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# The Demand for Euro Cash: A Theoretical Model and Monetary Policy Implications

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# DISCUSSION PAPERS





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# Contents

**Summary.** The present paper analyses currency in circulation in the euro area. The second part presents a theoretical model for the euro currency demand in which the traditional transactions and opportunity cost variables are supplemented by factors capturing hoarding and the underground economy and foreign demand for euro cash. The third part comprises the monetary policy implications resulting from a higher or lower demand for euro currency in the future. In general, the demand for cash enhances the effectiveness of monetary policy. Nevertheless, monetary policy should be able to adapt adequately to a situation of a shrinking demand for cash.

**Резюме.** В статията се анализират парите в обращение в еврозоната. Във втората част е представен теоретичният модел на търсене на еврото, при който традиционните трансакции и променливите на алтернативните разходи са допълнени от фактори, обхващащи трупането на банкноти във вид на съкровище, „сивата“ икономика и търсенето на евро на международните пазари. В третата част са разгледани изводите, свързани с паричната политика, произтичаща от по-голямото или по-малкото търсене на еврото в бъдеще. Като цяло търсенето на налични пари повишава ефективността на паричната политика. Независимо от това паричната политика би трябвало да се адаптира адекватно към свиващото се търсене на пари в наличност.

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# 1. Introduction and Motivation

The introduction of the euro banknotes and coins at the beginning of 2002 raised the question how the demand for the new currency will evolve. The often propagated cashless society seems to be far away, at least as far as the euro area currencies are concerned (see Table 1). But it is also recognized that the demand for the legacy currencies of the euro was relatively heterogeneous across the euro area countries in the past two decades. 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 as well as heterogeneous payment habits, which are likely to be related to the different legacy banknote denominations 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.

**Table 1**

**CURRENCY HOLDINGS PER CAPITA***

| | 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** | 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 |

* Based on purchasing power parities calculated by the OECD and Eurostat.
** 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.
*** 1982 shown instead of 1980.

Source: ECB, NCBs, Eurostat, national accounts.

On the one hand, there are EU countries with a very low currency per capita ratio, *e.g.* Finland, France, Portugal, UK (see *Viren*, 1989, 1992, 1994, for Finland and *Goodhart and Krueger*, 2001, as well as *Snellman et al.,* 2000, for an international comparison including these countries). This should be mainly due to the influence of cash-substituting financial instruments, *e.g.* credit and debit cards. On the other hand, there are currencies for which the traditional transactions and opportunity cost considerations alone are obviously unable to explain the huge amounts demanded. The first thing one has to take into account in this respect is the hoarded cash (see *Boeschoten*, 1992, for the Netherlands; *van Hove*, 1999, *van Hove and Vuchelen*, 1999, for Belgium and *Krueger*, 2000, for Germany). Second, informal or underground economic activities as well as tax evasion foster the use of cash due to its anonymity. This relation is generally discussed by *Schneider and Enste*, 2000, and empirically estimated for Spain by *Banco de Espaca*, 1996, and for several EU countries by *Schneider and Osterkamp*, 2000, and *Carid and Passerini*, 2001. Third, there is also the potential demand from abroad which seems to be especially relevant for the case of the German mark (see *e.g. Seitz*, 1995 and *Stix*, 2001, for a comparison of holdings of German marks, Austrian schillings and US dollars in Central and Eastern Europe).[1] In this respect, *Drehmann et al.,* 2002, interestingly find that the tax ratio (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.

Therefore, several potential (and also nonstandard) determinants have to be taken into account to gauge the demand for euro cash. However, the demand for euro banknotes may differ from the past demand for the national banknotes in the euro area. National peculiarities in the demand for currencies which may have been related to the different denominations of the euro legacy currencies may change over time. Moreover, the payments media used in transactions are not constant. On the one hand, it may be argued that the introduction of euro notes and coins constitutes an incentive to use cashless payments, especially electronic money as well as debit and credit cards, more frequently, as payment instruments will become further harmonized across

[1] A case study for the German 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*, 2002. The German mark is a good example of a currency where all different motives for holding a currency were present during its existence.

the euro area. On the other hand, however, the demand for euro cash might also rise with the physical introduction of euro banknotes and coins, as the cross-border use of cash in the euro area countries implies less transaction costs compared with the past. In addition, the foreign demand for euro banknotes may differ in the medium to long term from the foreign demand for the sum of the national banknotes of the euro legacy currencies in the past. A strong and, in particular, a fluctuating demand for euro banknotes from abroad would 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 and Judson*, 1996, *Lambert and Stanton*, 2001). 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 neighboring countries due to close economic connections. Exchange rate arrangements linking a local currency to the euro and euroization may also increase further in the future, implying a demand for euro from abroad.

