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EVOLVING PAYMENT SYSTEMS, CENTRAL BANK MONEY AND THE CONDUCT OF MONETARY POLICY

Vítor Gaspar[1]
Daniela Russo[2] [3]

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Abstract: Modern payment systems are based on the coexistence and complementarity between central bank money and commercial bank money. Such coexistence favors the provision of an *elastic currency* that responds to the transactions needs of the economy. For this to happen, competition and innovation are paramount. Moreover, the involvement of central banks promotes stability and trust, providing the bedrock for a well-functioning market economy. For most of the twentieth century payments and settlement systems were stable and easy to characterize., They became a hidden, non-strategic aspect of central banking. The picture changed dramatically in the last decades of the last century. Technology, globalization, liberalization, consolidation and the response of public authorities all contributed to dynamic and fast changing payments systems. Central banks adapted their operational frameworks so as to ensure effective control over interest rates in the market for daily funds. During this period many central banks adopted the corridor system as their framework for monetary policy implementation. In this paper, we argue that such framework is well designed to cope with pervasive change. We believe that it will continue to prove so in the foreseeable future.

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[1] Special Advisor, Banco de Portugal.
[2] Deputy Director-General, Directorate-General Payment Systems and Market Infrastructure, European Central Bank.
[3] The views expressed are the authors' own and do not necessarily reflect those of Banco de Portugal, the European Central Bank or the Eurosystem's. We are grateful to ... for assistance in compiling the statistical information included in the paper and to ... for helpful comments and corrections. The responsibility for the remaining errors is our own.

1. Introduction.

Economies rely on very large numbers of transactions to determine resource allocation. The ability to perform those transactions, and the corresponding transactions costs, depends on payments technologies and payments practices available to society. In this paper, we will be focusing on the concept of money as a medium of exchange or, more explicitly, money as a provider of liquidity or payments services. In sum, our concern will be with money as a facilitator for transactions. In almost all societies, documented through historical records, we find money. The reason for the universality of money is, in our view, precisely that it facilitates trade, it saves on transactions' costs.

Such perspective was already explicit in John Stuart Mill as it is clear from:

"There cannot be intrinsically a more insignificant thing, in the economy of society, than money; except in the character of a contrivance for sparing time and labour. It is a machine to do quickly and commodiously, what would be done, though less quickly and commodiously, without it: and like many kinds of machinery, it only exerts a distinct and independent influence of its own when it gets out of order."[4]

As a social institution, providing transactions services and savings on transactions costs, money relies on universal acceptance. Hence, it is the case for money, as it is for many other fundamental social institutions, such as language and the system of weights and measures that its success depends more on the fact of agreement than on its content.

Padoa-Schioppa (2004, p. 22) argues that two changes in payments practices lie at the root of central banking. The first was the use of paper money to substitute for commodity money. The second was the use of bank deposits to substitute for currency that is to substitute for bank notes and coin. These two developments led to a stable situation, which prevailed for most of the twentieth century. It may be characterized as follows: money as composed mostly of banknotes, issued by the central bank, and by deposits with commercial banks. Money circulated through physical handover or through written instructions. Orders were transmitted at a distance through postal services. Central bank money was central for multilateral netting and settlement. Given the stability of the payment system it became a stale and non-strategic area in central banking. Most central bankers simply took it for granted. Towards the end of the twentieth century payments systems started changing fast. The main drivers of developments in payments systems were, in this period, technological innovation (the IT revolution), globalization, liberalization, consolidations and the responses of public authorities (see BIS, 2003).

These changes have been so profound that recently, a number of authors (for example Benjamin Friedman, 1999 and Mervin King, 1999) have raised the question of whether technological innovation will render the central bank powerless to use the relevant levers of the monetary transmission mechanism. It would be fittingly symmetric if it

[4] J.S. Mill, 1848 *Principles of Political Economy*, London. Quoted in Friedman (1968).

were the case that central banking rise and fall were both associated with changes in payments' practices in society.

Padoa-Schioppa (2004, chapters 2 and 8), relying on the theoretical framework of Kashyap, Rajan and Stein (1999)[5], emphasizes that commercial banks are special because their core business is to provide liquidity on demand. On the liabilities' side of the balance sheet banks stand clearly ready to convert deposits into currency. On the asset side banks provide the same service through credit lines. In this context, commercial bank money and central bank money should be regarded as complementary, contributing together to the provision of liquidity to the financial system. Still according to Padoa-Schioppa, what makes a currency area distinct is that within its limits central bank money and commercial bank money are exchanged at absolutely fixed rates. Specifically, the relevant characteristic is that central bank money and commercial bank money are exchanged at par.

In this paper, we will assume that the complementarity between central bank money (inside money) and commercial bank money (outside money) is a fundamental characteristic of modern banking, payments and financial systems. We will want to address a number of questions:

1) How did the main trends in payment systems affect the use of central bank money in the last decades?
2) How have these developments interacted with the operational framework of monetary policy implementation? Has the ability of central banks to determine the monetary policy stance and to deliver monetary policy been undermined?
3) Are developments going forward likely to change our answers?

In section 2, we describe the role of central bank money in payment systems in modern economies. We will start by providing a stylized description of the payment systems and, in particular, the role of the various institutions providing payment services, the various forms of claims transferred, the means through which those claims are transferred and the means of transferring them. We will document the co-existence of central bank money and commercial bank money and the changes of their respective importance over time. It seems to us that system relying on the both central bank money and commercial bank money allows a rapid response to the opportunities created by, for example, new ways of doing business or new technologies. Such flexibility allows the economy to rely on an *elastic currency*, which responds endogenously to the needs of the economy. At the same time, the central bank plays the role of a publicly mandated, non-profit institution thereby focusing on stability and trust.

In section 3, we will look at the interaction between payments systems and monetary policy implementation. In order to do so we use William Poole's model of commercial banks reserve management as a buffer stock problem. In Poole's model the ultimate source of uncertainty, facing commercial banks, is a residual (informational or operational) friction that (following Furfine, 2000) we interpret as deriving from imperfections or lags in commercial banks information systems, payments or settlements failures, bookkeeping errors, and other operational problems for the individual bank. The fundamental shock affects banks end-of-day current accounts and

[5] Reference to the work of Eugene Fama (1980) and of Scott Freeman (1985) is also warranted.

it is, therefore, properly labeled late liquidity shock. The fact that the stochastic behavior of late liquidity shocks depends on the characteristics payments and settlements systems, provides the relevant link. Its quantitative importance is shown in research work relating the volatility of interest rates in the market for daily funds to, for example, the volume of payments processed (see, for example, Furfine, 2000 or Hilton, 2005).

We will follow Woodford (2001, 2003) in combining Wicksell's (1898, 1935) concept of a pure credit economy with Poole's (1968) model of commercial banks reserve management referred to above. Specifically, we will follow Woodford in extending Poole's framework to tackle monetary policy implementation through a "corridor system"[6]. Such a system delivers control of interest rates in the market for daily funds. The process is completed, following the Wicksell-Woodford approach, since it provides a way of thinking about the conduct of monetary policy in terms of interest rate rules. By systematically changing daily interest rates in response to developments in the economy the central bank is able to safeguard the value of the currency. In other words, it is able to deliver price stability.

In section 4 we will comment on the relevance of some very recent trends and future developments in payments system, for the demand for liquidity. We look specifically at changes pertaining the relative importance of commercial bank money versus central bank money in settlements; potential spillovers from settlement problems in one currency for settlements in another; the frequency of demand for central bank money and the potential convergence of a new alternative to commercial bank money in settlements. In section 5 we will conclude.

[6] See, for example, Bartolini et al., 2001, 2002, Bindseil, 2001, 2004, Gaspar et al., 2004, Perez-Quirós and Rodrigues-Mendizabal, 2006, Whitesell, 2006, Woodford, 2001, 2003.

2. Evolving payments systems and the importance of central bank money.

2.1. The payment system model: the coexistence of central bank money and commercial bank money.

Payment systems, broadly speaking, consist in the set of instruments, conventions, procedures, rules and institutions enabling economic agents to discharge their contractual obligations, whenever they acquire financial resources or other goods and services. In modern economies, most exchanges are settled through the transfer of widely acceptable claims, which perform the key function of medium of exchange in the economy. In history, some commodities performed the social role of claims widely acceptable in payment, for example, gold. Since the demise of Bretton Woods, money has lost its golden fetters and the ultimate means of settlement is simply a claim on the monetary authority: it is central bank money[7]. The special status of central bank money explains why commercial banks choose, as a rule, to settle in central bank money (see, for example, Borio, 1997, BIS, 2003)[8].

A general and stylized overview of the major players and linkages is provided in Figure 2.1 (largely based on Borio, Russo and van den Bergh, 1991). The Chart focuses on common elements across payments systems disregarding differences in banking systems and legal frameworks across geographical areas. In any case, before going through Figure 2.1 in some detail, it is worthwhile to repeat that in the last four decades payment systems have been fast changing, reflecting profound changes percolating all through the financial system. As stressed in the following, especially in section 4, the main drivers for change in financial systems have been technological innovation (the IT revolution), globalization, liberalization, consolidations and the responses of public authorities (see BIS, 2003). These remarks should suffice to convey the message that payment systems are no longer a static reality.

In each currency area, the major players, in payments systems include non-banks (households and firms), banks, operator of funds transfer systems and the central bank(s). Funds transfer transferred are either liabilities of the central bank held by the non-bank public (bank-notes) and vis-à-vis the banking system (banks' reserve deposits) or liabilities of banks and vis-à-vis the non-bank public (banks deposits) or other banks (correspondent bank deposits).

The most traditional and direct means to transfer funds among households and firms is through the use of currency (cash). When an obligation is discharged using cash, settlement is, by convention, immediate. The transfer of other funds takes place, in book entry form, on the accounts of the issuing institutions. Such operation typically involves a time-lag for the completion of the transfer, from the payer's account to the payee's

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[7] A qualification pertains to the role of metallic coin (which is a responsibility of national Treasuries). For all practical purposes metallic coin is quantitatively negligible and irrelevant for the purposes of this paper. Central bank money is constitutes by banknotes *plus* current accounts at the central bank.

