (see Seitz, 1995) and in the Netherlands the sizeable domestic hoarding pattern (see Boeschoten and Fase, 1992, for a detailed analysis) dampen the importance of seasonality.

- The seasonal fluctuations of currency in circulation are most pronounced in Greece. Given the highest long-term inflation (from 1949 to 2000 inflation was on average 9.7%, whereas it was 2.7% for Germany) among euro area countries and the relatively low-value banknotes observed in Greece, it can be expected that in Greece, currency is mainly used for small-value transactions and probably less for hoarding purposes. Furthermore, foreign demand for Greek Drachmae should be negligible. This should lead to the observed higher variability in seasonality in Greece.
- Seasonal fluctuations of currency in France are broadly in the middle of the seasonal fluctuations observed for the currency series in the euro area countries. In addition, the seasonal pattern for the different months looks very stable, suggesting that no major structural changes affected the seasonal pattern which would potentially distort its use as an indicator for the importance of currency that is used for domestic transaction purposes.

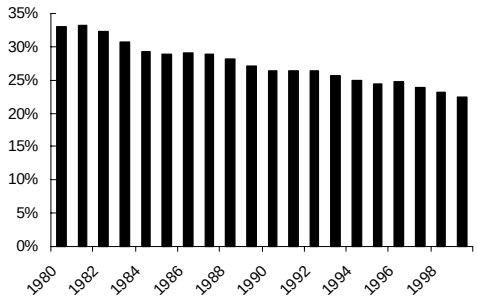
Europe and Northern America

- As expected from the known high demand of US dollar by non-residents, seasonal fluctuations in the US are the most dampened in the set of countries studied in this exercise, followed by the euro area.
- The seasonal patterns of currency in Canada are similar to the patterns observed in the euro area, making Canada a candidate for benchmarking currency demanded from abroad in the euro area. However, the strongly declining trend of the seasonal fluctuation in December might hint to developments that are possibly linked to specific changes in seasonality caused by factors that distort the analysis over time of the share of currency used in the euro area for transaction purposes. However, in this case, currency in Canada can still be used to derive average shares. In addition, the domestic hoarding pattern in Canada might be assumed similar to those in the euro area.
- The seasonal patterns of currency in circulation in Switzerland, Sweden, Norway and the UK show very distinct features, making their use as benchmark series problematic. In Switzerland, seasonality seems to be confined mainly to December. In addition, contrary to the observation in most euro area countries, the US and Canada, the summer months show seasonal patterns well below the average fluctuation. A similar observation can be made for

Sweden and, to a lesser extent Norway. The seasonal patterns for currency in circulation in the UK on the other hand are quite unstable for several months, which would make the estimate of the share of currency used for transactions in the euro area very volatile.

As described above, currency in circulation in Greece might be an obvious candidate as a benchmark series to derive the amount of currency used for transaction purposes in the euro area.[59] In fact, such a setting would reveal that between 24% and 34% of currency would be used for pure transaction purposes in the euro area (see *Chart 18*).

Chart 18: The share of currency held for transaction purposes in the euro are using the Greek Drachmae in circulation as benchmark series (in percent)



How to distinguish between domestic hoarding and non-resident demand for currency

The estimation described above derives the share of cash used for non-transaction purposes in the euro area. This result does therefore not allow any quantification of the demand by non-residents as opposed to domestic hoarding. One option to reach such a split is the choice of a reference currency that exhibits similar hoarding pattern as compared to the euro (and euro legacy currency before) but is not demanded significantly abroad. Whereas the similarity of domestic hoarding pattern depends on a number of factors (e.g. denomination structure of banknotes, tax regulations, importance of the informal economy) and is difficult to quantify, the euro cash changeover offered a unique opportunity to get some insights into this issue (see Section 6). First, the developments of non-resident demand for euro legacy currency and for euro banknotes can be monitored around the cash changeover via balance of payment figures on the shipment of banknotes and via deposit developments in euro area neighbouring countries, so that it is possible to calibrate the estimations to represent the non-resident demand. In addition, this procedure might be further monitored by checking changes in tax regulations in the euro area. A second unique opportunity offered by the euro cash changeover is the fact that the pattern of decline in the growth rates of currency in circulation in 2001 in the run-up to the euro cash

[59] In this context, euro area always refers to euro area excluding Greece.

changeover gives some insights into the importance of hoarding. In case currency hoarding is substantial in one country, one can assume that the flowback of hoarded money took place already from early 2001 onwards, partly due to the need to exchange large amounts of banknotes without being checked by tax authorities. In addition, there is evidence that the substantial backflow of currency from abroad for euro legacy currencies seems to have taken place rather late in 2001. When comparing the developments during 2001, the French Franc in circulation seems to be a good candidate for a reference currency. Moreover, foreign demand for French Franc seems to be rather low. The comparison of the growth rate pattern of France and the euro area excluding France during 2001 is shown in the chart below.

Chart 19: Annual rates of growth of currency in circulation in the run-up to the euro cash changeover (in percent)

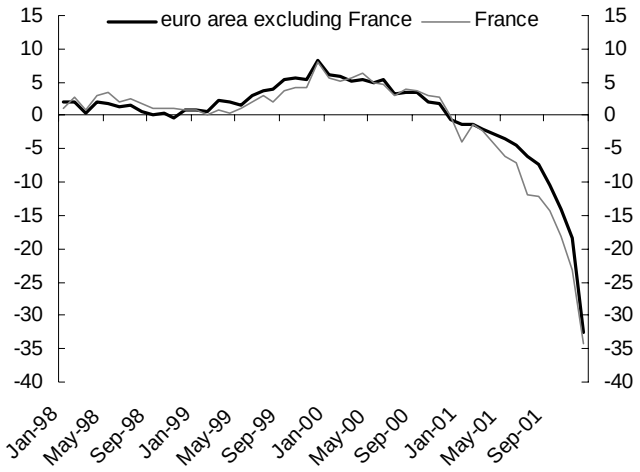
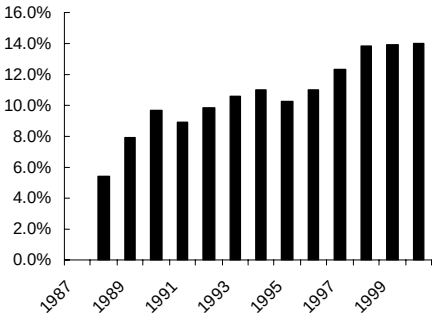


Chart 19 demonstrates the strong similarity in the annual rates of growth of currency in circulation in France and in the euro area excluding France in pattern and size. In fact, in end-December 2001, the annual rates of growth were -34.1% and -32.6% respectively. Given the high heterogeneity in the annual rate of growth of currency in December 2001 in the euro area countries (ranging from –7.4% for Greece to -48.6% for the Netherlands), this confirms the appropriateness of the choice of France as a benchmark country in addition to all other advantages already presented in 5.1.2. A second benchmark might be the Canadian dollar that is not demanded abroad and might have a similar domestic hoarding pattern.

Chart 20: Share of currency demanded abroad using French currency as benchmark



With these two benchmark currencies, the non-resident demand for euro legacy currencies in 2000 would have been between €25 billion (reference country Canada) and €40 billion (reference country France). This would correspond to 8% to 13% of currency in circulation in the euro area at that time. This estimation would not be too unreasonable given the evidence for 2002 from data on the shipment of euro banknotes to abroad. This evidence hints to an amount of €30 billion that is used abroad. Together with the information from central and eastern European countries that the euro banknotes seem to have broadly taken over the role of the D-Mark in these countries, the confidence in the estimated results is rather high. In addition, it is close to the results derived by Seitz, 1995, for Germany by using different benchmark countries.

