BANK OF FINLAND DISCUSSION PAPERS

26 • 2001

Harri Lahdenperä
Research Department
12.12.2001

Payment and financial innovation, reserve demand and implementation of monetary policy

Suomen Pankin keskustelualoitteita
Finlands Banks diskussionsunderlag

Suomen Pankki
Bank of Finland
P.O.Box 160
FIN-00101 HELSINKI
Finland
☎ + 358 9 1831

http://www.bof.fi

BANK OF FINLAND
DISCUSSION PAPERS

26 • 2001

Harri Lahdenperä
Research Department
12.12.2001

Payment and financial innovation, reserve demand and implementation of monetary policy

I would like to thank Risto Herrala, David Mayes, Juha Tarkka, Jouko Vilmunen, Matti Virén and Tuomas Välimäki for many helpful comments and discussions.

Suomen Pankin keskustelualoitteita
Finlands Banks diskussionsunderlag

http://www.bof.fi

ISBN 951-686-761-8
ISSN 0785-3572
(print)

ISBN 951-686-762-6
ISSN 1456-6184
(online)

Suomen Pankin monistuskeskus
Helsinki 2001

Payment and financial innovation, reserve demand and implementation of monetary policy

Bank of Finland Discussion Papers 26/2001

Harri Lahdenperä
Research Department

Abstract

The consequences of electronic trading, payment and settlement have recently become one of the main topics in monetary economics. New innovations in payment and settlement technology are challenging the central bank's monopoly over the supply of base money, which is generally considered the cornerstone of the central bank's power to set the short-term interest rate for the economy. This paper demonstrates that the development of the economy's transaction technology over time has indeed had a significant quantitative impact on the demand for currency and bank reserves, and indirectly on the modalities of the supply of reserves by the central bank. In contrast to past trends, the latest innovations in payment and settlement technology imply not only a quantitative change but also a qualitative one, as they enable private institutions to issue settlement money that competes with the liabilities of the central bank. The paper presents a model on the implementation of monetary policy in an economy where such private substitutes for central bank money are available for the settlement of transactions, showing that effective monetary control by the central bank might indeed be compromised in those circumstances. However, the study also highlights several attributes that may distinguish central bank liabilities from any private alternatives, some of which are based on the central bank's traditional role as the banker for the Government.

Key words: monetary policy, reserve demand, payment systems, financial innovation

JEL classification numbers: E41, E43, E51

Rahoitusinnovaatioiden vaikutukset reservien kysyntään ja korkopolitiikan toteutukseen

Suomen Pankin keskustelualoitteita 26/2001

Harri Lahdenperä
Tutkimusosasto

Tiivistelmä

Elektronisten maksuvälineiden sekä elektronisen kaupankäynnin ja selvityksen vaikutukset keskuspankkien toimintaan ja korkojen määräytymiseen ovat viime vuosina nousseet yhdeksi rahatalouden keskeisimmistä tutkimuskohteista. Koska keskuspankin valta ohjata rahamarkkinakorkoja perustuu viime kädessä sen monopoliasemaan rahaperustan eli talouden perimmäisen selvitysrahan tarjonnassa, maksu- ja selvitystekniikan innovaatioilla voi potentiaalisesti olla merkittäviä vaikutuksia rahapolitiikan toimintamahdollisuuksiin. Tässä tutkimuksessa osoitetaan, että maksuvälineiden ja maksutekniikan kehityksellä on ajan saatossa todella ollut merkittävä määrällinen vaikutus käteisrahan ja pankkien reservien kysyntään ja tätä kautta myös keskuspankkien reservien tarjonnan ehtoihin. Uusimmat tekniset innovaatiot vähittäis- ja tukkumaksuissa voivat merkitä myös laadullista muutosta, sillä ne mahdollistavat keskuspankkirahan kanssa kilpailevan yksityisen rahan liikkeeseenlaskun. Tutkimuksessa mallinnetaan korkopolitiikan harjoittamista tällaisessa kilpailevan rahan maailmassa ja osoitetaan, että yksityinen selvitysraha muodostaa vakavan haasteen keskuspankin mahdollisuuksille ohjata talouden korkotasoa. Tutkimuksessa tuodaan kuitenkin esiin useita tekijöitä, jotka erottavat keskuspankin liikkeeseen laskeman rahan yksityisistä kilpailijoista ja saattavat siten mahdollistaa tehokkaan korkopolitiikan harjoittamisen myös kilpailevan rahan maailmassa. Osa näistä tekijöistä perustuu keskuspankin perinteiseen toimintaan valtion pankkina.