[8] Borio argues that the main reasons banks choose to settle in central bank money are: (i) direct access to the ultimate source of liquidity in the system; (ii) reduction in credit risk, associated with settlement in a risk-free asset; (iii) competitive considerations given central banks status as a neutral arbiter.

account. Furthermore, whenever the counterparties do not hold deposits with the same institution, the execution of the payment will require a compensating exchange of funds between the two relevant institutions. The funds, which need to be acceptable to both institutions, take the form of either the liability of a third party (the settlement agent) or of reciprocal accounts (correspondent balances) between the two institutions. Payments in commercial bank money involve, therefore, a chain of registers in the books of commercial banks (acting as payments agents) and a corresponding chain of documents, giving the relevant instructions and certifying the corresponding transfers of funds. Clearly interbank funds transfers may be settled individually and may take place in continuous time (real time gross settlements systems) or may be based on netting schemes and settled over some conventional discrete time interval (net settlements systems). The settlement agent can be the central bank or another financial intermediary.

Inside a given currency area the various forms of central bank money and commercial bank money are exchanged at par. However, this stylized model of payments' systems, may also be used for cross-border payments. These latter payments are normally effected between parties residents in different currency areas and are finally settled through some form of domestic payment. The foreign bank can access the domestic payment system directly (through a branch or on a remote basis) or make use the services of a correspondent bank, which, in turn, accesses the relevant system directly or through the services of another local bank. The model is also applicable to the payment arrangements associated with securities settlement systems. Securities settlement systems ensure, among other things, final delivery of securities from the buyer to the seller. When securities are traded in exchange for funds (as it is usually the case) the Securities Settlement System (SSS) also ensures the transfer of the related funds in the relevant payment system. This payment system maybe embedded in the SSSs or external to it. In this respect, a Securities Settlement System, in settling the cash leg of securities transactions, behaves as any other participant in the Payment System.

The instructions for funds transfers vary with respect to their legal characteristics and the nature of the technology involved. In modern industrialized economies economic agents, households and firms, have a choice among a wide variety of means of payments. Given their intended transactions they can select the instrument and the system that best suits their needs. Commercial banks and other intermediaries compete in order to offer the payment services that customers will value most.

Payment systems based on the co-existence between central bank money and commercial bank money allow the combination of two key aspects of payments systems. The first is the provision of an elastic currency responsive to the needs of the economy. Such ability follows from competition and innovation in the context of a changing business environment due, for example, to transformation in business practices and technological innovation. The second is the maintenance of a social convention based on stability and trust, given the ability to exchange commercial bank money into central bank money at par. The central bank, as a non-profit organization, with a public mandate, naturally focuses on systemic stability requirements. By doing so, it contributes to a sound open market economy with free competition.

2.2. Trends in central bank money and commercial bank money.

Over the past three decades, financial markets have undergone a radical transformation and rapid expansion, driven by deregulation, liberalization, and globalization and advances in information and technology.

Schinasi (2005), is one of the authors documenting profound changes in financial systems in the last few decades. Financial systems expanded significantly more rapidly than the economy. At the same time the importance of commercial bank money increased relative to central bank money. In this section, charts 2.1 – 2.4, we use Germany as a paradigmatic example. For example in Chart 2.1, it is clear that M3 increased significantly relative to GDP, between 1972 and 1992. At the same time the monetary base was remained comparatively stable. Graphically, Chart 2.1 shows that the payments pyramid has become substantially larger, while still resting on the same central bank money vertex. Thus, it allows one to visualize the two characteristics of the system that we have been stressing: first, its elasticity; second, the importance of preserving stability. The inverted pyramid conveys a perception of instability. Such tendency must be countered. As already stated in the Introduction the countervailing forces are stability and trust.
Chart 2.2 shows that the monetary base has remained relatively stable as a percentage of GDP. Chart 2.3 shows that broader monetary aggregates, especially M3 have grown significantly faster than GDP, especially a trend decline in the velocity of broad money. Clearly, as plotted in Chart 2.4, the money multiplier has trended up over time.

Chart 1.5 compares developments in funds transfer systems in US, UK and euro area in relation from GDP (Germany is considered as a benchmark for the euro area before the introduction of the euro). The chart conveys one fundamental message from the viewpoint of the paper. The volume of payments processed in funds transfer systems is related to the design of the payment systems. Two considerations can be made in this respect. First, funds processed through transfer systems settling in central bank money grew at an annual rate higher than that of the GDP until 2000. After 2000 the ratio of funds processed in funds transfer systems to GDP has been reasonably stable. This can be partly explained to the development in the last five years of new facilities or payment arrangements that reduce the need for central bank money. These facilities and payment arrangements and their impact on the use of funds transfer systems and the demand for central bank liquidity are described in section 4. Second, the level of payment processed in handling systems depend on some structural features of the financial system (and consequently of the payment system). In this respect, it is interesting to look at the comparison between United Kingdom and the other countries. Before 2000, the ratio payments to GDP was lower in the United Kingdom ,due to the two-tier structure. After 2000, the ratio in the United Kingdom is not very different from the other countries after 2000, as a consequence of the new features developed in the payment systems of the other countries.

What is true for the volumes of payment processed is also true when looking at the level of central bank money reserves used for settlement purposes. Here again, available statistics confirm that the demand for liquidity necessary to ensure the smooth

functioning of payment systems is related to the design of the payment systems and to the framework for monetary policy. Table 2.1 compares the level of settlement means (i.e. central bank and commercial bank deposits) used in payment systems at the end of 1988 with the level – end 2004) in selected G-10 countries. The level of balances with the central banks decreased in all the considered G-10 countries despite of the increase in the volumes of payments. In particular, the table shows that whereas in some countries (euro area, US and Sweden) the reduction of balances with central banks has also been accompanied by even a more considerable reduction in correspondent banking balances, in other countries (Canada, Switzerland and UK) the reduction of balances with the central bank has, instead, accompanied by an increase of the transferable deposits with other banks. These developments are due to a set of factors (including the introduction of the euro). Limiting to what is relevant for the argument of the paper, this can be explained in part with the above mentioned introduction of liquidity saving mechanisms in the design of payment systems and in part with adjustment in the framework for monetary policy. As far as payment system design, one can mention the introduction of the TARGET system and of liquidity saving mechanisms in the German component of TARGET system in the euro area. Liquidity saving mechanisms have also been introduced in the United States (CHIPS). The level of commercial bank money interbank deposits increased in the countries characterized by two-tier arrangements.

Looking at changes in the monetary policy framework the changes introduced in the late 90s in the coefficient of compulsory reserves as well as the averaging mechanisms for compliance with the reserve requirements has in the euro area played a crucial role in reducing the amount of reserves demanded for transaction purposes.

3. A standard model of monetary policy implementation.

In section 2, we have seen that payment systems have changed substantially during the last few decades. In parallel to these developments we have witnessed considerable changes in the operational framework for monetary policy implementation. Since the 1980s, a consistent shift has occurred towards emphasizing control of money market interest rates instead of (narrow) money. According to a textbook approach such a trend has not been accidental. On the contrary, it is in line with the argument in Poole (1970) about the relative merits of money and interest rates as intermediate targets for monetary policy. The basic idea is that fast changing and complex payment systems make liquidity shocks pervasive and hard to predict which, in turn, call for the design of a monetary policy framework that allows for automatic absorption of such financial disturbances. We do, however, agree with Bindseil (2004) when he argues that the most promising analytical approach follows Wicksell (1898, 1935) in emphasizing the importance of systematic monetary policy through interest rate rules and Poole (1968) who modeled the demand for liquidity by commercial banks as a buffer stock problem. An integrated synthesis of both is presented in Woodford's textbook (Woodford, 2003).

Operational frameworks have evolved and adapted in the last decades. A couple of decades ago they were fit for the static and stable concept that, as Padoa-Schioppa stressed, characterized most of the twentieth century. More recently, they have adapted so as to perform effectively in the context of widespread transformation and fast change in payments and settlements systems. Important aspects include a more resilient framework to absorb difficulties in forecasting liquidity shocks and a growing emphasis on the opportunity cost, for providers of payments services, of reliance on central bank money. As we will see in section 4, changes in the pipeline will not change the ability of monetary authorities to effectively adapt and respond to a changing environment.

As already referred above, the first author to look at bank's liquidity management as dependent on the incidence of stochastic shocks to banks liquidity positions was Poole, (Poole, 1968). It is fair to say that William Poole had formulated the basic model for banks reserve management. It provides the ground to model equilibrium in the interbank money market and implementation of monetary policy by the central bank. Recently, with the use of the corridor system, defined by central banks' standing facilities, there has been a revival research based on the model (see Woodford, 2003 and Bindseil, 2004 for a review of relevant issues and references to the literature). The framework proposed by Poole is flexible enough to deal with reserve maintenance periods with averaging provisions (see, for example, Gaspar et al., 2004 and Whitesell, 2006) and heterogeneity across commercial banks (Gaspar et al., 2004). Fortunately, the conceptual problems associated with the impact of payment systems on monetary policy implementation and the marginal demand for central bank money can be captured in the context of the simple single period model.

A typical bank, j, starts a trading day, labeled, T (which, for reasons that will become clear later on, refers to the last day of a reserve maintenance period) with a^j_T. Such a balance may be deposited with the central bank, in order to contribute to fulfilling reserve requirements, m^j_T, or it can be lent in the interbank market b^j_T (in case $b^j_T < 0$ the bank is borrowing from the market). The bank is assumed to have a reserve deficiency – the amount it needs to fulfill reserve requirements – of d^j_T at the beginning

of the period. When the bank lends funds in the market it earns the market interest rate, i_T (it pays the same market interest rate when it borrows funds from the money market).

The fundamental ingredient, in Poole's model, is, as we have already seen, a late shock to the banks liquid balances. The late shock is only realized after interbank money market transactions have already taken place. We will consider the case where the central bank offers two standing facilities: a marginal lending facility – where banks can get funds directly from the central bank at a penalty rate i^l – and a deposit facility – that banks can use to deposit funds with the central bank at the deposit rate i^d.