5.1.4 The use of benchmark series related to the use of currency for transaction purposes

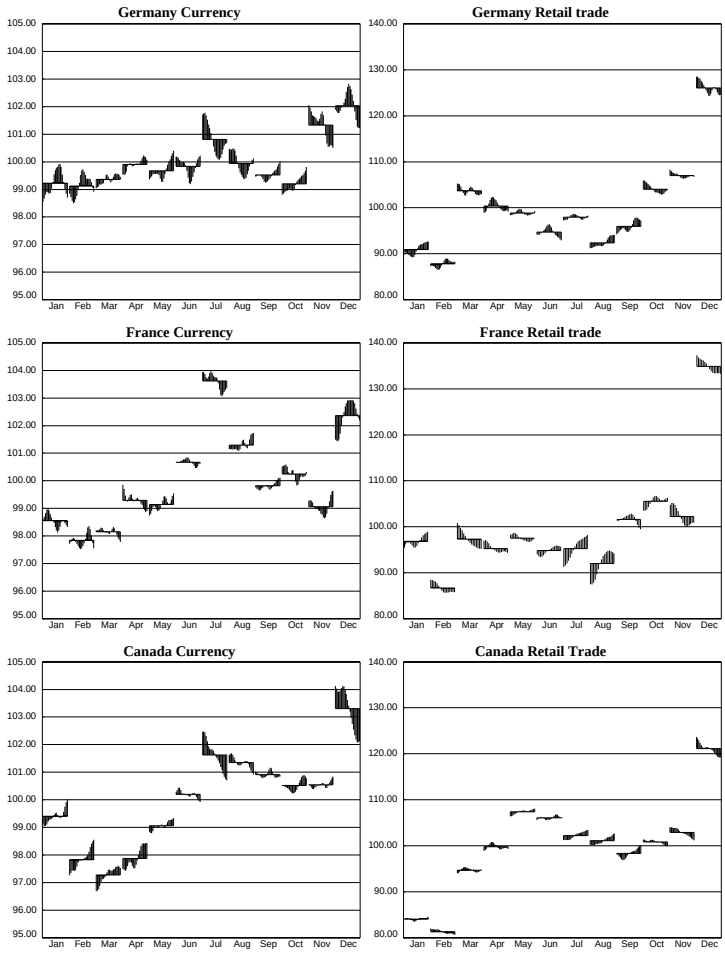
In addition to using a simple comparison of seasonal fluctuations of currency in a country of interest and a benchmark country, one might use as well the relation between the seasonal fluctuations of transaction-related variables like retail trade or private consumption and the seasonal fluctuation of currency. Such an approach leads again to an estimate of the non-transaction related share of currency and in case the relative importance of domestic hoarding is similar to an estimate of the non-resident demand for currency, under the assumption that the relation between these two seasonal variations between a country of interest and a benchmark country is only different due to a different share of currency not used for transactions. Equation (30) is used in order to derive such quantification for the euro area. The lack of data for retail trade statistics for the euro area before 1996 makes it necessary to use German figures instead of euro area figures. However, as suggested by anecdotal evidence before the euro cash changeover and by the fact that data on shipment of euro banknotes in 2002 further confirms that the vast majority of banknotes circulating outside the euro area originated in Germany (see also Seitz, 1995), it seems reasonable to replace data for the euro area by German data and continue to use

France and Canada as benchmark countries. A further justification for this procedure is that the size and development of the shadow economy is not too different in these three countries (see Schneider, 2001, 433). *Chart 21* below gives an overview of the seasonal pattern of currency in circulation and retail trade for the above-mentioned countries.

The stylised facts are:

- The main seasonal peaks and troughs for retail trade are identical in all three countries. The seasonal peak is observed in December, a seasonal trough in February.
- The seasonal fluctuations in retail trade are much more pronounced than the seasonal fluctuations in currency. In fact, the seasonal factors range from 20% below the average seasonal variation to 30% above the average level.

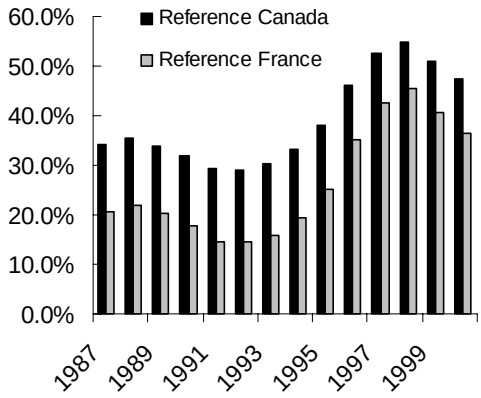
Chart 21 Monthly seasonal factors of currency in circulation and retail trade in Germany, France and Canada between 1980 and 2000



The similarity of the seasonal patterns in February and December between the countries under investigation and between retail trade and currency within the countries suggest that the

proposed approach of focussing on the seasonal range between December and February fulfils the necessary conditions. In a first step, the regression coefficients $\hat{\gamma}$ from equation (30) are derived for France and Canada. Applying these regression coefficients (estimated range between 1987 and 2000) to the seasonal range of German retail trade leads to the following estimates of the share of non-transaction related cash (see Chart 23):

Chart 22: Share of DEM cash used abroad using the regression coefficient of French and Canadian currency against respective national retail trade series as benchmark



Assuming that the bulk of this share is driven by non-resident demand and that the bulk of the non-resident demand for euro legacy banknotes were DEM banknotes, one might again derive an estimate for the non-resident demand for euro legacy banknotes. One might argue that the developments of the share of non-transaction balances over time cannot be considered to have a high quality in this approach, as the link between fluctuations in the seasonal factors of retail trade and the fluctuations of seasonal factors in currency might not always be perfect. Therefore we concentrate on an average share of non-resident demand, which was 25% of the level of DEM currency in circulation when using France as a benchmark country and 40% when using Canada as a benchmark country (see Chart 23). This would result at the end of 2000 to a non-resident demand of between €30 billion and €50 billion, slightly higher than the estimates derived from the comparison of seasonal variability of currency. For the euro area total, this share would be between 9% and 15% of currency in circulation at that time. However, one might assume that the domestic hoarding pattern in Germany, given the availability of relatively high denomination banknotes as compared to France and Canada, is more pronounced. This leads to results that include not only the non-resident demand but as well the relative higher importance of domestic hoarding in Germany.

5.1.5 The analysis of daily seasonal patterns

The analysis of monthly data on currency in circulation allowed detecting some of the stylised pattern in the use of currency in circulation. However these data are only available as end-of-month figures and one might therefore miss some interesting issues. Furthermore, the "pure" seasonal patterns of the currency used for domestic transactions might be that of the daily nature. Fridays should be characterised by a higher demand for cash due to e.g. the need for weekend shopping. This specific seasonal pattern might again be used to get insights into the amount of currency that is not used for transactions.

In order to model the daily series of banknotes, the structural time series model developed in Cabrero, Camba-Mendez, Hirsch and Nieto, 2002, is used and modified for some of the different euro area countries.[60] It assumes that the log transformed time series of banknotes can be decomposed into unobserved components, e.g. a stochastic trend, a stochastic seasonal component, and a deterministic component for festivities. The complication concerning the seasonal component enters via the existence of three different types of seasonality, namely an intra-yearly seasonality, an intra-monthly seasonality (think for example of the payment of salaries) and an intra-weekly seasonality (e.g. end-of-the week shopping, etc). The first two seasonal components are estimated via periodic seasonal cubic splines, whereas the latter is estimated via appropriate dummy variables but is made stochastic by modelling the vector of daily parameters as a random walk.

Stylised facts

The following charts show the average intra annual (Chart 24), the average intra monthly (Chart 25) as well as the average daily seasonal pattern (Chart 26) as observed for euro area banknotes in circulation between 1994 and 2000.

[60] The main differences concern the adaptation to specific national holiday patterns and country-specific outliers. In some cases the position and the number of the knots for the periodic splines to estimate the seasonal pattern has been modified as well. Another approach to modelling the daily demand for banknotes in the euro area (incorporating the same stylised facts) is undertaken by Bindseil and Seitz, 2001.

Chart 23: Intra-yearly seasonal pattern of banknotes in circulation (average 1994-2000)

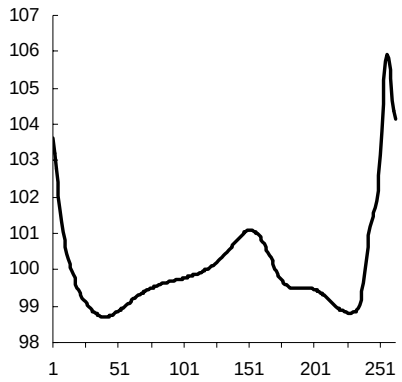


Chart 24: Intra-monthly seasonal pattern of banknotes in circulation (average 1994-2000)

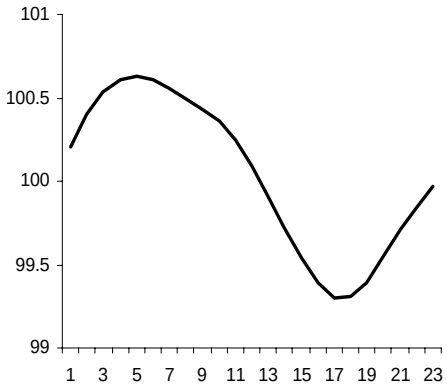
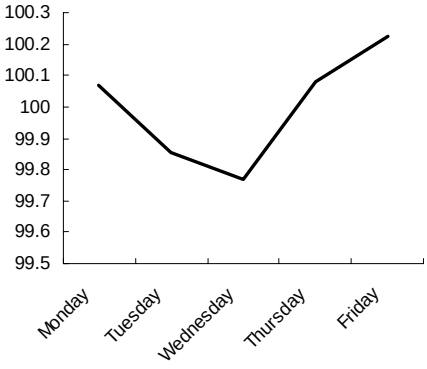


Chart 25: Intra-weekly seasonal pattern of euro area banknotes in circulation (average 1994-2000)



The following stylised facts are observable:

- The period around Christmas shows the most intensive use of banknotes within a year. The level of banknotes in circulation increased by around 6% during that period. The only other main seasonal peak can be observed in the summer period. This period is characterised by an increased circulation of banknotes of around 1%. However, the peak is observable over a longer period than the seasonal peak around Christmas.
- The intra-monthly seasonality of euro area banknotes in circulation is characterised by a seasonal peak at the beginning of the month (use of cash from monthly salary/payments received at the end of the month). The use of currency then declines until around the 17th working day of the month and increases again towards the end of the month. The seasonal impact of intra-monthly effects in euro area banknotes is much smaller than that of the intra-annual seasonality. In fact the amplitude of the seasonality ranges only between +0.6% on

the 5th working day of a month to –0.8% at the 17th working day of the month compared to a fluctuation between –1.5% to 6% for the intra-yearly seasonality.