Against this background, the present paper concentrates on the specification of a theoretical model of currency demand for the euro incorporating the different motives for holding cash (Section 2). Section 3 discusses the monetary policy implications for the Eurosystem of more or less currency in circulation. The last section summarizes and concludes.[2]

## 2. A Theoretical Model of Euro Currency Demand

This section presents a theoretical model of euro 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.[3] It captures the role of money as a store of value, a medium of exchange as well as an asset to satisfy precautionary motives (*Holman*, 1998). The model combines and extends the models of *Rogoff*, 1998 (appendix), and *Obstfeld and Rogoff*, 1996), Chapter 8.3). Although the empirical literature on currency demand has long recognized the importance of currency use in

[2] A more comprehensive treatment of many different aspects of euro currency holdings including the estimation of currency demand functions as well as the amounts hoarded, demanded in foreign countries and used for domestic transactions may be found in *Seitz at al.,* 2003.

[3] One of the latest theoretical attempts to rationalize holdings of fiat money is presented in *Schroder*, 2001.

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.[4]

Consider a two-country model with two currencies. Both economies produce and consume perishable goods.[5] 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 $u$ of the representative agent at home and abroad, as in (1) and (2), respectively:

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

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

where $c(*)$ is consumption at home (abroad) per period $t$, $cu$ ($cu_f$) denotes the home (foreign) nominal currency stock, $b^{(*)} < 1$ 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, i.e. the euro, which have a real value of $e \cdot cu^*/p^*$.[6] 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 concentrate on 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 $\tau$. 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 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:

[4] One exception with respect to the first argument is *Rogoff*, 1998. However, there are theoretical papers on the situation in parallel-currency ("dollarized" or "euroized") countries, see *e.g. Lane*, 1992 and *Seitz*, 1995, Chapter IV.

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

[6] In Chapter 8.3.8, *Obstfeld and 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.

$$(3)\quad p_t b^i_{t+1} + cu^i_t = p_t(1+r)b^i_t + cu^i_{t-1} + p_t y(1-\tau g(\frac{cu^i_t}{p_t y})) - p_t c_t$$

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 (the euro) $cu$ and their legal tender $cu_f$. In order not to overcomplicate 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:[7]

$$(4)\quad p^*_t b^*_{t+1} + cu^*_{f,t} + e_t cu^*_t = p^*_t(1+r^*)b^*_t + cu^*_{f,t-1} + e_t cu^*_{t-1} + p^*_t y^* - p^*_t c^*_t - p^*_t T^*_t$$

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:

$$(5)\quad \tau g\left(\frac{cu_t}{p_t y}\right) = \frac{cu_t + cu^*_t - cu_{t-1} - cu^*_{t-1}}{p_t}$$

$$(6)\quad e^*_t = \frac{cu^*_{f,t} - cu^*_{f,t-1}}{U^*_t}$$

Thus, the home country (5) earns seigniorage from the demand by residents and nonresidents. This lowers the domestic tax burden. By contrast, the foreign country (6) 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 maximization of (1) and (2) with respect to the budget constraints (3) and (4) imply:

$$(7)\quad y_c\,\mathrm{l}p_t(\frac{py_t}{c_t}) = \mathrm{l}1+g)\,uy_c\,\mathrm{l}p_{t+1}(\frac{py_{t+1}}{c_{t+1}})$$

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

$$(8)\quad \frac{1}{p_t}u_c(c_t,\frac{cu_t}{p_t})\left[1+\tau g'(\frac{cu_t}{p_t y})\right]=\frac{1}{p_t}u_{cu/p}(c_t,\frac{cu_t}{p_t})+\frac{1}{p_{t+1}}\beta u_c(c_{t+1},\frac{cu_{t+1}}{p_{t+1}})$$

$$(9)\quad u^*_{c^*}(c^*_t,\frac{cu^*_{f,t}}{p^*_t},\frac{e_t cu^*_t}{p^*_t})=(1+r^*)\beta^* u^*_c(c^*_{t+1},\frac{cu^*_{f,t+1}}{p^*_{t+1}},\frac{e_{t+1}cu^*_{t+1}}{p^*_{t+1}})$$