Banks are assumed to be risk-neutral profit maximizers in the interbank market. Thus the banks problem may be written:

$$\max_{b_T^j} \pi^j_T = i_T b_T^j - c_T^j \qquad (1)$$

where c_T^j is the net cost incurred by the bank because of its use of the central bank's standing facilities. The key step in what follows relates to the formulation of c_T^j. The expression for c_T^j may be written as:

$$\begin{aligned} c_T^j = {} & i^l \int_{-\infty}^{d_T^j + b_T^j - a_T^j} (d_T^j + b_T^j - a_T^j - \lambda_T^j) f_\lambda^j(\lambda_T^j) d\lambda_T^j + \\ & + i^d \int_{d_T^j + b_T^j - a_T^j}^{\infty} (d_T^j + b_T^j - a_T^j - \lambda_T^j) f_\lambda^j(\lambda_T^j) d\lambda_T^j \end{aligned} \qquad (2)$$

The equation for the cost of using the standing facilities makes explicit assumptions about the late liquidity shock λ_T^j. As already said above the late liquidity shock is stochastic and it will be assumed to have a continuous probability density function (pdf) $f_\lambda^j(\lambda_T^j)$. We make the convention that the liquidity shock creates settlement balances for the bank concerned. Therefore, if the liquidity shock is small enough, the bank will not have enough balances to fulfill reserve requirements without using the central bank's marginal lending facility. When that is the case the bank has to pay the marginal lending facility's interest rate on the remaining deficiency. For a given shock $\lambda_T^j < d_T^j + b_T^j - a_T^j$ the amount that the bank will have to pay to the central bank is:

$$i^l \times (d_T^j + b_T^j - a_T^j - \lambda_T^j).$$

The first integral just computes the expected cost over all realizations of the late liquidity shock implying recourse to the marginal lending facility. In case the late liquidity shock is large enough the bank will have more than enough funds to fulfill its reserve requirement obligations. Thus the excess amount will be deposited in the central banks deposit facility. Specifically when $\lambda_T^j > d_T^j + b_T^j - a_T^j$, the excess funds will be deposited and the bank will receive:

$$i^d \times (a_T^j + \lambda_T^j - d_T^j - b_T^j) = - i^d \times (d_T^j + b_T^j - a_T^j - \lambda_T^j).$$

Thus, the term on the right hand side represents the negative of the cost of using the deposit facility. It explains the second integral in the expression for the cost associated with the use of standing facilities[9].

Using (2) to substitute for c_T^j in (1) and computing the first order condition w.r.t. b^j_T one obtains:

$$i_T = i^l \times F_\lambda^j(d_T^j + b_T^j - a_T^j) + i^d \times (1 - F_\lambda^j(d_T^j + b_T^j - a_T^j)).$$

The expression may be re-arranged as:

$$\frac{i_T - i^d}{i^l - i^d} = F_\lambda^j(d_T^j + b_T^j - a_T^j),$$

that may be solved for b^j_T in order to get the net supply of funds by bank j to the interbank money market as:

$$b_T^j = a_T^j - d_T^j + \left(F_\lambda^j\right)^{-1}\left(\frac{i_T - i^d}{i^l - i^d}\right) \qquad (3)$$

In interpreting (3) a number of remarks are in order:

Remark 1: The net supply of clearing balances is (as intuitively expected) an increasing function of the money market interest rate, i_T.

Remark 2: If all interest rates in (3) are increased by the same proportional amount, the excess supply of funds is unchanged. Banks determine their optimal net supply of money market funds as a function of the ratio between the *difference* between the market rate and the deposit rate *relative* to the overall width of the corridor defined by the two standing facilities. The level of interest rates does *not* play a direct role.

Remark 3: When the spread between the interest rates of the standing facilities increases, the elasticity of excess supply of reserves, by a representative bank, declines (the excess supply function becomes more vertical close to the center of the interest rate corridor).

Remark 4: Poole (1968) single period model does not explicitly take into account the existence of required reserves and a reserve maintenance period with an averaging provision. However the extension has been made, for example, in Perez-Quirós and Rodriguez-Mendizábal (2006). They show that the shape of the excess supply of reserves on the last day of the reserve maintenance period is exactly as in the one period model. However, on days before the last the elasticity of excess supply close to the

[9] In Poole's original contribution the operational framework considered was not based on the corridor system. Specifically, it incorporated a discount window (similar to a Lombard facility or marginal lending facility) but it disregarded the existence of a deposit facility. It was in line with the Federal Reserve System's operational framework at the time. Poole's formulation is a particular case of the model formulated above when the interest rate on central bank's deposits is taken to be zero.

middle of the corridor increases substantially, the more so the further the period is from the last day of the reserve maintenance period (see Figure 3.1.). Naturally it is theoretically true and empirically confirmed that the standing facilities, defining the interest rate corridor are more intensely used closer to the end of the reserve maintenance period Figure 3.2.

Remark 5: it is possible to aggregate (3) across banks. It is the standard exercise of summing horizontally net supply curves across suppliers. Assuming perfect competition and the probability distribution function is the same across banks implies, because the net supply across all banks has to be zero in equilibrium and using capital letters to identify aggregate values per bank one obtains:

$$0 = A - D + (F_\lambda)^{-1}\left(\frac{i_T - i^d}{i^l - i^d}\right),$$

or, solving for the equilibrium interest rate:

$$i_T = i^d + (i^l - i^d) \times F_\lambda (D - A) \qquad (4).$$

In the two last equations we have used capital letters to denote aggregate variables. P to now we have considered the distribution of late liquidity shocks as given exogenously. It is clear, however, that such distribution depends on the information and accounting systems of commercial banks (**IA**) and on the architecture of market infrastructure, summarized by the characteristics of payments and securities settlement system (**PS**). Therefore, we may write:

$$\lambda_T^j \cong f_\lambda^j(\lambda_T^j; IA, PS) \qquad (5),$$

the important point to bear in mind is that the ability of the central bank to control interest rates in the market for daily funds does not depend on the characteristics of the stochastic distribution of late liquidity shocks. Clearly, as in Figure 3.3., the stochastic behavior of interest rates depends on the distribution of late liquidity shocks. Specifically, as shown already in Poole (1968) an increase in the volatility of late liquidity shocks increases the elasticity of excess supply of reserves by a representative bank. In Figure 3.3. it means that the excess supply function becomes more horizontal close to the middle of the interest rate corridor. However, given any distribution of late liquidity shocks the central bank will be able to adjust other characteristics of the operational framework to ensure control over daily interest rates with an adequate degree of volatility of daily market rates. In order to do so the central bank may want to change, for example, the width of the corridor and the length of the reserve maintenance period. More generally the central bank will always be able to maintain control under the assumptions of the model.

More fundamentally money is normally characterized by its functions as *unit of account, means of payment* and *store of value*. The idea is that if central bank money retains the fundamental role as *numeraire* in economic contracts *and* it retains its social role as the *final means of settlement*, then it does follow that central banks will maintain their ability to implement monetary policy (aiming at the stability of the unit of account

– price stability) while being at the same time intrinsically involved in the maintenance of financial market stability.

As we have seen in the previous section, the architecture of payments systems is based on both commercial bank money and central bank money. Commercial bank money provides the means to perform most economic transactions but central bank money remains at the root of the system, because it provides the final means of settlement. If commercial banks remain dominant in providing liquidity on demand and central banks remain the banks' bank, the implementation of monetary policy, through some variant of the corridor system will remain an effective means of controlling short term interest rates.

This is exactly in line with the argument in Padoa-Schioppa (2004). He argues that modern central banking emerged gradually pushed by two key developments in payments practices. The first is the gradual replacement of commodity currency by paper currency. The second is the gradual use of commercial bank deposits to substitute for banknotes and coin in normal payments practices. These two developments, together with its monopoly in the creation of its own liabilities, place the central bank at the vertex of the full web of payment systems existing in the economy. Therein are the roots of central banking functions. On the one hand, monetary stability, that is the stability of the value of money or, in other words, the stability of money as a standard of value or, finally, more simply, price stability. On the other hand, financial stability and that can be referred to, somewhat loosely, as the preservation of orderly market conditions.

Naturally, it is conceivable that alternatives to the pyramid system described in section two could develop. Hayek (1986) has famously argued that competition among private suppliers of standard of value and means of payment would be workable. Nevertheless, it seems to us, that there is public interest in a stable unit of account, which deserves to be protected. Moreover, modern economies rely on efficient and stable payment systems. If central banks strive for the best possible standards on both dimensions, central bank money should continue to lay the ground for a complex and ever changing pyramid of transactions (see quote from Bagehot in the conclusions). Recent trends in payment systems and in the operational framework for monetary policy show that these trends have already been marked in the last couple of decades. The role of central bank money as the ultimate means of settlement has not been affected by these developments. The same applies to central banks ability to control interest rates in the market for daily funds. During this period central banks have shown a remarkable ability to change in order to ensure they remain effective in maintaining price stability and contribute to the availability elastic payment services in line with the needs of the economy. In section 4 we will review recent developments and foreseeable trends.

4. Comments on recent trends

4.1 Drivers of change in payment systems

The payment system model described in fig.2.1 and section 2.1 is not uniform across the EU and the G-10 countries. Today's payment systems are the product of many years of change in the design of payment and settlement systems and the markets which they serve. Also, as emphasized before, it has nowadays to be seen as fast changing and innovative. There are a number of economic forces, affecting the financial system, as a whole, that have implications for payment systems and, in particular, for the balance of use of central and commercial bank money. Specifically, over the last couple of decades, financial markets have been affected by powerful forces of: liberalization, technological advances, globalization and consolidation. These drivers will continue to play a decisive role in the foreseeable future.

Liberalization of the activities that different types of institution can carry out inevitably blurs the distinctions between these institutions. Different countries have placed differently the distinction between banks and non-banks but the situation becomes more complex in a world of global service providers. Three main examples may be mentioned: 1) the emergence of financial institutions (such as investment firms) increasingly important in making payments to settle securities or foreign exchange transactions; 2) the emergence of provider of payment or settlement infrastructure, with a banking license, and, therefore, also acting as settlement agent; and 3) emergence of specialized institutions providing payment-related services (e.g. operator of ATM) traditionally provided by banks.

Interbank payment systems are also increasingly affected by **technological advances**. In particular, increasing levels of automation have allowed payment systems: 1) to increase the number of participants by allowing a large number of resident or non-resident institutions to be connected to the payment systems; 2) to increase the number of transactions by increasing the technical capacity of the system but also the processing time of transactions; 3) to move from paper-based payment to electronic payment instruments (e-money); 4) to develop liquidity saving mechanisms.

The liberalization of capital movements has resulted in a significant growth in cross-border flows in recent years. As a result, financial institutions active in the securities, foreign exchange, derivatives and other financial markets have, over a period of time, become more active in making and receive payments in multiple currencies. Although correspondent banking remains the main vehicle for channeling these payments, recent years have also seen the emergence of other more formalized services to cater such **global needs.** The prime example has been the creation of Continuous Limited System (CLS). Another example is the growing demand for facilities which optimize the global liquidity management, including for instance the possibility to use a single global cross-currency pool of assets to collateralize exposures as well as central bank credit.