Asiasanat: rahapolitiikka, reservit, maksujärjestelmät, rahoitusinnovaatiot

JEL-luokittelu: E41, E43, E51

Contents

1 Introduction

The conduct of monetary policy through open market operations, in order to influence bank liquidity and interest rates, presumes a certain institutional and technological framework that in turn affects money demand function, the money supply process, and the nature of the transmission process relating short-term interest rates and inflation. In this study, we analyse how long-run changes in that institutional and technological framework affect the first two factors, ie money demand and supply, and their interplay in the determination of the interest rate.

The payment system, including both the major payment instruments in use as well as the type of value transfer technology, is the main part of the institutional framework, which affects money demand and supply in the long-run. The other major factor is the state of development of money markets. Their impact can clearly be revealed by reviewing the long-run evolution of money demand and supply models.

The close link between payment technology and money use is inherent in money demand models, which are based on the assumption that microeconomic units differentiate in their asset-holding behaviour between those assets that are and those that are not widely accepted as means of payment by other economic units. In other words, there is a demand for monetary liabilities issued by the central bank and deposit banks, even if monetary assets yield no or lower interest than other financial assets, as money is the only effective medium for settling transactions in the economy.

The transaction demand for money is crucially dependent on the sophistication of payment technology. Over decades, advances in payment systems have enabled a more economic use of cash balances, which is reflected in the trend-wise increase in the velocity of money. During the last two decades electronic card payments have substituted for physical cash for larger retail payments, but for small-value payments physical cash has remained the dominant payment method. In wholesale payment activity, savings in the use of reserve balances have been even more profound. With the development of electronic large-value payment systems and modern money markets, commercial banks' free demand for non-remunerated clearing reserves at central bank accounts has fallen to negligible amounts. Those developments have induced major changes in central bank operating procedures, the main tendency being a move from quantitative targets to short-term interest rate targets. At the same time, the disparity between the small size of central bank operations and vast volumes in private financial markets has grown steadily (Annex 1).

Reduced demand for central bank money has not hampered central banks' ability to conduct monetary policy, as they have retained the control of commercial banks' settlement balances. The monopoly over the supply of base

money gives the central bank enormous leverage over the value of transactions in the economy, even though the size of its balance sheet is small in relation to those of the private sector. Indeed, many regard central banks of developed economies today stronger than ever before, and no one in financial markets seems to be questioning central banks' ability to strongly influence the development of nominal and also real interest rates. Sometimes a mere signal by the central bank of an intention to change the level of short-term rates in the future can, via the interest rate expectations effect, strongly influence longer rates.

However, recent developments in payment media and systems underpinned by advances in electronic technology have brought the wave of change ever closer to the core of central banking by starting to innovate close substitutes to the monetary base. Smart debit and credit cards, ie payment cards containing an own microprocessor memory, facilitate the use of electronic payment cards, thereby speeding up the velocity of narrow money and substituting for the use of physical cash. More importantly, smart cards have also enabled the issuing of electronic cash, which directly rivals physical cash in small-value payments. Similar developments are going on in the wholesale side, where increased liquidity of money market instruments combined with further efficacy in payment technology have already reduced the demand for clearing balances at central banks to a minimum.

These prospects have alarmed economists and central bankers alike to consider, whether the development of e-money products and the prospects for electronic settlement will transform the monetary landscape in a fundamental way. Are we first moving from central bank money to private e-money, perhaps initially closely linked to deposit money, then to portfolio e-money and finally to electronic exchange economy, where money serves no more any role as means of exchange? Will these developments at the end render central banks obsolete in the same way that technological advances and commercial liberalisation have moved other in the past so powerful monopolies out of business? Those questions have sparked off a lively debate on the implications of e-payments and e-money for central banking, the main question being whether those innovations could at the end threaten the ability of the central bank to set the nominal interest rate for the economy.[1] This paper is also motivated by such questions, both as a survey of and an addition to the ongoing debate, with the aim of bringing the discussion closer to the actual practice of monetary policy implementation.