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

$$(11)\quad \frac{1}{p^*_t}u^*_{c^*}(c^*_t,\frac{cu^*_{f,t}}{p^*_t},\frac{e_t cu^*_t}{p^*_t})=\frac{1}{p^*_t}u^*_{cu^*/p^*}(c^*_t,\frac{cu^*_{f,t}}{p^*_t},\frac{e_t cu^*_t}{p^*_t})+\frac{1}{p^*_{t+1}}\beta^* u^*_{c^*}(c^*_{t+1},\frac{cu^*_{f,t+1}}{p^*_{t+1}},\frac{e_{t+1}cu^*_{t+1}}{p^*_{t+1}})$$

Conditions (7) and (8) refer to home optimization, (9) – (11) to foreign optimization. Conditions (7) and (9) are the standard consumption Euler equations. These state that at a utility maximum the consumer cannot gain from shifts of consumption between periods. Equations (8) and (10) determine the allocation of income between money and consumption. For the sake of interpretation let us concentrate on equation (8): $1/p_t$ 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 $\beta\, u_{c(.)}$ is the marginal utility of date $t$+1 consumption, discounted to date $t$. An analogous interpretation holds for (10). Finally, (11) states that an optimizing 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 (7) – (11) and given our assumptions on $g(.)$ yields a standard demand for money function increasing in $y$ and decreasing in the nominal interest rate $i$.[8] The important differences are that currency demand also depends positively on the marginal tax rate $\tau$, 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 potentially cash substi-

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

tution processes which may have repercussions on the currency demand function in the sense of a financial innovation influence (see *e.g. Kabelac*, 1999).

## 3. Monetary Policy Implications

In this section we present an overview of the main arguments put forward regarding the repercussions on monetary policy resulting from a higher or lower demand for euro currency in the future.

The academic literature on the impact of currency on monetary policy concentrates mainly on the consequences of cash for seigniorage revenues (see *e.g. Rogoff*, 1998). In its most general form seigniorage stands for the real value of monetary base creation, the most part of it consisting of banknotes (*bn*) on which we concentrate in what follows. It does not matter for what purposes banknotes are held, who holds the banknotes and where banknotes are circulating. In a modern central bank system with no direct monetary financing of the government budget, seigniorage accrues because private agents are willing to hold non-interest bearing cash against which there are interest bearing assets in the central bank's balance sheet. Thus, real seigniorage *S* may be defined according to the following formula:

$$
\begin{aligned}
S_t &= (i-\pi)\cdot\frac{bn_{t-1}}{p_t}+\frac{\Delta bn_t}{p_t} \\
&= (\mu+i-\pi)\cdot\frac{bn_{t-1}}{p_t} \qquad (12) \\
&= (\mu+r)\cdot\frac{bn_{t-1}}{p_t}
\end{aligned}
$$

In (12) $i$ is a nominal interest rate, $\pi$ is the inflation rate so that $r = i-\pi$ is the ex-post real interest rate, $p$ is the price level and $\mu = \Delta bn/bn$ is the rate of banknote growth. According to (12), a higher banknote issuance does not necessarily increase seigniorage revenues. On the one hand, $\mu$ increases. But, on the other hand, as long as this higher money growth leads to higher inflation, the seigniorage base $bn/p$ shrinks. However, if euro banknotes are held in other countries and also hoarded, they do not increase inflation in the euro area and the countervailing effect vanishes for these parts.[9]

[9] *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

Banknotes in circulation is one autonomous factor which the Eurosystem has to take into account in its daily liquidity management (see *e.g. Bindseil and Seitz*, 2001). Such autonomous factors relate to central bank activities determined neither by the central bank's liquidity management nor by counterparties. As the underlying transactions involve central bank money, transactions affecting these items have exactly the same liquidity providing or liquidity absorbing effect as monetary policy related transactions. Having this in mind, the logic of the ECB's liquidity management can be summarized very roughly as follows: the ECB attempts to provide liquidity through its open market operations in a way that, after taking into account the effects of autonomous liquidity factors (including banknotes in circulation), counterparties can fulfil their reserve requirements. If the ECB provides more (less) liquidity than this benchmark, counterparties will use or aggregate the deposit (marginal lending) facility.[10]