- The intra-weekly seasonal pattern is characterised by a through at the middle of the week. The most intensive use of currency can be observed at Friday, probably partly related to weekend shopping activities.

Besides analysing the seasonal patterns of banknotes in circulation for understanding better the habits of the population in using cash, this approach might be used as well for an analysis of the amount of banknotes not used for domestic transaction purposes.

Chart 26: Intra-yearly seasonal patterns for French francs in circulation(average 1994 to 2000)

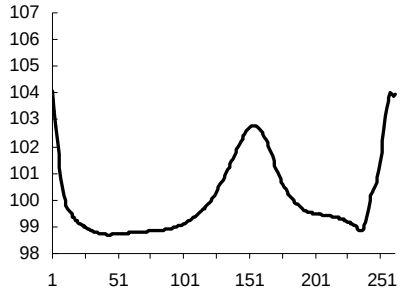
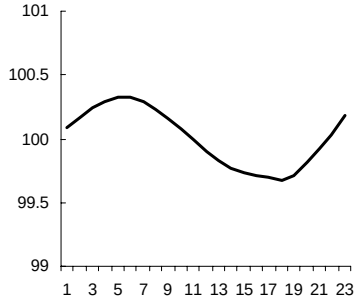


Chart 27: Intra-monthly seasonal patterns for French francs in circulation (average 1994 to 2000)

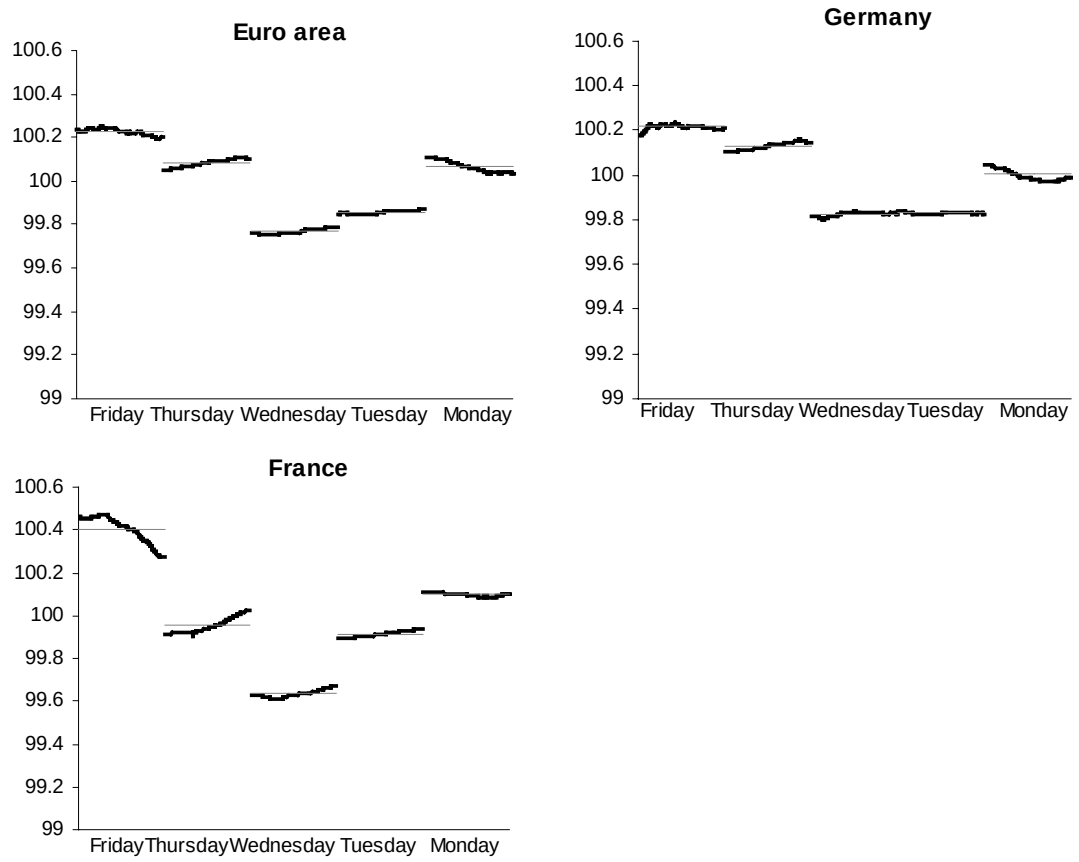


However, a comparison of the seasonal pattern of French francs in circulation with euro legacy banknotes in circulation reveals some difficulties of a further use of these figures (see Charts 27 and 28). In fact, the intra-monthly seasonal patterns in France are more dampened than the ones in the euro area, contrary to the expectations. This is probably linked to different salary payment patterns. The seasonal pattern for the French francs around Christmas is again more dampened than that of the euro area, whereas the summer peak is more pronounced and lasts longer than the comparable peak in the euro area.

The empirical results as well as the theoretical considerations presented above, make it therefore advisable to concentrate the analysis of the share of non-transaction related cash on the daily seasonal patterns of banknotes. *Chart 28* shows the daily seasonal pattern of banknotes in circulation for some euro area countries. The stylised facts are in line with expectations:

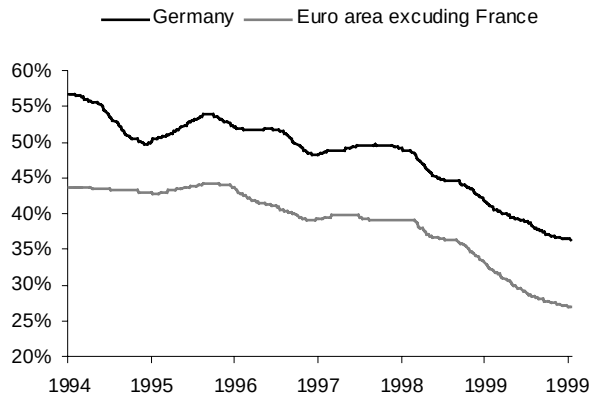
- On Fridays, in Germany, France and the total euro area, the most intensive cash demand can be observed, whereas Wednesdays are the day with the weakest demand.
- The French seasonal patterns are most pronounced, whereas those of Germany are most dampened, in line with the expectation that the substantial demand of banknotes by non-residents will dampen the daily seasonal pattern.

Chart 28: Daily seasonal patterns per weekday between 1994 and 2000



In order to allow a comparison of the results of the non-resident demand derived from the use of retail trade statistics, *Chart 29* shows the share of non-resident demand (assuming again that domestic hoarding patterns are similar) for DEM banknotes in circulation by using the seasonal range between Fridays and Wednesdays in comparison with the benchmark country France. The results (a share of between 55% in 1994 declining to a share of 35% in 2000) are slightly higher than that obtained by the use of retail trade statistics. The results for the euro area excluding France seem especially high as they range between 44% in 1994 to 25% in 2000, which might be related to the fact that the euro area daily pattern might be more dampened due to institutional reasons. Moreover, one has to bear in mind that hoarding is probably more important in Germany than in France. A calibration to results close to the shares of non-resident demand as derived from data on shipments of banknotes might therefore be advisable.