In the European Union, the introduction of the single currency required the creation of an integrated payment and settlement system infrastructure. Already at the very start of the Monetary Union in 1999, a single RTGS system was introduced for settlement of all the payment transactions, denominated in euro, between market participants located in the different countries of the European Union. On the settlement side, the single market

and the single currency pushed towards **consolidation**. Although at the moment there is no single settlement systems for securities transactions of the whole euro area, some consolidation of infrastructure has taken place within the Euroclear group, as well as the Stockholm Stock Exchange. The effects of this consolidation have been an increase of concentration of payment flows in a few systems and participants. To the extent that consolidation takes place in systems settling in commercial bank money, and or facilitates the development of two-tier arrangements this has, in turn, affected the share of settlement in commercial bank money.

4.2 Recent trends in payment and settlement systems.

This sub-section elaborates on the likely implications that change in the design of payment systems may have on the demand for liquidity. The possible changes have been grouped according to whether they concern: 1) the "related weight" of settlement in central bank money versus settlement in commercial bank money; 2) potential spillover effects of settlement problems from one currency to another; 3) the time horizon for the demand of central bank money; 4) the potential emergence of a third alternative means of settlement. i.e. non bank commercial money.

4.2.1.*Central bank money versus commercial bank money*

Four types of changes are described in this sub-section: 1) development of some infrastructure providing settlement in commercial bank money; 2) development of central counterparty clearing and/or hybrid systems; 3) Development of formal or informal tiering arrangements and consequent internalization of settlement.

At the moment all the "domestic" large-value payment systems settle in central bank money. The three most important case of infrastructure providing settlement facilities in commercial bank money related either to systems settling securities transactions (Euroclear and Clearstream Banking Luxembourg) or to multi-currency systems (CLS). In the case of securities transactions settlement in commercial bank money is originated by the fact that a large number of participants in Securities Settlement Systems (SSSs) are non banks and do not have access to central bank money. In the case of multi-currency system settlement in commercial bank money is motivated by the need to keep different currencies account at the same institution. At the moment there is no institution that can open settlement accounts in central bank money in all the currencies. The development of securities markets can increase the need for settlement in commercial bank money to the extent that transactions are carried out by institutions which do not have access to central bank money. In this respect, in principle, the existence of institutions, like Clearstream and Euroclear, which have a banking license and provide securities settlement systems does not increase the level of commercial bank money but only increases its concentration. However, to the extent that these systems also channel transactions that can be settled in central bank money they may affect the relative share of the two settlement means. In particular, the fact that these systems provide more liquidity for settlement (since concern a large share of participants than systems settling in central bank money) and some additional added-value services for settlement of securities (e.g. securities lending, third-party repos) may, in normal situation, encourage a shift from settlement in central bank money to settlement in commercial bank money (see table 4.1).

Central counterparties have been since long operating in the field of derivatives. More recently they have expanded their activities so as to cover also securities. It has been the case in Europe for London Clearing House (LCH), Clearnet and more recently also Eurex. By increasing net versus gross-settlement CCPs have reduced the size of cash settlement triggered by securities transaction. The unique position of a CCP, in being the counterpart to each contract, greatly simplifies the ability to have multilateral netting on CCP arrangements. Past studies have shown that netting can result in significant decreases in obligations of exchange members relative to the underlying gross positions---exceeding 90 per cent reductions in some cases.[10] A practical example, of this potential has been shown by the reduction in the amount of settlement of German bunds registered after the introduction of Eurex facility for cash securities.

Hybrid systems are system that combines features of gross and net settlement systems. The movement from "pure" settlement systems to "hybrid" systems has led to a reduction of settlement in central bank money, due on the use of netting facilities, i.e. the possibility to net over time payments of payments sent and received instead of having recourse to central bank credit for immediate settlement of the transactions. When an hybrid system operate in parallel to a pure RTGS system, further reduction of settlement in central bank money can be due to shifts of settlement from the RTGS to the hybrid system.

Two-tiering systems are systems where some participants (so-called second tier participants) do not settle their balances directly on the central bank accounts but through the settlement accounts of other participants (called first tier participants, or settlement members or clearing members, according to the system). Settlement between first and second tier participants takes place in commercial bank money in the correspondent accounts. The existence of two-tier systems mainly facilitates concentration of settlement in a few institutions. However to the extent that it introduces some form of netting in the books of the first tier institutions it reduces the size of settlement in central bank money. As already mentioned in section 2, countries (such as for instance United Kingdom) characterized by a strong tiering structure have in fact lower settlement volumes than countries without such a structure.

4.2.2 *Multi-currency central bank money*

Multi-currency and offshore systems normally settle in commercial bank money. In principle participants in these systems are not allowed to settle in central bank money since they are located in a different country than that of the central bank issuing the currency. This is true by definition for offshore systems and largely true for most of the currency settled in a multicurrency system. The creation of these systems may affect the monetary stance to the extent that they may create an "external" additional demand for liquidity, aim at ensuring the smooth functioning of a payment system that is not under the control of the central bank of issue. The central bank concerned must take these factors into account. The development of the CLS included the expansion of the range of eligible currencies from 7, when it was launched in 2002, to 15 by the end of 2004, contributed to reduce credit and liquidity risk in foreign exchange settlement. The extension of eligible currencies, of which the euro is the second largest, is still under

[10] See for example, BIS (1990) and Considine (2001).

consideration. Should a major problem occur in CLS (e.g. if a participant is not able to fund its obligations as far as euro transactions are concerned) and given the importance of the euro in CLS currency distribution (20.4% in 2005 compared to 46.6% for USD), injections of euro liquidity may be warranted, in order to prevent systemic implications

Offshore systems are systems that enable transactions denominated in one currency to be processed in another currency area. There are for instance two offshore systems for euro, notably the Swiss EuroSIC and the EuroCHATS in Hong Kong respectively launched in 1999 and 2003. Both systems settle in commercial bank money. It could be feared that this last characteristic might have impacts on the control of the monetary stance. To the extent that these systems settle in commercial bank money they could increase the share of settlement in commercial bank money. In fact the system just replaces bilateral settlement in commercial bank money with more structured settlement in central bank money. In this respect, in normal situation the impact is largely to be closed to zero. Moreover, given the low values settled these systems (e.g. for euro they represents less than 1% of the value processed in TARGET), it is unlikely that their impact may be significant.

4.2.3. *Demand for intraday liquidity*

The demand for intraday liquidity is influenced by three main developments.

The possibility of developing intraday markets would allow commercial banks to exchange intraday deposits in central bank money thereby reducing the demand of central bank money to the central bank. The business case for the development of such a market depends on the opportunity costs for central banks money. As long as the central bank intraday credit is not priced and there is enough collateral available to secure the operations, this possibility is not likely to materialize, as it is the case today in the euro area.

The development of hybrid systems (as described above) and liquidity saving features in large value payment systems (e.g. queue release algorithms, offsetting algorithms) can allow reducing the demand for intraday credit. These facilities allow by definition to postpone payments when available liquidity is not sufficient.

4.2.4 *Non bank commercial bank money*

Central banks and commercial banks are no longer the only issuers of money in an economy. For example, since a few years, we have witnessed the development of electronic money provided by non-banks; e.g. mobile phone operators, internet payment facilities. In theory those do not differ from commercial money, provided that they are equally accepted.

However, this change raises level playing field concern as these entities are not subject to the same regulatory regime as banks. From a central bank perspective, this difference in terms of regulation might have consequences especially in case of crisis. Hence, given that they are less strictly regulated than banks; their effect of their difficulties might be larger, implying a higher level of liquidity demand and therefore impacting the control of the monetary stance. It can then be argued that these institutions might have a

competitive advantage in not supporting the same level of regulation but benefiting of the same level of liquidity provision as banks.
In the European Union, the money directive – currently under review – has been developed in 2000 to cover this evolution of non-credit institution issuing money.

4.2.5 *Summary and Overview.*

The recent developments in the field of payment and settlement systems may lead to increase or decrease in the use of central bank money as settlement means for payment system transactions. In particular, the effects of the recent developments in payment systems described in the previous paragraphs have been summarized in tables 4.1 and 4.2 considering, respectively, normal situations and crisis.

As shown in the table 4.1., the recent developments in the design of payment systems have been successful in determining in normal situation a reduction of the demand of central bank money for settlement of payment and securities transactions. (2^{nd} column). The use of technology has increased the velocity of circulation of money by allowing optimization mechanisms that, in turn, allow the re-use of the same funds for the settlement of an increasing number of payments. Moreover, the emergence of more sophisticated (global) markets and products and the consequent need for more sophisticated tools for liquidity management and in the EU the growing relevance of "banks-providers of settlement facilities" has increased concentration of payment flows in a few operators and to a certain extent settlement in commercial bank money. The only recent development that goes in the direction of increasing the use of central bank money is the possibility of use foreign assets to collateralize central bank credit. The eligibility of foreign assets increases the pool of collateral that in particular global players may use in their operations with the central bank (1^{st} column). Finally the need for intraday liquidity has been generally reduced by the introduction of hybrid systems and other optimization routine. (3^{rd} column).

However, whatever is the sign of the change, in normal situations (and if the system is well designed) these changes do not affect the ability of central banks to control the monetary stance. Indeed we have seen in section 3 that modern operational frameworks adapt automatically to such developments.

We discuss crisis situations separately. The effects of various designs for payment systems on the marginal demand for central bank liquidity in case of a financial crisis are summarized in table 4.2.

When the systems are not properly designed and, in particular, in crisis situations the smooth functioning and/or regular closing of payments systems will create a demand for central banks to create additional liquidity. This would be partly due to difficulties in transferring liquidity (it would be the case in case of operational problem) or additional uncertainties in the effective liquidity conditions (due to the fact that it will become unclear to what extent payments carried out or to be carried out by the defaulting institution and/or system would be effectively settled with finality). In this case, the spillover effect of systemic risks will be affected by the design of the payment systems. In particular, 1) in case of systems characterized by high concentration (two tier systems, internalization) spillover effects will be **lower** if the first tier or internalizing institution will be able to "absorb" and filter the losses for the rest of the system) and

higher in case in which instability in the payment systems is generated by one first tier or internalizing institution; 2) in case of optimization facilities based on netting mechanisms the systemic effects will depend on whether the netting arrangements will be legally binding is all the relevant jurisdictions and enforceable also in case of insolvency; 3) in case of CCPs and/or payment or settlement systems with banking license, it will depend on the effectiveness of the risk framework of these systems. However, even in the event of such extreme circumstances, the framework of section 3, still applies as the relevance of payments systems on monetary policy is still felt through their impact on the stochastic characteristics of the demand for liquidity.