The daily banknote time series displayed in Chart 1 shows a rather regular daily, weekly, monthly and seasonal pattern. These regularities in the circulation of banknotes reflect social patterns in the use of banknotes such as consumption behavior, holidays, the role of the Christmas shopping season, but also parameters of the banking system such as the number of ATMs. Also apparent is the Y2K effect and the decline of currency in circulation in the second half of 2001 in anticipation of the euro cash changeover. The regularities guarantee that the changes of the banknotes in circulation can be forecast to a relatively large extent by the ECB. Therefore, banknotes in circulation generally facilitate the operational implementation of monetary policy.

It is the monopoly power of central banks to issue the monetary base that allows them to control their operational target, in the case of the Eurosystem the short-term money market rate, at least in the short run. The hypothesis has now been stated that the further development of e-commerce and electronic money and associated computerization will attenuate, or even remove altogether, the demand for monetary base, notably for currency, and that such vanishing demand for monetary base will in turn limit, or even prevent, the central bank from setting nominal interest rates in such a system (*e.g. Friedman*, 1999).[11] In assessing this proposition, one first has to consider that 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. The problem with a rising underground economy is that it expands currency in circulation potentially leading to higher inflation.

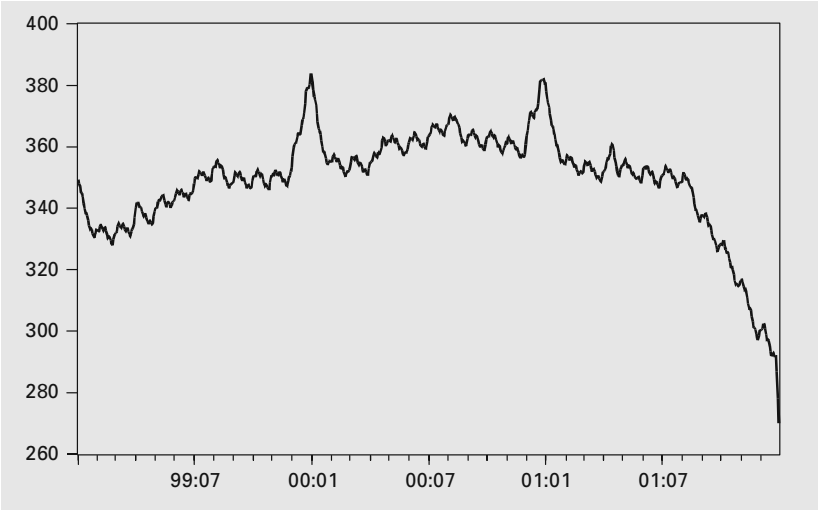
[10] The relationship of this "logic" to the thesis put forward by *Sinn and Westermann*, 2001, that the €/$ exchange rate is mainly influenced by relative movements in euro cash and dollar cash is critically evaluated in *Seitz and Bindseil*, 2001.

[11] *Costa Storti and De Grauwe*, 2002, analyze whether the emergence of electronic money is likely to affect the optimal size of monetary unions. According to them, irrespective of whether

**Chart 1**

**BANKNOTES IN CIRCULATION IN THE EURO AREA ON A DAILY BASIS**

(€ billions)




IT revolution is not going to remove the demand for currency altogether in the foreseeable future (*European Central Bank*, 1998). And even if it does, worldwide experience has shown that it is technically feasible for central banks to steer money market conditions even in a position of surplus in the interbank market. For that purpose, the central bank may, for example, issue debt certificates or set incentives for banks to use the deposit facility. Moreover, at least in the euro area, electronic money issued by monetary financial institutions is subject to reserve requirements, which compensates for the adverse balance sheet effects of the shrinking cash balances and the central bank may itself issue electronic money. Together with the obligation to redeem electronic money at par with central bank money, this would create a link to central banks ensuring the effectiveness of monetary policy. Finally, as *Goodhart*, 2000, argues, the ability of a central bank to control money market rates ultimately depends upon the fact that it is the government's bank and thus has the power to intervene in (financial) markets without concern for profitability.