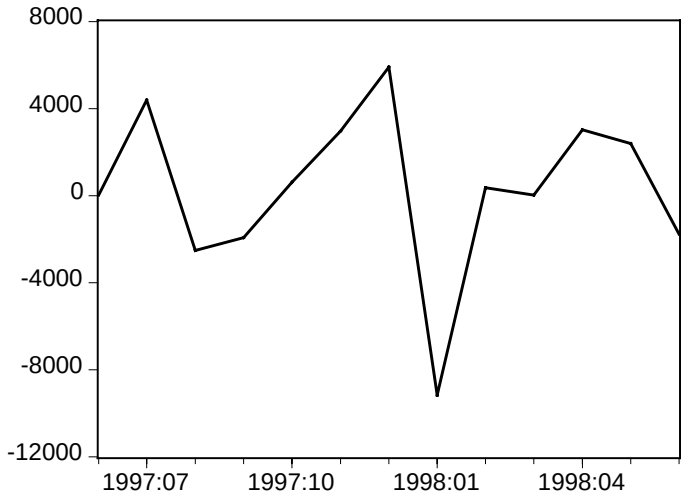
Chart 29: Share of banknotes in circulation demanded abroad (Germany and euro area excluding France)



5.2 The evolution of currency in different months during a year

Another related indirect source of evidence concerning the use of currency for domestic transactions combines data on currency flows and their composition with their seasonal pattern in the course of a year (see Kimball, 1981, for an early attempt in this direction in the case of the US dollar). As mentioned above, in November and December of each year the amount of currency in circulation increases substantially due to holiday transactions, the Christmas season and travel (see *Chart 30* for the years 1997/98). This is especially true for small-value banknotes mostly used for transaction purposes. These outflows are reversed in January as excess currency flows back to the central banks. In *Chart 30* we selected the years 1997/98 for expository reasons as in these years the evolution of currency should not be distorted by the Y2K problem and the introduction of the euro.

Chart 30: The intra-yearly evolution of currency in the euro area (€ millions)



As is evident from *Table 15* and *Table 16* not only do the net currency flows back to the national euro area central banks during January differ significantly from the outflows over a one-year period from June to June but also the banknote composition in terms of small and large denominations. Although, over time, the proportion of net flows accounted for by small denomination bills should decline due to inflation, the inflows during January consistently show a much higher proportion of these bills (see *Table 15*). Since the June-to-June outflows should consist of additions to banknotes both for transactions and for other purposes, while the January inflows predominantly consist of excess currency resulting from the seasonal decrease in the level of transactions, the composition of the January inflows is more likely to be similar to that of changes in cash balances used for transactions purposes.

Table 15: Currency flows to and from national euro area central banks

	Average January decline		Average June-to-June increase	
	€ millions	Annual growth rate	€ millions	Annual growth rate
1980/81 to 1984/85	4,305.1	34.4 %	8,213.5	6.8 %
1985/86 to 1989/90	5,512.7	35.2 %	12,018.7	7.1 %
1990/91 to 1994/95	8,975.5	34.2 %	16,200.7	7.0 %
1995/96 to 1999/00	10,334.6	34.7 %	8915.1	3.4 %

Table 16: Composition of banknote flows to and from national euro area central banks (% of total banknotes in circulation)

	Average January decline		Average June-to-June increase	
	Small denominations	Large denominations	Small denominations	Large denominations
1990/91 to 1994/95	20.6	62.2	9.3	74.6
1995/96 to 1999/00	21.7	56.2	5.5	85.0

Note: "Small" and "large" taken together do not sum up to 100 % due to some denominations qualified as "neutral" (see chapter 2).

By using the information from *Table 16* on the composition of additions to transaction balances and the composition of all new banknotes, it should be possible to derive rough estimates of the division of the total increase in banknotes between those held for transactions and those held for other purposes (see *Table 17*). This is done in Table 18 from the beginning of the 1990s onwards. *Table 17* is based on the assumption that all small bills are used for transactions within the euro area and that the composition of additions to currency used for transactions purposes is similar to the January currency declines.[61] According to this procedure the additions to banknotes held for

[61] Alternatively, one may use coins as representing solely transaction balances. In the case of the euro area, data availability constraints exclude this possibility.

transactions purposes was 45% in the first half of the 1990s just to fall back to about 25 % in the second half of the 1990s.[62] Taken the 1990s together the average additions to transaction balances amounted to about 35%. The figures for the first half of the 90s might be distorted upwards by the opening up of eastern Europe, German unification and the inclusion of figures for Portugal for which data are only available from 1991 onwards. These events might have increased the demand for the small denominations. However, the figures in *Table 17* represent only the divisions of the marginal increment to banknotes. Therefore, the proportion of banknotes actually held for transaction purposes should exceed the figures in the table. In general, it should also be taken into account that the chosen division between large and small denominations influences our result (see Section 2).

Table 17: Estimated proportion of additions to currency used for domestic transactions (in %)

Period	Transaction balances
1990/91 to 1994/95	45.1
1995/96 to 1999/00	25.3

5.3 A best fit approach

According to quantity theoretical considerations, domestic price developments should be closely related to monetary developments at home. Accordingly, the amount and development of currency used for domestic transactions should be closely connected with domestic price developments, implying, in turn, that inflation developments might be informative for determining the share of currency used for domestic transactions. One natural candidate for overall domestic transaction balances is narrow M1 which consists of currency in circulation outside the banking system and overnight deposits of private euro area residents held at MFIs within the euro area. Unfortunately, the stock of cash used for transactions within the euro area is not known as some portion is probably held outside the euro area (e.g. Seitz, 1995) and some portion of domestically held currency is not held for transactions purposes (e.g. Rogoff, 1998, Snellman et al., 2000).

[62] For the US, Kimball, 1981, estimated with an analogous model that at the beginning of the 1980s about 20 % of currency was due to transactions demand.

Having all this in mind, we determine the average amount of currency held for domestic transaction balances by a grid search with annual data from 1980 to 2000. Consider the forecasts of inflation using the following linear bivariate model[63]

$$(31) \qquad \pi_{t+1} = \alpha + ß(L)\pi_t + \gamma(L)\cdot(od_t + \theta \cdot cu_t) + \chi time_t + \varepsilon_{t+1},$$

where $\pi_t = ln(p_t/p_{t-1})$ is the annual inflation rate measured by the HICP, *cu* are nominal cash balances, *od* are overnight deposits, $ß(L)$ and $\gamma(L)$ are polynomials in the lag operator *L*, *time* is a deterministic time trend and ε is the white-noise residual. We choose a forecast horizon of one year as the money-price nexus is usually a medium-term one and in order not to loose too many degrees of freedom. Furthermore, the statistical fit of (31) deteriorates drastically with longer forecast horizons. To capture domestic transaction balances we use the parameter θ. Its unknown value measures the constant proportion of currency used for domestic transactions. It is added to overnight deposits to establish the total available transaction balances at home. All that is initially known about θ is that $0 \le \theta \le 1$. For $\theta = 0$, cash is irrelevant for domestic transactions; for $\theta = 1$, all cash is used for transactions within the euro area. An attempt is now made to establish the value $\theta = \theta^*$ for which (31) yields the best fit. For this purpose, we let θ move in steps of 0.01 between 0 and 1 and determine the maximum of the log likelihood function (*LL*).[64] The domestic portion θ^* is determined from the maximum of LL. ($1-\theta^*$) is then equivalent to the share of cash balances used for other motives.[65]

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[63] This methodology to assess the potential leading indicators for inflation was applied to the euro area by Nicoletti Altimari, 2001. However, he does not consider currency in circulation.

[64] *LL* is defined as $\mathrm{LL} = \frac{N}{2} + \left(\frac{N}{2}\right)\log(2\pi) + \left(\frac{N}{2}\right)\log\left(\frac{SSR}{N}\right)$, where *N* is the number of observations and *SSR* the sum of squared residuals.

[65] In estimating equation (31) we relate the **levels** of π and *cu* which are both *I(1)* over the sample period considered. This is in line with trying to establish a long-run (cointegration) relationship.