5. Conclusion.

"Credit in business is like loyalty in government. (...) an immense system of credit, founded on the Bank of England as its pivot and its basis, now exists. The English people, and foreigners too, trust it implicitly. Every banker knows that if he has to *prove* that he is worthy of credit, however good may be his arguments, in fact his credit is gone: but what we have requires no proof. The whole rests on an instinctive confidence generated by use and years. Nothing would persuade the English people to abolish the Bank of England; and if some calamity swept it away, generations must elapse before at all the same trust would be placed on any other equivalent. (...) Those who live under a great and firm system of credit must consider that if they break up that one they will never see another, for it will take years upon years to make a successor to it.

Walter Bagehot, *Lombard Street*, (originally 1873), page 81, in Norman St John-Stevas, *The Collected Works of Walter Bagehot*, vol IX, London, The Economist, 1978.

We have argued in this paper that money is one of the fundamental institutions of society. Money is able to provide liquidity and to facilitate transactions because it is based on stability and trust. It is unclear whether our current system based on the co-existence of central bank money and commercial bank money is optimal. Given the present state of research it is not even obvious on the basis of what criteria one would evaluate optimality. What is clear is that the current system does work and that it does provide valuable services to society. Clearly there is tremendous value associated with the general agreement around such a social convention. Building up an alternative would be, as Bagehot, warns us a long and difficult process.

From the viewpoint of central banking these remarks are truly fundamental. We agree with Padoa-Schioppa (2004) when he argues that the issuance of central bank money lies at the root of all central banking functions.

In this paper, we have also argued that the coexistence of central bank money and commercial bank money in payments systems enables it to supply an *elastic currency* responsive to the transactions needs of the economy. It allows the flexibility, dynamism, innovation and efficiency of an open market economy to be reconciled with the fundamental requirement of preserving stability and trust. We think it is not exaggerated to state that stability and trust provide the foundations for dynamism, innovation and efficiency.

The stylized model of payments systems, allowing for the coexistence of central bank money and commercial bank money that we have described in section 2, is not uniform across geographical areas. Moreover, it has been changing fast in the more recent decades. However, such transformations have not endangered the central banks ability to determine the monetary policy stance. In today's world the conduct of monetary policy is exercised through the control over money market interest rates, normally the interest rate in the market for daily funds.

According the modern theory of monetary policy, monetary policy can be best understood as operating through the control of interest rates. By systematically changing interest rates, in response to the relevant circumstances of the economy, the

central bank is able to safeguard the value of the currency. In other words, the central bank is able to deliver price stability. At the same time, the central bank contributes to the overall stability of the economy, in general, and of the financial system, in particular.

In this paper, we have argued that an operational framework for monetary policy, based on the corridor system, for daily interest rates, is likely to prove robust to changes in payments practices and in the relevant technology. In a sense we would even go so far as to argue that the prevalence of the corridor system in industrialized countries today reflects the fact that such framework seems particularly well suited to work towards a concept of elastic currency. Moreover, the central bank, as a non-profit institution, is ready to adapt its way of operating to changing business circumstances. The importance of these considerations is reflected in the current practice of remunerating reserves or, alternatively, to allow averaging around zero or very low bank reserve levels. Clearly, control over the monetary stance depends on control over the opportunity cost of settlement balances at the margin. The operational framework can be designed in such way as to make average costs arbitrarily small. Therefore, the current concept will prove resilient as long as the banking system will continue to be the main provider of payment services in the economy.

It would be wrong to interpret our line of argument as providing reasons for complacency. Monetary policy has been able to remain effective and successful because it has adapted to a fast changing environment. The importance of the ability to adapt to changing circumstances will remain key.

REFERENCES

Bagehot, 1873, *Lombard Street*, London: The Economist.

Bindseil, U., 2004, *Monetary Policy Implementation: Theory, Past, and Present*, Oxford: Oxford University Press.

BIS 1990, Report of the Committee on interbank netting schemes of the Central Banks of the G-10 countries, November

BIS, 2003, The role of central bank money in payment systems, Bank for International Settlements.

Borio, Claudio, 1997, The Implementation of Monetary Policy in Industrial Countries: a Survey, *BIS Economic Papers*, Nº 47, July.

Borio, Claudio, 2000, A hundred ways to skin a cat: comparing monetary policy operating procedures in the United States, Japan and the euro area, *BIS Economics Paper*, 9.

Borio, C., D. Russo and P van den Bergh, 1991, Payment System Arrangements and Related Policy Issues: a Cross-Country Comparison in Franco Passacantando (ed.), *Payment System Issues in the Perspective of European Monetary Unification*, Banca d'Italia.

Considine, Jill, 2001, "Embracing, but risk-managing our differences ", in Albert Bressand, (ed), *Capital Markets of the 21st Century*, Paris-Luxembourg, The Edmond Israel Foundation with PROMETHEE.

Fama, Eugene, 1980, Banking in the Theory of Finance, *Journal of Monetary Economics* 6, January: 39-57.

Fleming, M., Garbade K., 2005, Explaining Settlement Fails, in *Current Issues in Economics and Finance*, Volume 11, n. 9 Federal Reserve Bank of New York, September

Freedman, C., 2000, Monetary Policy Implementation: Past, present and future. Will elecronic money lead to the eventual demise of central banks?, *International Finance* 2 (3): 211-227.

Freeman, S., 1985, Transactions Costs and the Optimal Quantity of Money, *Journal of Political Economy* 93, February: 146-157.

Friedman, Benjamin, 1999, The Future of Monetary Policy: The Central Bank as an Army with Only a Signal Corps, *International Finance*, 2: 321-338.

Friedman, M, 1968, The Role of Monetary Policy, *American Economic Review*, 58 (1), March.

Furfine, Craig, 2000, Interbank Payments and the Daily Funds Rate, *Journal of Monetary Economics*, 46: 535-53.

Gaspar, Vitor, Gabriel Perez_Quirós, and Hugo Rodrigues-Mendizabal, 2004, Interest Rate Determination in the Interbank Market, *ECB Working Paper* 351, April.

Goodhart, C., 2000, Can central banking survive the IT revolution? *International Finance* 2 (3): 189-209.

Hamilton, James, 1996, The Daily Market for Federal Funds, *Journal of Political Economy*.

Henckel, Timo, Alain Ize and Arto Kovanen, 1999, Central Banking without Central Bank Money, *IMF Working Paper*, March.

Hilton, Spence, 2005, Trends in Federal Funds Rate Volatility, *Current Issues in Economics and Finance*, Federal Reserve Bank of New York, July.

Kahn C M, W. Roberds, 2005 Payments settlement: tiering in private and public systems, April

King, Mervin, 1999, Challenges for Monetary policy. New and Old, in *New Challenges in Monetary Policy*, Kansas City: Federal Reserve of Kansas City.

Mc Andrews, Trundle, 2001, *New payment system designs: causes and consequences,* Bank of England Financial Stability Review, December

Orr, Daniel and W.G. Mellon, 1961, Stochastic Reserve Losses and Expansion of Bank Credit, *The American Economic Review*, vol. 51, nº4, September, pp.614-623.

Padoa-Schioppa, Tommaso, 2004, *The Euro and Its Central Bank: Getting United After the Union*, Cambridge: MIT Press.

Perez-Quirós, Gabriel and Hugo Rodrigues-Mendizabal, 2006, The Daily Market for Funds in Europe: Has Something Changed with EMU?, *Journal of Money Credit and Banking.*

Poole, William, 1968, Commercial Bank Reserve Management in a Stochastic Model: Implications for Monetary Policy, *Journal of Finance*, 23: 769-91.

Poole, William, 1970, Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model, *The Quarterly Journal of Economics*, vol. 84, Nº2, May, pp.197-216.

Wicksell, Knut, 1898, *Interest and Prices*, English translation by R.F. Kahn, London, Macmillan.

Wicksell, Knut, 1935, *Lectures on Political Economy: volume two – Money*, London: Routledge & Kegan Paul.

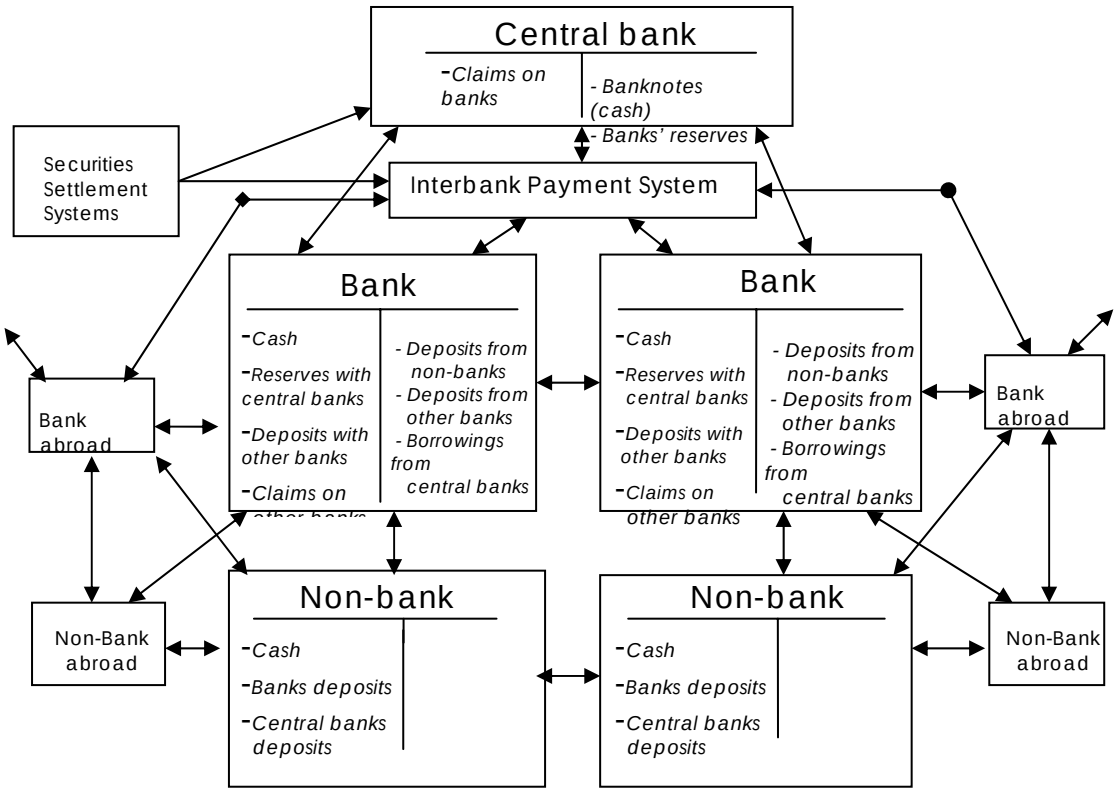
Woodford, Michael, 1998, Doing Without Money: Controlling Inflation in a Post-Monetary World, *Review of Economic Dynamics* 1: 173-219.