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electronic money supplements or rides free on existing publicly supported monetary networks, and after taking into account credibility issues, larger monetary areas are likely. But in the case of a supplementary function, monetary instability is also more likely which probably calls for a government action to solve the coordination problem of monetary unions.

One may even hold the position that even if currency and settlement balances are driven to zero and there are no reserve requirements, a high-reputation central bank could maintain the overnight rate within a band by setting the marginal lending and deposit rates at which it is prepared to lend and borrow overnight funds in a perfectly elastic way (see for an analogous argumentation *Woodford*, 2000).[12] There will be problems, however, if the banks are not willing to settle via the central bank (*Costa and De Grauwe*, 2001, 15). In this case, the central bank would not be able to provide the demanded liquidity by "a stroke of the pen" because its liabilities would not be the ultimate means of payments anymore (cash and settlement balances). Instead, the central bank would have to go to the market and borrow liquid funds itself which it would then lend out to commercial banks. This also implies that the central bank would have to provide collateral. If the borrowing banks are large relative to the central bank, the latter will not have sufficient collateral to make the operation possible. Thus, the loss of monopoly power in the provision of liquidity combined with the small size would make it hard for the central bank to control short-term interest rates. In other words: in such circumstances and without an external support, *e.g.* through the government, the central bank cannot credibly set up a standing facility in a cashless society.

The larger currency in circulation is, the higher the refinancing needs of banks at the central bank are. As far as the transactions demand for currency is concerned, replacement of cash by other payments media, especially debit and credit cards, is influenced by the extent of ATM and EFTPOS densities in different countries. On the one hand, the network effects of such high densities together with low user costs may foster a move towards cashless payments in retail payments (*Markose and Loke*, 2003).[13] On the other hand, however, a high density of ATM could also imply high cash withdrawals, which seems to be the case in a number of countries, *e.g.* Germany, and does not mean cashless payments.

[12] *Schreft and Smith*, 2000, derive theoretically that even perpetual declines in the demand for base money pose no threat to the traditional methods employed for conducting monetary policy. The effects of such reductions, however, do depend on how monetary policy is conducted. In this respect they compare four regimes: nominal-interest-rate targeting, inflation targeting, maintaining a fixed composition of government liabilities and money growth targeting.

[13] *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. Such perfect 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 analyze the markets for three different payments media, electronic cash cards, currency and debit and credit cards. They show how the transaction domain of each payment instrument depends on the market structures and transaction costs.

One essential element of the opportunity costs of currency use for domestic transactions is the foregone interest which may be approximated by a deposit rate. *Ceteris paribus*, the higher this rate is, the lower the proportion of cash financed expenditures is. Once a replacement of cash by transactions has taken place, consumers usually do not switch back even if circumstances change. Having this in mind and assuming an unchanged structural liquidity management policy of the central bank, this process leads to higher liquidity in banks and thus lower nominal interest rates. Furthermore, the cash-card substitution may itself be influenced by the monetary authorities with their interest rate policy. This is more relevant in economies which are highly EFTPOS linked and have low ATM unit costs. In such a situation cash and cards become close substitutes and cash-card substitution is highly interest rate sensitive. *Markose and Loke*, 2003, calculate for 11 industrialized countries (including the euro area countries Belgium, Finland, France, Italy, Portugal and Spain) that with full card network coverage an infinite cash-card substitution exists at interest rates of about 2%. Moreover, they show that cash and card networks are coexistent.[14] Therefore, even excluding foreign demand for currency, hoarding and currency used in the underground economy, the sometimes propagated cashless society seems to be far from reality.

Overall, a stability-oriented monetary policy should be interested in the amounts of currency used for domestic transactions. This is likely to be the part of 'money' with the highest degree of liquidity and, in turn, has probably a close link to domestic aggregate spending and price developments. If currency is to a large extent hoarded and held in foreign countries, the definition of 'money' according to its degree of liquidity or the transactions motive is more difficult. At the same time, an increased demand for currency, irrespective of where it originates or by whom it is exercised, generates a demand for base money. As this strengthens the ties between banks and the central bank, it enhances the potential effectiveness of monetary policy.