Chart 31: The log likelihood function for various values of θ

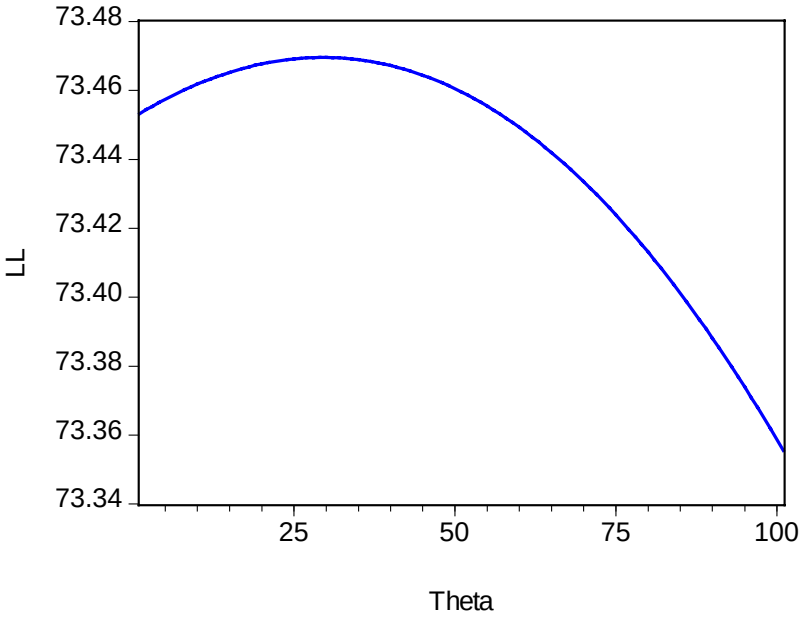

Chart 31 shows the log likelihood function. It reaches its maximum at $\theta^* = 0.30$. This means that 30% of the euro area currencies are held for transaction purposes.[66] Accordingly, 70% are used for other purposes (foreign demand, hoarding, underground economic activities not included in official transactions).[67] The concrete equation reads as (t-values in brackets below the coefficients)

$$(32) \qquad \pi_{t+1} = \underset{(-3.7)}{-1.13} + \underset{(7.3)}{0.84}\pi_t + \underset{(3.7)}{0.09}(od_t + 0.30 \cdot cu_t) - \underset{(-3.4)}{0.01}T_t + \varepsilon_{t+1}$$

This figure corresponds approximately to the one derived in the last section. Our result implies per capita transaction balances in cash of about €350 in year 2000. Compared to the actual per capita currency holdings of about €1,100 this figure seems to be more plausible and much more in line with anecdotal evidence and experience.

5.4 The evolution of the euro legacy currencies during 2001

The cash changeover to the euro provided a good opportunity to get some direct evidence on the demand for currency held for transactions as well as for hoarding purposes or from abroad. As currency hoarding and foreign currency holdings were to a large extent reduced at the end of

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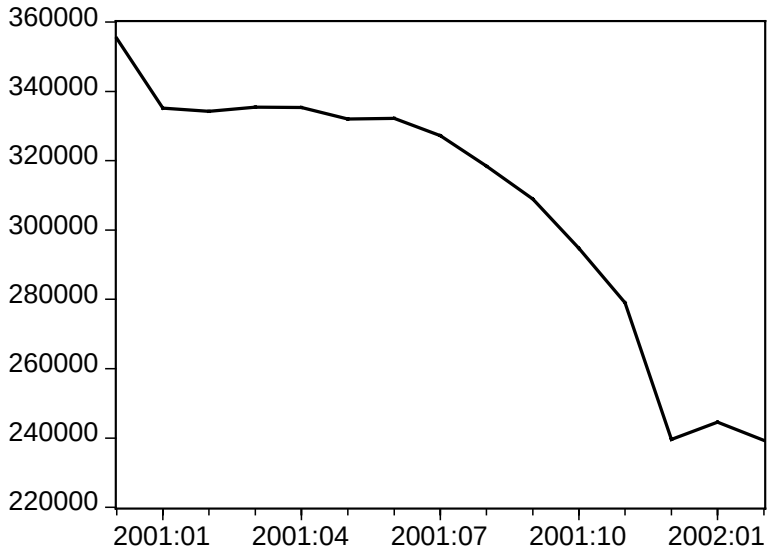
[66] Nearly the same amounts would result ($\theta^* = 0.37$) if we estimated the model with quarterly data to forecast the annualised quarterly inflation rate one quarter ahead. Boeschoten, 1992, ch. 2, found that slightly more than 10 % of the currency circulation in the Netherlands is needed to account for the transactions of households.

[67] Krueger, 2000, estimates that in the mid 1990s approximately 80% of Deutsche Mark in ciruclation outside the German banking system is held in foreign balances and internal hoards.

2001 (although not entirely as the evidence of substantial further flowbacks of currency in 2002 shows), currency in circulation at the end of 2001 might be a good approximation of an upper limit of the amount of currency held for domestic transactions.

In the course of 2001 currency in circulation on a non-seasonally adjusted basis shrank considerably from €356 billion at the end of December 2000 (including Greece) to €240 billion at the end of December 2001 due to the approaching cash changeover (see *Chart 32*), whereas it increased by +3.5% on average in the years from 1995 to 2000. As currency was still needed for (official) transaction purposes, apart from economising on currency holdings held for transactions, within the euro area the lower currency stocks resulted mainly from de-hoarding, inflows of currency held abroad, and to a limited extent also from switching to other currencies. Accordingly, the difference between the actual currency figure for the end of 2001 (€240 billion) and the amounts which would have prevailed had currency grown at a rate comparable to previous years (i.e. with 3.5%) may give a lower-bound estimate on the currency balances **not** needed for domestic transactions. This difference amounts to €128 billion or 37% of the average stock of euro legacy currencies in year 2000, implying that at least this share had been used for hoarding or held abroad on average in 2000, while at most 63% were probably held for domestic transactions purposes. This is very low compared to the amounts derived in the previous subsections which point to about a share double as high which is used for hoarding and held abroad. But recognising that currency in circulation at the end of 2001 did surely not exclusively consist of transaction balances and that the decline in euro currency continued in 2002 puts this figure into a more likely dimension.

Chart 32: Currency in circulation in 2001 (€ millions)



The existence of a substantial amount of hoarded euro legacy banknotes is also reflected in the more intense fall in large-value legacy banknotes, by around 30% (€73 billion) between December 2000 and December 2001, whereas low-value legacy banknotes in circulation declined only by around 20% (€12 billion) over the same period.[68] In addition, the decline of the latter was concentrated in December 2001, reflecting the use of these low-value banknotes for transactions, while the large-value banknotes had already declined substantially in the second half of 2001.

Furthermore, currency in circulation fell most notably in the run-up to the cash changeover in those countries in which the value of the legacy banknotes had been highest. In particular, in Germany and the Netherlands, which had the highest-value legacy banknotes (i.e. the DEM 1,000 and the NLG 1,000 banknotes), this decline in currency in circulation was the most pronounced of all the euro legacy currencies between end-2000 and end-2001, at 46.0% and 48.6%, respectively. By contrast, the annual rate of change of currency in circulation in Greece, which had the lowest average value of legacy banknotes in circulation, was only -7.2%.

In addition to euro area residents, non-euro area residents also appear to have reduced their holdings of euro legacy currencies in 2001. While euro legacy banknotes were held partly until the end of 2001 in order to exchange them directly for euro banknotes, there are also indications that non-euro area residents substituted their euro legacy banknotes for euro-denominated deposits in their home countries.[69] According to a survey conducted by the ECB in co-operation with the central banks of 30 countries in central and eastern Europe, the western Balkans, Turkey and other Mediterranean countries, euro-denominated deposits rose by more than €13.5 billion (about 40%) in these countries in 2001, with the bulk of the increase taking place in the fourth quarter of 2001, in which, according to anecdotal evidence, the bulk of the euro legacy banknotes was shipped back to the euro area from abroad.[70]

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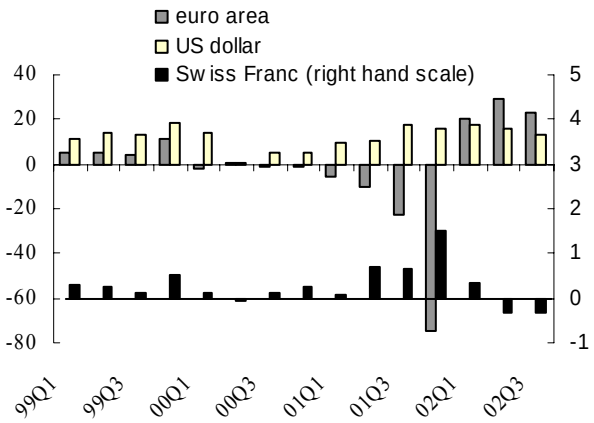
[68] The amount of banknotes which were accounted as neither large nor small declined by € 24 billions between December 2000 and December 2001.

[69] For evidence on the substantial exchange of euro legacy banknotes in euro banknotes and local currencies in central and eastern Europe see Stix, 2001a.

[70] The increase of deposits was particularly pronounced in countries in the broad geographical vicinity of the European Union, such as Croatia, Hungary, Poland, Turkey and Israel. In terms of regions, the countries of the former Yugoslavia experienced the largest increase in euro-denominated deposits in 2001, rising by more than 80% (€ 4.4 billion). Accession countries followed, with an increase of roughly 50% (€ 4.0 billion).