Most of the vast e-money literature has focused on cash substitution and paid little attention to innovations in large-value payment systems. This is somewhat striking as interest rate control in all developed countries is based on the central

[1] The 1999 and 2001 Jackson Hole seminars, organised by the Federal Reserve Bank of Kansas City, give a good summary of the challenges that recent advances in information technology pose for monetary and economic policy.

bank's monopoly over bank reserves, whereas the supply of currency is normally demand-led. Our focus is innovations in banks' reserve demand, the main question being whether the central bank is likely to retain its control over the short-term interest rate in a future world, where it might not have full monopoly over the supply of banks' clearing reserves. However, cash substitution cannot be fully ignored, as currency accounts for the bulk of the monetary base, implying that its extinction would certainly weaken the central bank's position at the core of the banking system.

We will assume that even in the future e-world some monetary liabilities are used as a vehicle for settling transactions, but they can be issued competitively by public and private entities alike. Furthermore, future monetary liabilities might not be entirely denominated in fixed nominal terms but might also be issued as 'portfolio money', eg as small-denomination securities or as units of value representing a proportional claim on a set of marketable assets. As the electronic revolution in banking might ultimately bring about a return to a pure exchange economy, where money serves no role as a means of exchange, our discussion can be seen to focus on the period of transition before that final stage. However, as we estimate this intermediate period to be relatively long, perhaps several decades, it should be of major interest to central bankers today.

By restricting our focus on the control over the short-term interest rate in a world where some forms of money will still be used for settlement we can abstract from many broader macroeconomic issues, which the prospects for e-money and e-settlement have brought about. For example, we will not address the problem of price-level determination in a non-monetary world,[2] or the issue of time-inconsistency in implementing monetary policies in a world with competitive currencies.[3] Our work has some relation to the literature on free banking in the sense that we will discuss the role of legal restrictions in enhancing the central bank's monopoly over bank reserves, but we will refrain from any normative discussion on free banking as such.

The paper is organised as follows. The first part of chapter 2 contains a brief historical survey on demand and supply models for bank reserves, focusing on the impact of innovations in transaction technology and financial intermediation. The second part of the same chapter complements the first one by suggesting that some deficiencies in private financial markets, due to informational asymmetries, might provide an additional motivation for demand and supply of public reserves. In chapter 3, we discuss how modern innovation in payment and settlement technology may affect the demand for reserves, and what might be the implications for the operation of monetary policy. That chapter also contains a

[2] Recent papers that have addressed that issue include Woodford (1998) and Costa & de Grauwe (2001).

[3] See Marimon, Nicolini & Teles (1997).

brief survey of the recent debate on the issue. Chapter 4 focuses on the implementation of monetary policy in a future environment where close private substitutes for central bank money are available for the settlement of transactions. Chapter 5 draws some tentative conclusions on the implications of the new payment and settlement technology, and suggests some promising future avenues of research on the topic.

2 The need for reserves

2.1 Demand and supply for reserves

Modelling commercial banks' reserve management has a long history, tracing its early roots to Edgeworth (1888). The rising interest in the issue followed naturally the evolution in banking in the 19th century, which developed into fractional reserve system, where only a portion of overall claims was backed by commodity money. The rest of borrowed funds were invested at interest in illiquid assets, such as long-term loans to agriculture and manufacturing. Since that time banks' reserve management problem has essentially been to balance the foregone interest of holding too large reserves against costly stockouts of holding too small an inventory of reserves.