Domestic hoarding and the holdings of banknotes abroad do not have to affect the information content of monetary aggregates which give a high weight to currency as long as both change relatively smoothly. However, in both cases there might be times of strong shifts in currency demand. For instance, the period before the introduction of the withholding tax on interest income from financial assets in Germany in 1987 has shown that the demand for cash can react significantly in case of anticipated tax changes. This may

[14] See for a theoretical model *Kabelac*, 1999. According to her model, a specialization of different payment media for different transaction values seems probable.

have even contributed to abandoning the so-called central bank money stock with its high currency weight as an intermediate target and to switching to M3 by the Deutsche Bundesbank. In addition, currency outflows into foreign countries seem to be influenced by the external value of the respective currency, measured *e.g.* by exchange rate movements as the theoretical model above suggests. But, as it is known from the international finance literature, exchange rate movements are to a large extent unpredictable. Furthermore, a political crisis and/or a rise in inflation in foreign countries can trigger large currency movements. Thus, currency, narrow money demand or the velocity of circulation may become unstable or erratic due to underground, hoarding and foreign demand for home currency. The evolution of currency in the course of 2001/2002 presents evidence in this respect as currency hoarding and foreign currency holdings were to a large extent already reduced in the course of 2001. *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.

If a currency is strongly demanded in other countries or if a foreign country (officially) "euroizes" or "dollarizes", home monetary policy has effects on these countries. This might lead to the demand that the home central bank should take the economic conditions in these countries into account (see *Antinolfi and Keister*, 2001, who also exemplify the argument for the case of the US and official dollarization). If that request is fulfilled, however, this would lead to a loss of monetary independence not only of the foreign country, but also of the home country.

Let us finally approach the relationship between currency in circulation and price level determinancy. The essential question in this respect is whether the demand for currency issued by a central bank is necessary to tie down the price level and prevent inflation (*Fama*, 1983).[15] The root of the indeterminacy problem can be formulated as follows (*Costa and De Grauwe*, 2001). Private agents that do not suffer from money illusion care only about relative prices. They do not worry about nominal variables such as the price level or the nominal money stock. If there is nobody else in the system who cares

[15] Strictly speaking, it is not the demand for currency but the demand for base money which also includes bank reserves (required reserves and working balances) at the central bank that is decisive.

about nominal variables, these will not be determinate, but can take any value. It is therefore important that some institution exists that takes the responsibility for nominal variables. In a fiat money system this responsibility is taken by central banks. They can either control the money stock or they can try to control the inflation rate, thereby avoiding the indeterminacy problem. In a world with only privately issued currency (*e.g.* electronic money) and no bank reserves held at the central bank, this control would cease to exist. Therefore, *Costa and De Grauwe*, 2001, suggest to strengthen the supervisory role of central banks in such a case. Especially, they should expand their supervisory control of any money issued, independently of its type or origin. Additionally, they should not only use microeconomic criteria (*e.g.* the structure of balance sheets, the value of collateral, *etc*.), but also macroeconomic criteria (*e.g.* the state of the business cycle or the degree of asset inflation) for supervision.

To sum it up, central banks should have an interest that fiat currency does not vanish altogether. However, such a situation is far from reality, at least in the euro area. But even if it happens once, there are alternatives for a proper and effective functioning of monetary policy.

## 4. Summary and Conclusions

In this paper we argued that theoretical and empirical models of currency demand should incorporate the possibility of hoarding, underground economic activities and foreign demand.

Such a specification seems to be especially suitable for the euro area. Overall, 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, in particular if it gives a significant role to the analysis of monetary developments. For monetary policy, it is essential to know the share and in particular the change of the share of currency in circulation which is not used for domestic transactions. On the other hand, the demand for currency in general – irrespective of where it originates, for what purposes currency is held and who holds the currency – enhances the effectiveness of monetary policy. In any case, monetary policy should be able to adapt adequately to different levels of the demand for cash even if it is difficult to predict the longer-term evolution of the demand for euro cash.

There are some natural extensions of the present 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 cur-

rency function. Second, inclusion of different payment media into the theoretical model would allow analyzing cash-substitution processes to take place. Third, it would be interesting to switch to empirics, i.e. to econometrically estimate currency demand functions for the euro, split into small and large denominations, as well as to try to estimate the amounts hoarded and demanded abroad.

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