Chart 33: Currency in circulation in the euro area, United States and Switzerland
(quarterly flows in € billion, seasonally adjusted figures for Swiss francs)



Source: BIS, ECB, own calculations.
Notes: Data on US dollar and Swiss francs are converted into euro using the average exchange rate in 2001.

Finally, both non-euro area residents and euro area residents may have exchanged euro legacy banknotes for other major currencies' banknotes, such as US dollar and Swiss franc (see *Chart 33*). While there seems to have been some exchange for Swiss Francs, the impact of this exchange on the development of euro area currency in circulation was small in 2001 and 2002, given the relatively low amount of Swiss Francs in circulation. By contrast, the demand for US dollar in 2001, but also in 2002, was clearly higher than the average demand over the period from 1995 to 2000. However, it is difficult to attribute this to euro cash changeover effects. For example, the situation in Latin America in 2001 and 2002 may have led to an increased demand for US dollar outside the United States in 2001 and 2002, which probably had a more significant impact than any effects linked to the cash changeover. Taking both this and further anecdotal evidence into account, it is likely that the substitution of euro legacy banknotes for US dollar banknotes lies within a range of single digits in euro billions. ***Table 18*** summarises the results of the indirect approaches which we used in this section in calculating the transactions demand for cash in the euro area. It shows that probably only around 25% to 35% of currency are used for transaction purposes. This result is rather robust using three different estimation methods. In addition, it is likely that around 8% to 15% of currency are circulating abroad.

Table 18: Overview table of share of currency in circulation used for transaction purposes and non-resident demand

Share of currency used for transaction purposes								**Share of currency used abroad**		
Seasonal method I		Intra-yearly movements		Best-fit		Situation 2001/2002				
								S. M. I	S.M. II	S.M. III
€ bn	% of total	€ bn	% of total	€ bn	% of total	€ bn	% of total	% of total	% of total	% of total
80-110	24-34	110	35[a)]	100	30	210	63[b)]	8-13	9-15	25-44 [b)]

Notes: a) taking the 1990s as reference; b) upper-bound estimate.

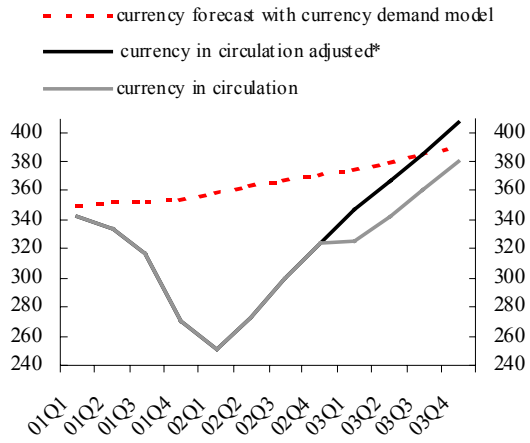
6. Currency developments in the period after the euro cash changeover and in the longer term

This section analyses currency developments after the cash changeover. The development of currency in circulation and particularly that of large-value euro banknotes in 2002 and 2003 is informative for the resumption of hoarding. In addition, information from the balance of payments on the shipment of euro banknotes to abroad as well as evidence from surveys provide information on the foreign demand for euro banknotes. Moreover, some considerations regarding the longer-term demand for currency in the euro area are presented.

6.1 The demand for euro currency in 2002 and 2003

In the course of 2002 and 2003, currency in circulation recovered steadily. In order to see to what extent currency in circulation recovered, we estimated the model presented in Section 4 until the end of 2000 and forecast currency in circulation on the basis of the resulting coefficients up to 2003 Q4. According to this model, in 2003 Q4 the level of currency was roughly in line with the level expected on the basis of the currency demand model (see *Chart 34*). At the same time, it has to be noted that until the end of 2003, no clear signs of a slowdown in the recovery process could be observed.

Chart 34: Actual and model-based currency in circulation in the euro area
(in € billion)



** notional stocks with base period January 2001 might be more informative, as the accounting agreement to take out euro legacy currencies from currency in circulation as of 1 January 2003 that were not returned to central banks introduces a statistical break in the series.*

Following the fall in currency hoarding and holdings abroad in 2001, the recovery of the demand for currency in 2002 and 2003 was, to a large extent, driven by the resumption of currency hoarding by euro area residents and by the demand by non-euro area residents. In particular, large-value euro banknotes increased strongly as evidenced by the number of €500 banknotes in circulation. According to anecdotal information, hoarding in the legacy currencies was in part

converted directly into euro banknotes in the first months of 2002, which should have contributed to the pronounced increase in large-value euro banknotes. By contrast, the number of low-value banknotes and coins in circulation declined in most months of 2002. In the first weeks following the cash changeover, this was mainly due to the initially high amount of low-value euro banknotes held by MFIs (vault cash) and retailers for precautionary and logistical reasons. As can be seen from *Table 19*, the average value of euro banknotes increased from end-January 2002 (€28) to end-January 2004 (€50) by more than 75%. Furthermore, the end-January 2004 value was around 40% above the average legacy banknote value in the euro area in December 2000. Consequently, the average euro banknote value has been above the level of the Netherlands in December 2000 (€43) and comparable to that observed in Germany in December 2000 (€49). In these two euro area countries, the denomination structure of the legacy banknotes had been very similar to that of the euro.

Table 19: Euro banknotes in circulation
numbers in million, value in € million

	€ 500	€ 200	€ 100	€ 50	€ 20	€ 10	€ 5	Total (number)	Total (value)	average value per banknote in €
2002 Jan.	61	75	364	1,417	1,962	2,000	1,922	7,800	221,489	28
2002 Feb.	80	88	438	1,612	1,926	1,822	1,506	7,473	246,535	33
2002 Mar.	93	95	477	1,780	1,910	1,742	1,302	7,398	264,150	36
2002 Apr.	103	99	502	1,820	1,828	1,622	1,186	7,159	271,138	38
2002 May	112	103	527	1,902	1,802	1,591	1,151	7,186	281,821	39
2002 June	122	106	552	1,964	1,813	1,576	1,136	7,268	293,023	40
2002 July	131	110	578	2,039	1,833	1,548	1,120	7,358	304,765	41
2002 Aug.	134	110	583	2,068	1,814	1,518	1,110	7,336	307,475	42
2002 Sep.	140	111	592	2,093	1,793	1,512	1,112	7,353	312,440	42
2002 Oct.	147	113	606	2,143	1,802	1,523	1,115	7,448	320,875	43
2002 Nov.	155	115	619	2,165	1,774	1,495	1,107	7,430	326,468	44
2002 Dec.	167	121	673	2,435	1,975	1,643	1,191	8,204	358,535	44
2003 Jan.	169	118	648	2,224	1,762	1,475	1,102	7,498	339,525	45
2003 Feb.	175	119	657	2,258	1,757	1,468	1,095	7,530	345,422	46
2003 Mar.	182	122	672	2,295	1,759	1,466	1,093	7,589	352,781	46
2003 Apr.	189	123	690	2,398	1,847	1,532	1,125	7,904	365,797	46
2003 May	194	124	698	2,428	1,849	1,537	1,135	7,965	371,008	47
2003 June	200	126	711	2,467	1,868	1,547	1,138	8,056	378,042	47
2003 July	208	129	733	2,553	1,908	1,558	1,144	8,233	390,011	47
2003 Aug.	209	128	734	2,558	1,897	1,542	1,139	8,207	390,447	48
2003 Sep.	214	128	738	2,556	1,863	1,532	1,138	8,170	392,651	48
2003 Oct.	221	129	747	2,585	1,858	1,536	1,141	8,217	398,366	48
2003 Nov.	228	131	759	2,617	1,857	1,540	1,145	8,277	405,233	49
2003 Dec.	238	135	810	2,896	2,054	1,685	1,218	9,037	436,131	48
2004 Jan.	239	133	782	2,669	1,849	1,528	1,144	8,344	415,615	50

Source: ECB.

Related to the cumulation of small-value and high-value euro legacy banknotes, the euro banknotes were grouped into small-value (€5, €10, €20) and large-value (€100, €200, €500) banknotes in order to get some information about the denomination structure compared with the

past. As in Section 2, the small-value euro banknotes are assumed to be mainly used for domestic transactions, while the large-value euro banknotes are postulated to be predominantly used for other purposes. The €50 banknote has not been included in this classification, as it is likely to be held for all the different motives mentioned. This split is broadly similar with the euro legacy banknotes classification.[71] Therefore, the shares of small and large-value to total banknotes in circulation are compared with the shares of the euro legacy banknotes.