With the triumph of the Keynesian economics since the 1930s, analysis of banks' reserve needs became closely linked to the growing money demand literature. The Keynesian theory of money demand distinguished three motives for holding reserves – the transaction motive, the precautionary motive and the speculative motive. The early models on the transaction demand for reserves, pioneered by Baumol (1952) and Tobin (1956), followed an inventory theoretic approach, where the transaction motive for holding reserves is modelled by means of costly stock adjustment. In those models reserves are used to pay a stream of transactions, which is perfectly foreseen. Holding reserves is costly, as there exists the alternative to invest in interest-bearing bonds. On the other hand, selling bonds for reserves induces transaction costs, which explain the positive demand for reserves. The demand for reserves in that framework is explained by the famous square-root rule, as described in equation 2.1.

$$R^d = \sqrt{\frac{2cY}{r^B - r^R}}, \tag{2.1}$$

where Y is the volume of transactions, c is the fixed cost per adjustment, r^B is the interest rate on bonds and r^R is the remuneration on reserve holdings, which is

usually assumed to be zero. The demand for reserves is positively related to the transaction volume Y and to the reserve adjustment cost c, and negatively to the interest rate on bonds r^B.

The simple inventory model is useful in explaining several long-run trends in banks' payment and reserve arrangements. As the transaction demand for reserves is ultimately due to their use in clearing and settling payments, the need for clearing reserves by banks is naturally closely linked to the evolution of payment technology and payment systems, as emphasised by Pauli (2000). As holding reserves is costly, the main driving force in the endogenous development of payment arrangements has always been banks' need to economise on the cost of liquidity.

The inventory model predicts three structural factors, which in the course of years have had a major (negative) impact on banks' reserve needs. First, the model suggests that there exist major economies of scale in reserve management. A strong tendency towards centralised reserve management within banks and banking groups is supportive for that conclusion. Second, as reserve needs depend on the volume of transactions, there is a strong incentive for netting payments between banks, whose customers are commercially linked with each other. The efficiency gain of netting can be achieved by using interbank credit in place of immediate settlement in currency. A third prediction of the model is that lower costs of reserve adjustment will reduce the need for non-remunerated reserves. That links the need for clearing reserves closely to the development of the financial market, in particular the money market.

The netting motive induced banks at an early stage to develop multilateral cooperative arrangements, where the value of all payments due to and due from each bank in the network could be settled on a net basis at the close of each day. For such an arrangement, a central counterparty is needed, against which the multilateral net position of each participant can be calculated. In the nineteenth century, such cooperative clearing arrangements developed both in the check-based (US) as well as in the giro-based (European) payment systems. To economise on transfers of currency and coin, members of the clearing arrangement started to keep the bulk of their reserves in the vaults of the central clearing institution ('clearinghouse'), receiving in return clearinghouse certificates, which could then be used for settlement. As a result of such private innovation, centralised reserve institutions ('reserve banks') had emerged, providing reserve accounts and clearing and settlement services to their members.

It is still debated whether the rise of central banks was ultimately an endogenous process closely intertwined with the emergence of commercial banking and development of payment arrangements, or whether central banks reached their position due to the support of privileges and legal restrictions issued by the Government. Be it either way, early twentieth century clearinghouses looked in many respects like central banks today. For example, Gorton (1985)

documents that, in addition to providing clearing services, the New York City Clearinghouse Association admitted, expelled and fined members, imposed capital and reserve requirements, and audited members to insure compliance with the regulations. Further, in periods of distress the Clearinghouse Association issued loan certificates, backed by bank portfolios, to its members but occasionally also directly to the public (Timberlake, 1984). In this way, large amounts of private money could be created and issued to the public in exchange for demand deposits.

Government sponsored banks, which particularly in Europe were often established due to political considerations or as bankers for the central government, had in some respects natural advantages to serve also as a central reserve institution in multilateral payment arrangements. In particular, government sponsored banks had the implicit backing by the state implying that commercial banks' claims on the central bank were not subject to a solvency risk. Furthermore, late 1800s and early 1900s experienced gradual monopolisation of clearinghouse powers to the government's own bank, which strengthened its position as banker to other banks. First measures were the nationalisation of note issue and legal tender rules which gave the new central banks the ability to provide liquidity to commercial banks by rediscounting illiquid commercial bills. Furthermore, in case of liquidity runs central banks were able to provide lender of last resort support to banks.[4] Another response to liquidity crisis was the obligation for commercial banks to hold a minimum amount of reserves at the accounts of the central bank.