Woodford, Michael, 2000, Monetary policy in a world without money, *International Finance* 2 (3): 229-260.

Woodford, Michael, 2001, Monetary Policy in the Information Economy, in *Economic policy for the Information Economy*, Kansas City: Federal Reserve of Kansas City.

Woodford, Michael, 2003, *Interest & Prices: Foundations of a Theory of Monetary Policy*, Princeton: Princeton University Press.

Figure 2.1.: Transfer of funds in payment systems



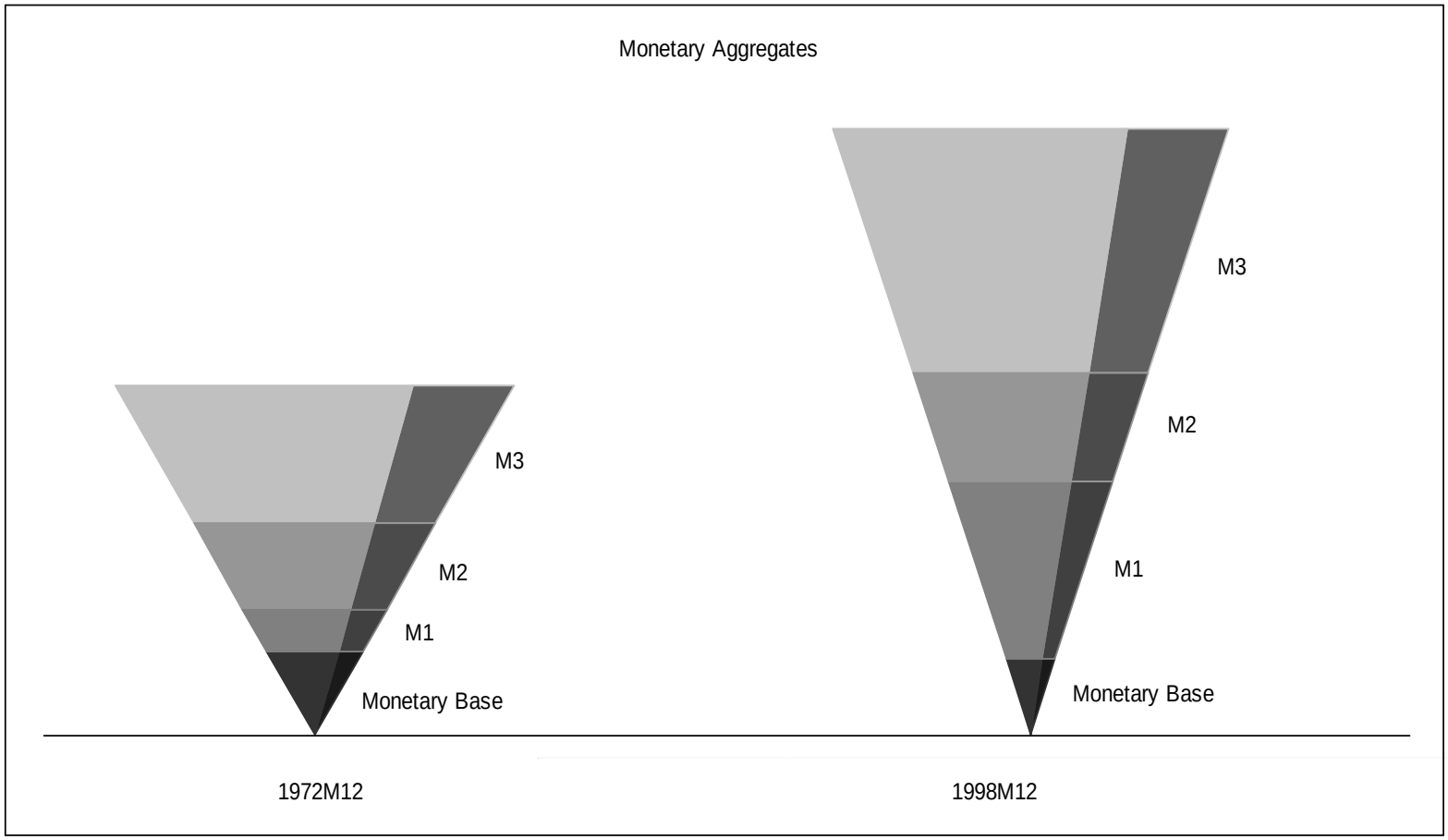


Chart 2.1 – Monetary Aggregates in Germany

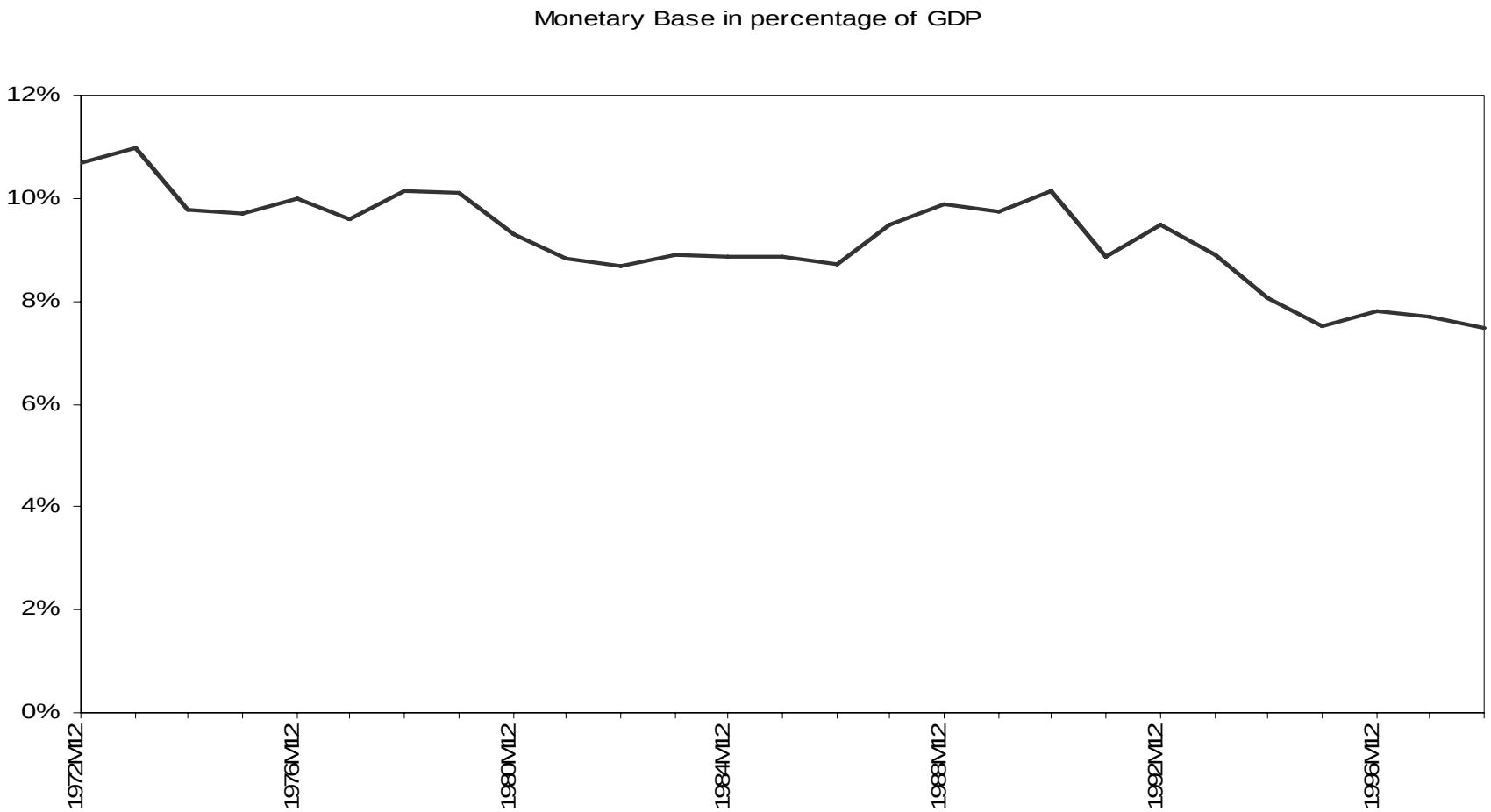


Chart 2.2 – Monetary Base in percentage of GDP in Germany

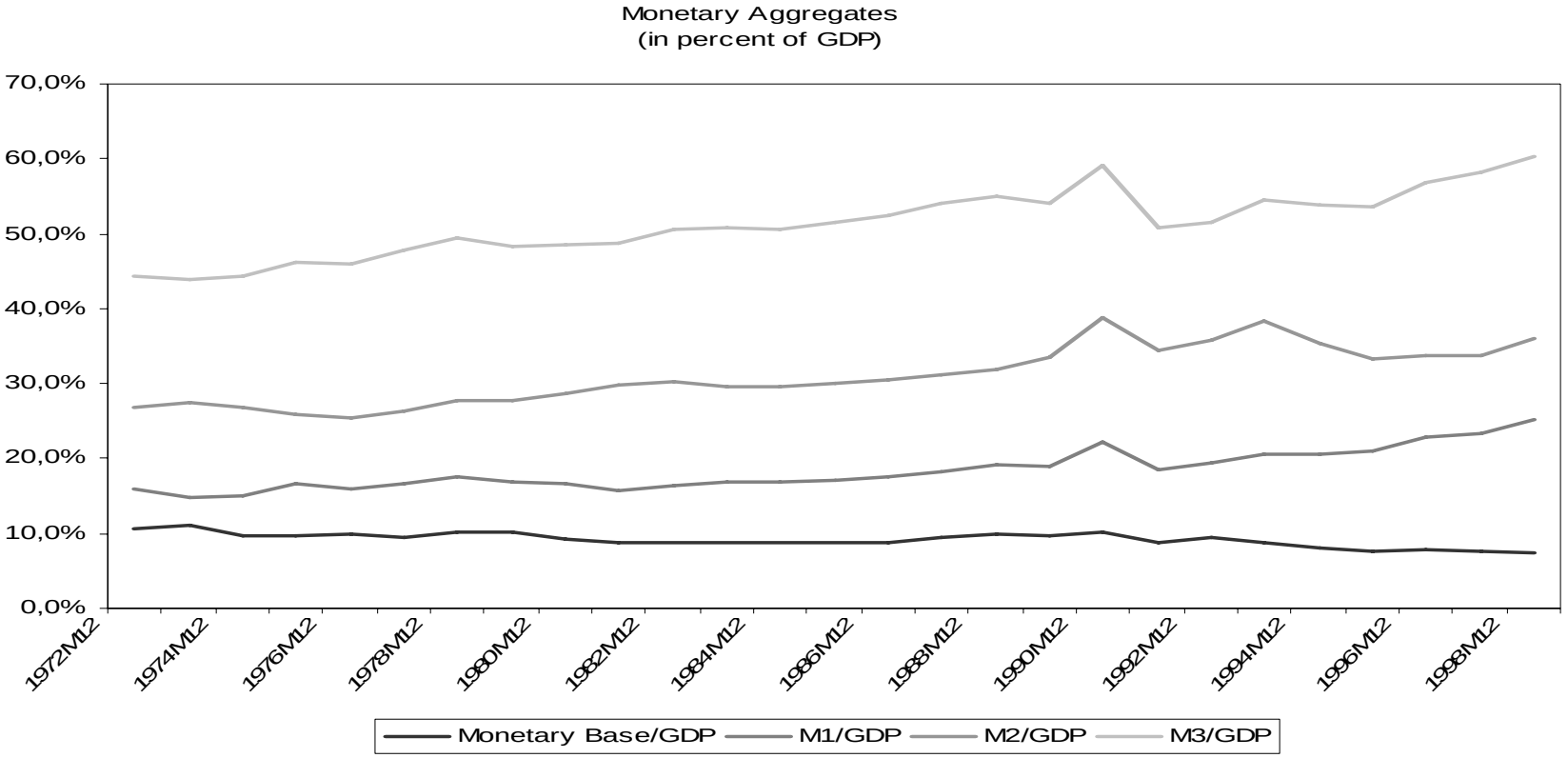


Chart 2.3 – Monetary Aggregates (in percent of GDP) in Germany

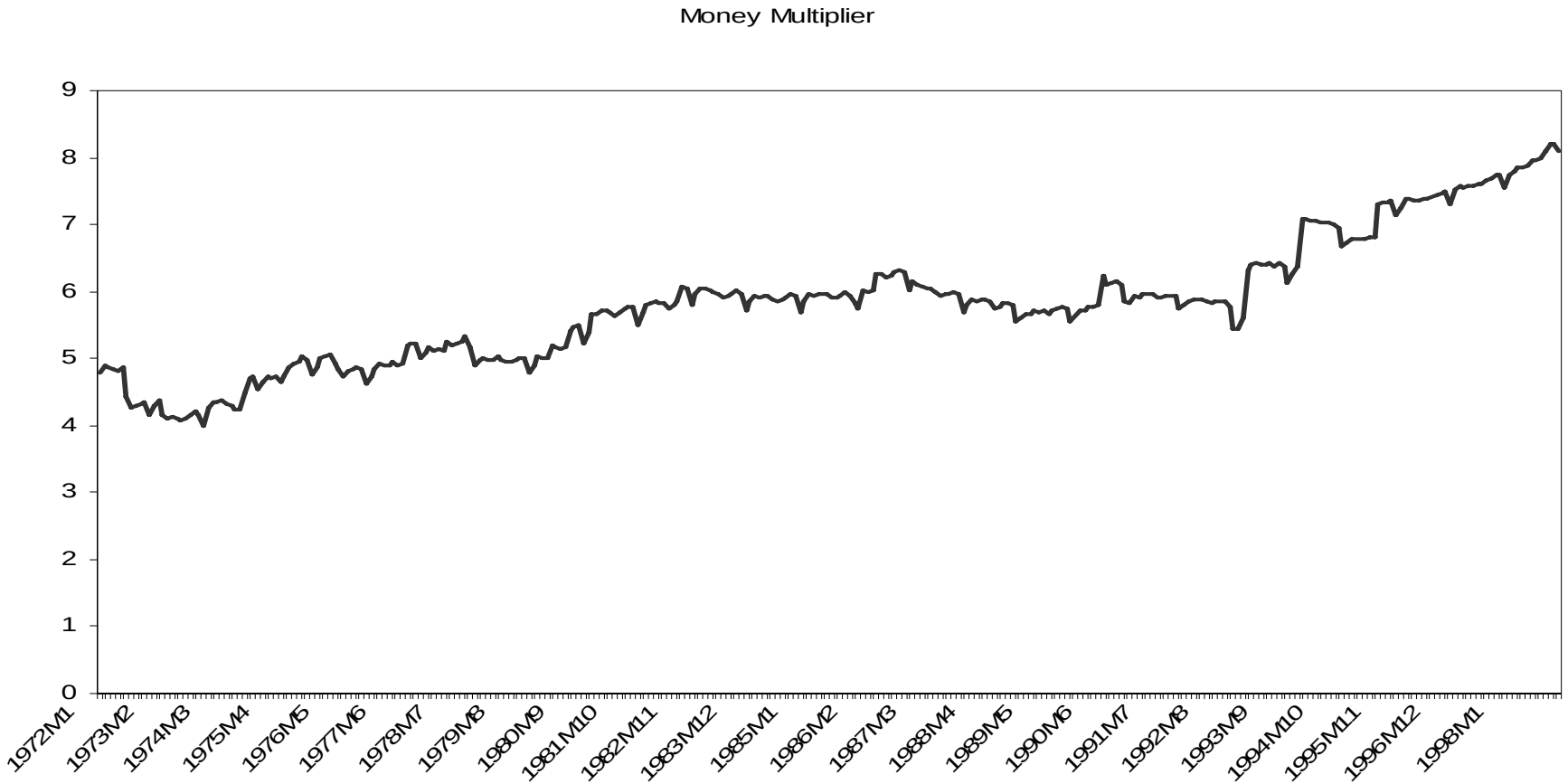


Chart 2.4 – Money Multiplier in Germany

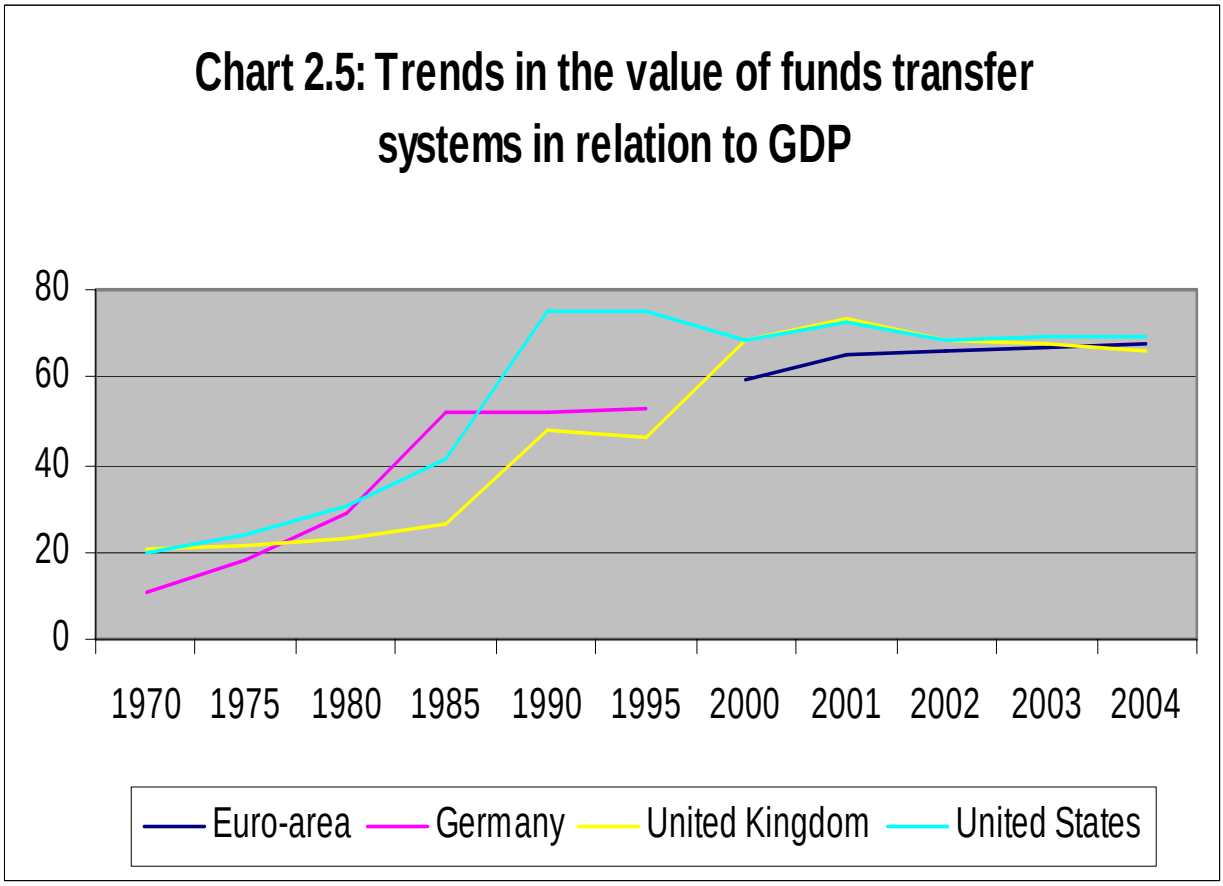


Chart 2.5: Trends in the value of funds transfer systems in relation to GDP
80
60
40
20
0
1970
1975
1980
1985
1990
1995
2000
2001
2002
2003
2004
Euro-area
Germany
United Kingdom
United States

Table 2.1: Funds used in payment systems (end 1988 – end 2004)

	Non-bank settlement media				**Settlement media**			
	as a percentage of GDP							
	Currency in circulation		Value of overnight deposits with banks		Balances with Central Bank		Transferable deposits with other banks (1)	
	1988	*2004*	*1988*	*2004*	*1988*	*2004*	*1988*	*2004*
Euro-area	7	5.54	25	34.56	3	1.80	5	1.17
Canada	3.5	3.37	16	24.30	0.4	0.00	0.5	0.60
Japan	10	14.78	36	74.40	1	5.50	2	2
Sweden	5	3.86	42	54.40	0.00	0.00	11	3.10
Switzerland	9	8.12	20	35.30	2	1.20	2	16.20
United Kingdom	3.32	3.32	44	268.70	0.20	0.20	17	42.70
United States	4	5.99	12	7.80	1	0.20	0.70	0.20