At the end of January 2004, 14% of the value of euro banknotes were small-value banknotes and 54% were large-value banknotes (see *Table 20*). In December 2000 (taken as a benchmark in which the effects of the upcoming cash changeover were still small), the share of the small-value banknotes of the euro legacy currencies in the total euro legacy banknotes was very similar, at 15%, whereas the share of the large-value banknotes was somewhat higher, at 67%.

Table 20: Ratio of small-value and large-value to total banknotes in circulation (in value terms, in percentages of total euro (legacy) banknotes in circulation)

	small to total	large to total	neutral to total
2000 Dec	15	67	18
2001 Mar	15	67	18
2001 Jun	15	67	18
2001 Sep	16	66	18
2001 Dec	17	67	16
2002 Jan	31	37	32
2002 Feb	26	41	33
2002 Mar	24	43	34
2002 Apr	22	45	34
2002 May	20	46	34
2002 Jun	20	47	33
2003 Jan	16	51	33
2003 May	16	52	33
2004 Jan	14	54	32

Source: ECB

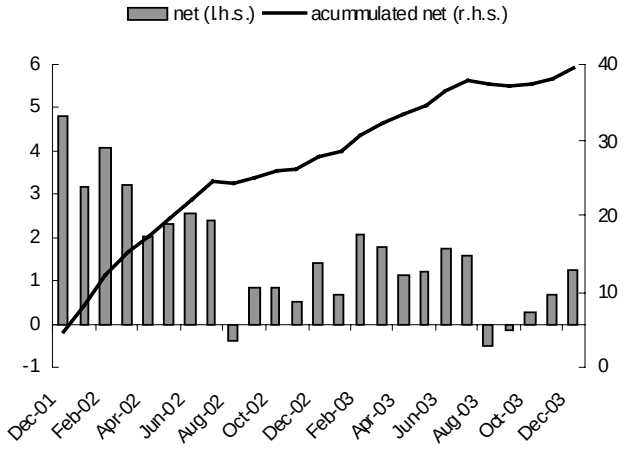
Note: For the classification of small and large legacy banknotes, see TABLE 5.

The substantial increase in large-value euro banknotes is probably also linked to the demand for euro banknotes from outside the euro area. Based on data on the shipment of banknotes to destinations outside the euro area, including data on the frontloading of euro banknotes at the end of 2001, an accumulated net amount of €40 billion euro banknotes was sent abroad via the

[71] In Section 2, it was explained that the classification into small and large-value banknotes is based on country-specific considerations, but that denominations with a converted value of more than € 30 could generally be classified as large-value, while denominations with a value of less than € 30 were generally classified as small-value. In a number of cases, euro legacy banknotes were neither classified as small nor large, when it was likely that these banknotes were used to a considerable extent for both transaction and hoarding purposes at home and abroad, for instance DEM 100 (€ 51.13), NLG 100 (€ 45.38).

banking channel between December 2001 and end-December 2003 (see *Chart 35*).[72] This suggests that either the majority of euro legacy banknotes, which had been circulating abroad before the euro cash changeover, has already been converted into euro or that there arose new demand for the euro very quickly.

Chart 35: Shipment of euro banknotes to outside the euro area
(in € billions)



Source: ECB

According to information received from central banks in central and eastern European countries, the western Balkans, Turkey and other countries in the Mediterranean, a significant share of the frontloading and initial shipments was targeted at these countries, where evidence had previously pointed to a substantial demand for euro legacy banknotes (Stix, 2001a). Estimates available from the national central banks of Bulgaria, Croatia, Kosovo, Serbia and Slovenia for early 2003 suggest that one-fifth of the amount shipped outside the euro area is held in these countries.

At the same time, with the possible exception of Turkey, shifts from euro legacy banknotes to other currencies, whether foreign or domestic, seem to have been limited. Furthermore, in Russia, where the US dollar has been the dominant foreign currency, foreign cash transactions by authorised banks increasingly involve the euro. In mid-2002, according to data published by the Central Bank of Russia, customers' purchases of euro even approached the level of US dollar purchases.[73] This suggests that, at least for the purpose of tourism, the demand for foreign cash became more evenly spread between the euro and the US dollar in Russia.

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[72] Banknotes shipment data (euro area balance of payments statistics) only report the euro banknotes shipped by the domestic banks to countries outside the euro area, whereas the physical cross-border banknote transport (e.g. workers' remittances, tourists' money, but also money from illegal activities) is not captured. Especially for the first months of 2002, it can be assumed that most of the banknotes were shipped abroad via the banking channel.

[73] See the report entitled "Foreign Currency Brought into and Taken out of the Russian Federation by Authorised Banks", which is published on a monthly basis on the web page of the Central Bank of the Russian Federation.

Close economic connections between the euro area and its neighbouring countries, as well as the accession process of some of these countries to the EU may further strengthen the demand for the euro in these countries.

Finally, the substitution of euro legacy banknotes for US dollar and Swiss francs by both euro area residents and non-euro area residents seems to have been, to a large extent, a temporary rather than a structural phenomenon, as indicated by the weaker growth of the US dollar and negative flows of Swiss francs in circulation in the course of 2002.

6.2 Some longer-term considerations regarding the demand for euro

Despite the long-term trend towards a more intensive use of cashless payment instruments, currency holdings per capita and in relation to private consumption so far continue to show a sizeable demand for currency in the euro area (see Section 2, Tables 1 and 2). When taking into account that mainly the currency holdings of non-banks for domestic transactions are relevant for monetary policy as they are closely connected with aggregate demand and domestic price developments, relevant currency holdings are lower. According to the estimates presented in Section 5 (see ***Table 18***), only around 25%-35% of the total currency holdings may be used for domestic transaction purposes in the euro area, which would correspond to around €290-€410 per capita in 2000. Nonetheless, this amount per capita indicates a continued sizeable preference for cash.

Whether or not the cash changeover to the euro will lead to a structural change in the demand for the euro currency is still too early to judge. Some considerations regarding the pros and cons of such a possible structural change are presented in this section.

The introduction of the euro might have reduced somewhat the demand for currency by economising cash holdings for cross-border uses in the euro area countries. For instance, travellers within the euro area do not need to hold several currencies and there is no longer a need for exchange booths to keep the 12 euro legacy currencies. In addition, lower transaction costs of using payment cards in the Monetary Union compared with cross-border card payments in the past and the likely further harmonisation of payment systems in the euro area could speed up the longer-term trend towards a more intensive use of cashless payment instruments.[74] Lower fees for cross-border automated teller machines (ATM) transactions may also decrease the level of currency holdings, as the need to hold large amounts of currency is reduced.

[74] A higher use of payment cards occurred only in the first few days of 2002 (according to anecdotal evidence) to smooth the cash changeover, but does not seem to have lasted for a longer period.

At the same time, the facilitated use of currency across the euro area countries due to the introduction of the single currency could also lead to a higher demand for euro currency. For instance, it cannot be ruled out that euro area residents when travelling within the euro area will use cashless payment instruments less and pay more with the euro currency. In addition, contrary to above, lower fees for cross-border cash withdrawals from ATMs could lead to an increased use of currency when travelling within the euro area. Moreover, the change in the denomination structure of banknotes, which implied larger-value banknotes compared with most of the previous euro legacy banknotes, could lead to a higher demand for cash as large-value banknotes are especially appropriate for hoarding purposes and for the use in the informal economy (Rogoff, 1998). Compared with the largest USD banknote (USD 100), the €500 banknote has a considerably larger value and might also attract an increasing share in the demand from abroad over time. At the same time, one may argue that the non-existence of a €1 or €2 banknote may somewhat limit the use of the euro abroad compared with the US dollar, where small-value banknotes exist. This would be related to a lack of convenience in using the euro abroad.[75]

Moreover, a stability-oriented monetary policy and the size of the euro currency area may contribute to a rise in the international demand for euro banknotes for transactions as well as for hoarding purposes over time, especially in the euro area neighbouring countries due to close economic connections. Exchange rate arrangements linking a local currency to the euro and euroisation may also increase further in the future, implying a higher demand for euro from abroad.

In addition to a slow change of payment behaviour, an important reason to hold currency is its privacy. Compared with the anonymity of currency, for cashless payment instruments a recording of the payment is generally possible and done, which reduces the trust in the anonymity of the transaction. Electronic money[76] could theoretically be a substitute for banknotes, which might avoid the disclosure of the identity of the users and thus ensure privacy. However, so far electronic money only plays a very minor role. The main arguments concern the lack of interoperability of e-money schemes, doubts concerning the safety of e-money systems given the risks involved in such complex transactions, including the risk of counterfeiting, as well as the inability of these cards to be used directly between trade partners without leaving a

[75] As change can be given to a larger extent in banknotes, which are, in contrast to coins, internationally accepted. An argument against the introduction of a small-value banknote, is, however, higher production costs as compared to coins due to a lower durability of banknotes.