Apart from specific terms of lender of last resort support, the early literature did not pay much attention to central bank operating procedures, ie to the modalities of the supply function of reserves. Monetary policy was implemented via control of the monetary base, which was linked to monetary aggregates through the money multiplier. Alternatively, the central bank could affect the money multiplier and money supply by adjusting the required reserve ratio. However, money supply considerations were not the only motivation for high reserve ratios that were generally applied in those days. There was also a persistent fear that banks' voluntary reserve holdings will stay too low to stand large deposit withdrawals. Equilibrium in the money market is then given by the equality of the interplay of demand and supply of money, where money demand is

[4] However, note monopoly alone was not always sufficient to ensure efficient monetary control for the young central bank. For example, monopoly over note issue was reserved for the Bank of Finland in 1886. Despite that, Korpisaari (1920) documents that in the following decades the central bank was not able to strongly affect commercial bank lending rates in normal times, as banks had no need for central bank financing. However, during recessions the central bank's grip over commercial banks strengthened due to higher need for liquidity. At that time, last resort lending during periods of financial distress was often conceived as the most important function of the central bank.

a function of the income and the interest rate and money supply is an exogenous constant fixed by the central bank. Equating money demand and supply for each income level then produces an upward-sloping portfolio balance schedule (LM-curve), which can be affected by changes in nominal money supply.

In later contributions, the simple inventory model was extended to incorporate elements of uncertainty. For example, Tobin (1958) used portfolio approach to show that the demand for reserves is not only a (negative) function on the interest rate on bonds but also a (positive) function on the uncertainty of returns for alternative investments. If a bank has two assets, non-interest bearing reserves, R, and earning assets, A, yielding r^A, higher volatility of r^A induces greater demand for reserves. Olivera (1971), Miller and Orr (1966) as well as Frenkel and Jovanovic (1980) continued to model the demand for reserves in the same tradition but assumed that net disbursements are governed by a stochastic process that leads to a need for precautionary reserves. Some of those models suggested that an increase in payment uncertainty might result in higher demand for reserves.

The growth of an efficient market for trading banks' reserve balances induced a major reformulation in modelling banks' reserve management. Given that central banks normally paid no interest on reserves and charged high penalties in the case of reserve deficiency, banks had a strong incentive to balance daily interbank positions between themselves. However, another prerequisite for the birth of efficient reserve trading was the development of the payment infrastructure to the stage, where banks could forecast their daily balances with some accuracy. This stage was first reached in the United States, where the growth of the Fed funds market in the 1960s provided banks the option to adjust reserve positions among themselves by buying or selling 1-day money with low transaction cost (bid-ask spread). Given that option, banks' were no more willing to hold non-interest bearing reserves for the settlement of anticipated transactions, if the yield on overnight funds or short-term Treasury bills was high enough to cover the transaction costs of interbank trading. Instead of transactions demand, the precautionary demand due to uncertainty about the size of future deposit withdrawals became crucial for the existence of excess reserves. Furthermore, as overnight funds began to trade at a market rate that was determined by supply and demand, it became evident that the discount rate affects the funds rate through its influence on the demand for reserves.

Poole (1968) was the pioneer to extend the inventory model of reserve demand in order to take into account the role of an efficient money market. He examined the significance of excess reserves, commercial bank borrowing from the central bank, and the central bank lending rate (the discount rate) as a problem of bank reserve management optimisation under stochastic demand. The model assumes that the representative bank's day-to-day adjustment of its reserve position takes place in the interbank overnight market and through borrowing

from the central bank. The model considers the optimal amount of reserves that a bank is willing to hold as a consequence of uncertain deposit levels. Holding reserves yields a return to the bank by preventing costs from unexpected deposit drains, but the other side of the bargain is the opportunity cost of reduced interbank lending. The problem the bank faces is to allocate its liquid funds optimally between reserves and interbank lending on the basis of costs and returns related to different assets.