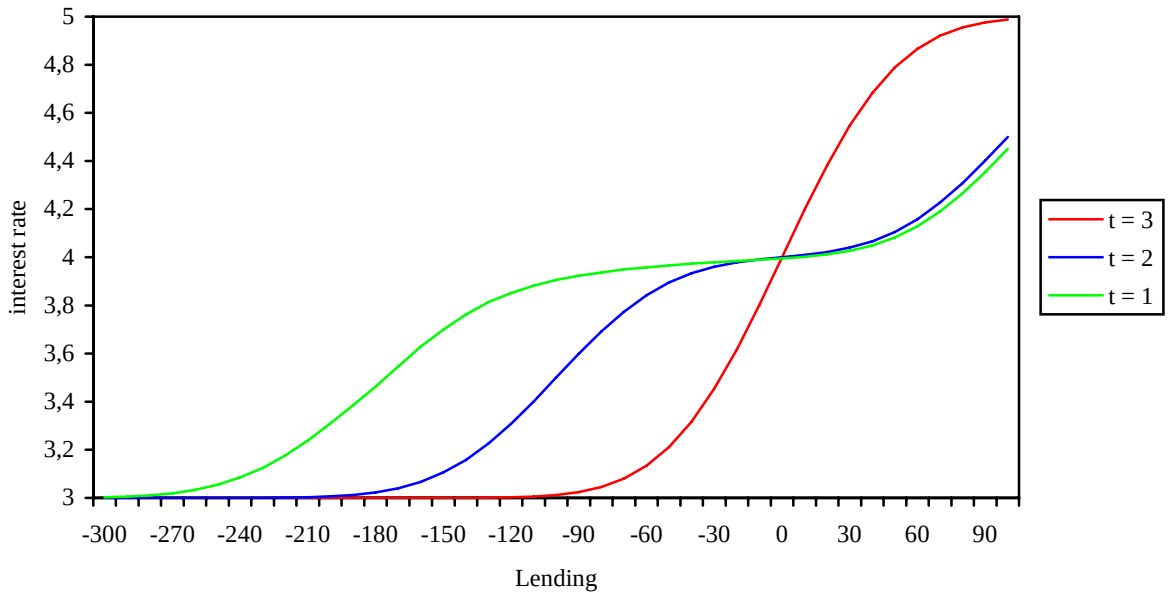


Fig. 3.1 – Excess supply of reserves in different days of the reserve maintenance period.

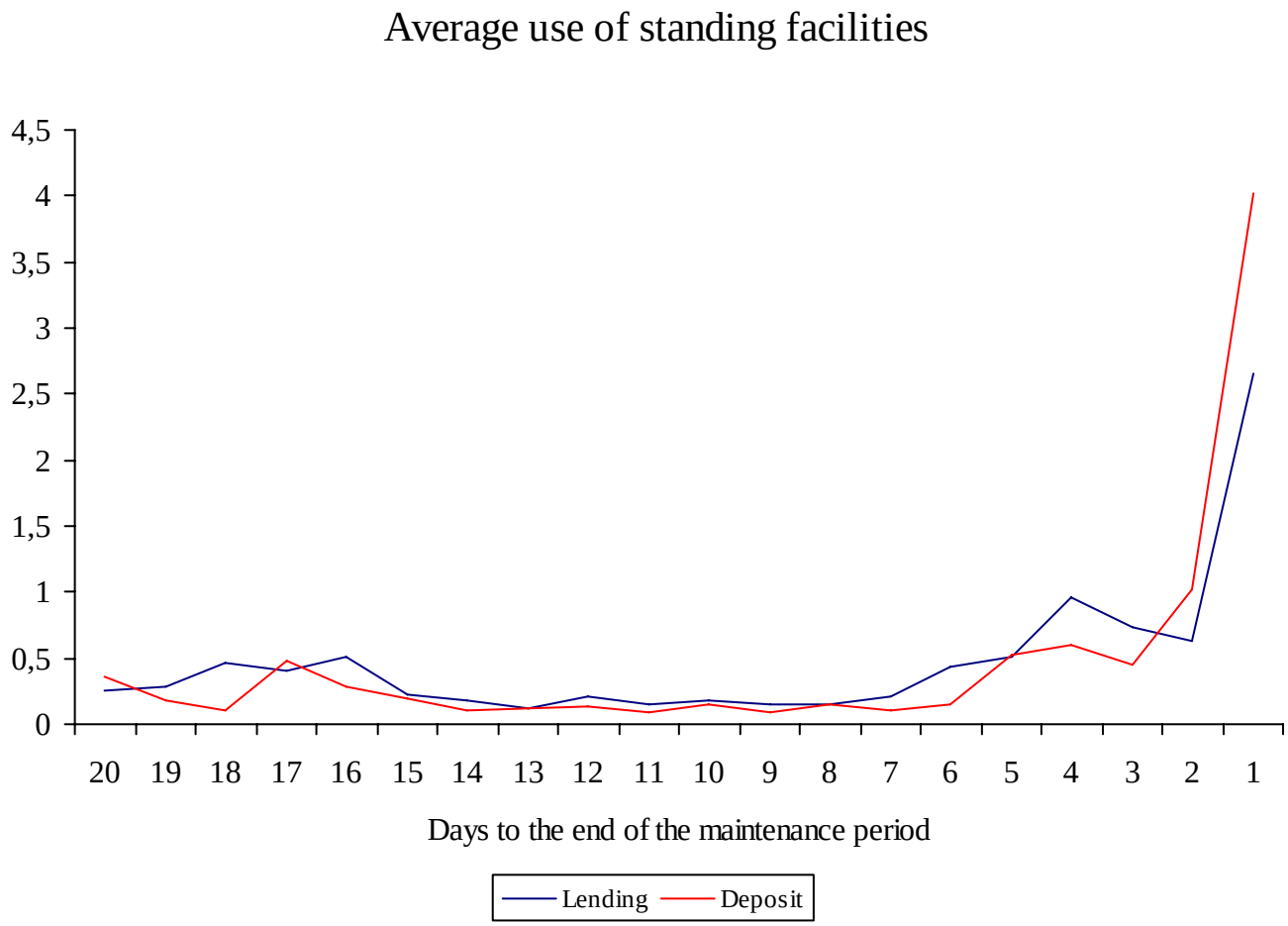


Fig. 3.2 Use standing facilities in the euro area.
Source: Perez-Quirós and Rodriguez Mendizabal

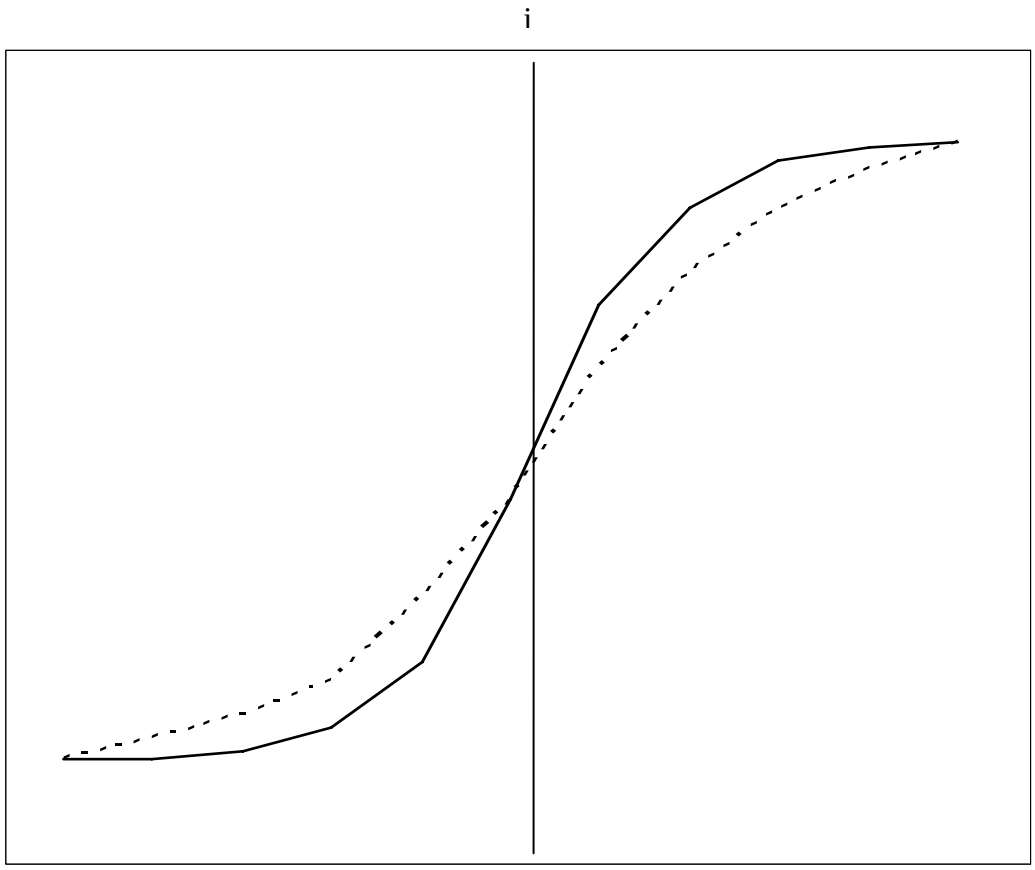


Fig. 3.3 Excess supply of reserves and volatility of late liquidity stocks.

Table 4.1: Normal situations

Impact on: Changes	Volume of Central bank money/ commercial bank money	Demand for liquidity (in central bank or commercial bank money)	Demand for intraday liquidity
Development of infrastructure settling in commercial bank money	In normal situations: Reduction of CeBM-		
Development of CCP	Reduction if CeBM (due to likely increase in tiering) arrangements)	Reduction	
Tiering	Reduction of CeBM-	Reduction (due to internalization)	
Internalization	Reduction of CeBM	Reduction	
Multi-currency facilities			
Use of foreign collateral	Increase of CeBM		
Development of intraday markets		Reduction	Reduction
Hybrid systems	Increase of CeBM	(reduction in case of netting)	Reduction
Non bank commercial bank	Reduction of CeBM		Reduction

Table 4.2: “Crisis” situations

Impact on: Changes	Central bank money/commercial bank money	Demand for liquidity	Demand for intraday liquidity
Infrastructure settling in commercial bank money	Increase	Increase	Increase,
Development of CCP		Reduction if default of a participants Increase if problem of a CCP	Same as previous column
Tiering	Reduction of CeBM-	Increase if default of the first tier	Increase
Internalization		Increase if default of the internalizing entity	Same as previous column
Multi-currency facilities		Increase	Possible increase
Use of foreign collateral			
Development of intraday markets		Reduction	Reduction
Hybrid systems			Reduction
Non bank commercial bank			