[76] Electronic money is broadly defined as an electronic store of monetary value on an electronic device that may be widely used for making payments to others than the issuer, without necessarily involving bank accounts in the transaction (see ECB, 1998).

trace for third parties (Drehmann et al., 2002). In fact, for these reasons, e-money schemes are mainly expected to be used as a substitute for holding coins and low-value banknotes for convenience reasons. Against this background, a move towards a considerable role of e-money seems unlikely, at least in the near future.

Overall, while the introduction of the euro may lead to a change in the demand for currency in the euro area countries as well as in the euro currency holdings abroad in the longer term, the size and even the direction of the change are currently difficult to assess. With regard to a possible lower demand for euro currency than in the past, there is so far no evidence on a speeding-up of the trend towards a more intensive use of cashless payment instruments in the euro area owing to the introduction of the euro. This is also suggested by the fast recovery of currency.

7. Conclusions

The presented estimates of the share of currency holdings for hoarding purposes or abroad allow a more accurate picture of the demand for currency that is relevant for monetary policy purposes. This is of particular relevance in periods in which the demand for currency not held for domestic transaction purposes changes considerably and could, if unknown, lead to a misinterpretation of currency developments. Aksoy and Piskorski, 2001a, b, as well as Jefferson, 2000, find that domestic money (the currency component of M1 or the monetary base corrected for the foreign holdings of dollars) contains valuable information about future movements of US real output and inflation. This is not surprising as such an adjustment tries to isolate the monetary aggregate actually used for domestic transactions (see also Kimball, 1981), which indeed should be related to aggregate demand and price developments, as mentioned above.

Central banks have an interest that currency does not vanish altogether. The demand for currency, irrespective from where it originates or from whom it is exercised, generates a demand for base money.[77] As this, in turn, strengthens the ties between banks and the central bank, it enhances the potential effectiveness of monetary policy. There seems so far no evidence of a substantial decline of the demand for currency in the euro area. With regard to the use of cashless payment instruments, there is no evidence that the introduction of the euro banknotes

[77] Rogoff, 1998, argues that if large denomination euro notes are used in huge amounts in illegal activities the revenue losses of direct and indirect taxes might outweigh possible seigniorage benefits. Ercolani, 2000, analyses theoretically and empirically a situation in which agents in the hidden economy are able to avoid direct and indirect taxes but unable to avoid the inflation tax because they require cash to carry out transactions.

and coins has given a major push towards a more intensive use of these instruments.[78] Against this background, the analysis of currency in circulation and in particular estimates on the share of currency which is likely to be used for domestic transaction purposes help to explain monetary developments and are informative for monetary policy. However, even if the demand for currency shrinks in the future, there would be alternatives for a proper and effective functioning of monetary policy (see e.g. Goodhart, 2000, Schreft and Smith, 2000, and Woodford, 2000). Monetary policy should thus be able to adapt adequately to a situation of a shrinking demand for currency.

Consequently, although the share of currency in circulation in broad monetary aggregates is relatively small, an analysis of currency developments is important for a central bank. For monetary policy, it is important to know the share and in particular the change of the share of currency in circulation which is not used for domestic transactions. For instance, an increase in the demand for currency from abroad fuels currency in circulation, without having consequences for domestic developments. Likewise, a de-stocking of currency hoarding does not imply, in the extreme, deflationary risks, although it reduces monetary aggregates. Against this background, the presented models on the demand for currency allow for a detailed analysis of currency developments in the euro area. On their basis, changes in the demand for currency, for large and small-value banknotes, which might indicate a change in the payment or hoarding behaviour of euro area residents or a change in the foreign demand for the euro, can be analysed, thereby contributing to a detailed assessment of monetary developments in the euro area.

There are some natural extensions of the paper. First, a stochastic version of the theoretical model may be considered, which would enable us to directly incorporate risk and uncertainty variables into the demand for currency function. Second, a panel econometric approach would reduce the aggregation bias and would highlight the heterogeneity of currency demand in the different euro area countries. Third, further indirect methods to try to gauge the transaction balances might be useful, e.g. the biometric method (see United States Treasury Department, 2000, appendix A.1.2) or, as time goes by, an evaluation of the "life" of banknotes (see e.g. Seitz, 1995). And finally, it would be worthwhile to consider the situation in a euro currency importing country and try to estimate the amounts held with the help of indirect methods.

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[78] Wallace, 2000, shows that the acceptability of payments instruments innovations is not only dependent on network effects but also on the knowledge of individual histories. Perfect such knowledge implies no role for money (currency). No such knowledge, while giving the greatest scope for a role for currency, leaves no role for credit in any form. To justify a mix of transactions one has to specify some degree of imperfect knowledge of individual histories. Shy and Tarkka, 2002, theoretically analyse the markets for three different payments media,

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α	*share of currency in circulation used for transaction purposes*
b	*real bond holdings*
bn	*banknotes in circulation*
ß	*discount factor*
big	*(logarithm of) large denomination bills*
bigr	*(logarithm of) real holdings of large denomination bills; nominal balances deflated by the private consumption deflator*
c	*(logarithm of) private consumption expenditures*
cu	*(logarithm of) nominal currency holdings*
cur	*(logarithm of) real currency holdings; nominal balances deflated by the private consumption deflator*
Δ	*logarithmic first difference*
e	*exchange rate (theoretical model); (logarithm of) the real effective exchange rate of the euro against the main 12 partner countries' currencies (empirical part)*
i3	*(logarithm of) 3-month money market rate*
icum	*cumulative interest rate term*
il	*yield on 10-year Government bonds*
iod	*own rate of interest of overnight deposits*
od	*(logarithm of) overnight deposits*
p	*price level; Harmonized Index of Consumer Prices (HICP)*
r	*ex-post real interest rate ($r=i-\pi$)*
π	*(annual) inflation rate according to the HICP*
σ	*volatility of inflation calculated as the standard deviation of CPI inflation over a rolling window of 4 years*
SC	*seasonal component*
small	*(logarithm of) small denomination bills*
smallr	*(logarithm of) real holdings of small denomination bills; nominal balances deflated by the private consumption deflator*
sp	*term spread, i.e. (il-i3)*
T	*taxes (theoretical model); deterministic time trend (empirical part)*
TC	*trend-cycle*
τ	*tax rate*
TY	*(logarithm of) share of taxes in GDP*
u	*unemployment rate as % of the labour force*
U	*lifetime utility*
y	*gross real income*
*	*foreign variables*

Annex 1: Unit Root Tests

	ADF		PP		KPSS	
variable	**Test specification**	**t-value**	**test specification**	**t-value**	**test specification**	**test statistic**
cur	T,2	1.76	C	0.17	T	0.17**
Δcur	N,1	2.36**	N	3.06***	C	0.34
smallr	C,1	4.20***	C	2.72	T	0.27***
Δsmallr	T,1	3.91**	T	6.25***	T	0.23***
bigr	T,3	0.80	T	0.81	T	0.28***
Δbigr	T,4	2.95***	T	4.08***	T	0.16**
c	T,4	2.26	T	1.88	T	0.12*
Δc	C,2	3.64***	C	9.17***	T	0.17**
i3	C,1	1.84	C	1.52	C	0.51**
Δi3	C,4	3,86***	C	6.10***	C	0.07
iod	T,1	2.28	T	2.03	T	0.22***
Δiod	C,4	3.98***	C	5.48***	C	0.17
sp	C,4	3.42**	C	2.14	T	0.09
e	C,1	2.44	C	2.41	T	0.18**
Δe	C,2	4.65***	C	6.66***	C	0.11
u	C,2	3.40**	T	1.28	T	0.12*
Δu	N,1	2.41**	T	4.12***	T	0.10
TY	T,4	1.98	T	2.55	T	0.11
ΔTY	C,3	5.46***	C	4.83***	C	0.09
σ	C,4	1.48	C	1.70	T	0.27***
Δσ	N	2.71***	N	3.56***	T	0.06
icum	T,3	2.14	T	1.21	T	0.17**
Δicum	C,4	3.86***	C	1.80	T	0.10

Notes: ADF: Augmented-Dickey-Fuller test, PP: Phillips-Perron test with the lag truncation parameter q chosen according to the formula $q = 4(n/100)^{2/9}$ rounded to the largest integer not exceeding the argument (n is the number of observations). In our sample q is set to 3. T: trend and constant, C: constant, N: no trend and no constant. The number of lags included in the ADF test is given after the test specification. KPSS: Kwiatkowski-Phillips-Schmidt-Shin test. ***(**,*): significant at the 1% (5%, 10%) level; t-value in absolute form.

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