Most of the models examining commercial bank reserve management up to present day are adaptations of Poole's seminal contribution, which can be briefly outlined as follows. The representative risk-neutral bank has beginning of day settlement balances (ie deposits net of loans), D, and needs to decide at the beginning of day how much to invest in the overnight money market at the interest rate r^{on} and how much to maintain as excess reserves R. Bank's deposits, credit lines, and loan repayments are all subject to random shifts without notice, with net bank withdrawals defined as X, with the density function f(X). If net withdrawals exceed reserves, that is, $X > R$, the bank must access a central bank discount window, at a rate r^L, ($r^L > r^{on}$). The bank chooses its reserves to maximise profits, π, such that

$$\pi = r^{on}(D - R) - r^L \int_R^\infty (X - R) f(X) dX \tag{2.2}$$

The first-order conditions of this problem result in a reserve quantity that satisfies the condition

$$r^{on} = r^L \int_R^\infty f(X) dX. \tag{2.3}$$

The first-order condition states that the probability of a reserve deficiency must equal the ratio r^{on}/r^L. This is the essential condition that must be met in reserve management models.

Poole noted that for a symmetric distribution with $E(X) = 0$, for the optimal reserves to be positive, it is required that $r^L > 2r^{on}$. This finding greatly helped to understand how the structure of central bank standing facilities (eg the discount window) affects banks' reserve demand. At that time, central banks' credit windows were typically a mixture of interest-rate costs and administrative penalties, which effectively induced a rising cost function for borrowed reserves. In normal circumstances, the above inequality is unlikely to hold, in which case the model predicts negative reserves. The model also helps to understand the role of discount rate changes and open market operations in the conduct of monetary policy. For given discount rate r^L, the central bank can affect a rise in the

overnight rate r^{on} by increasing the probability of reserve deficiencies through liquidity-absorbing open market operations. However, such operations cannot push the overnight rate higher than to the level of the discount rate. Alternatively, the central bank can raise the discount rate, which automatically raises the equilibrium overnight rate without any change in the liquidity position of the banking system. This can be seen from equation (2.3), where bank‘s reserve management is dependent on the ratio of the overnight rate to the discount rate, but not on the absolute level of either rate. Hence, Poole’s (1968) model explains how the central bank can affect market rates either through a liquidity effect or a pure signalling effect.

In the vast literature on bank reserve management, the basic model by Poole has been extended to include various aspects, which could be of importance in reserve management decisions. Some of the earlier applications incorporated legal reserve requirements, which were already studied by Poole. Another strand of literature added costly collection of information on customer habits, which can be used to reduce the variance of the underlying subjective distribution of stochastic withdrawals. More recently the emphasis has shifted to examine how modifications in central bank standing facilities and operating procedures affect the determination of overnight and longer-term market rates. There are two natural reasons for this shift in emphasis. First, central banks have generally shifted to interest rate targeting, where the day-to-day operational target is a short-term money market rate, such as the overnight rate. Secondly, the application of rational expectations in financial markets has helped to understand how the central bank can influence long-term rates through signalling its intention to change the level of short-term rates in the future. This implies that communication on the future trend of central bank rates can be as, or even more, important for private economic behaviour than actual changes of those rates today.

One way to achieve high transparency in interest rate policy is to set an explicit target for the overnight rate, as the Federal Reserve has done, and to use daily open market operations to steer the actual path of the overnight rate to follow the target level. However, given a desire to discourage borrowing from the central bank, Poole’s result implies a rather high effective discount rate r^L. In such a framework, shocks in reserve demand induce large swings in the overnight rate between 0 and r^L. Even a very accommodating liquidity management policy by the central bank cannot fully eliminate such swings, as even the central bank is unable to perfectly forecast aggregate reserve shocks. That problem of interest rate volatility is accentuated in smaller countries, where the interbank market is less competitive than in the United States.

One possible response to that problem is to introduce a reserve requirement with averaging provisions. Commercial banks can be required to hold a share of their liabilities as minimum reserves on accounts with the central bank. Allowing averaging provisions implies that the compliance with the reserve requirement is

judged by the average of the daily balances a bank has on its reserve account during the maintenance period. Averaging provisions give banks the possibility to borrow funds at a low rate to build up excess reserves at the beginning of the maintenance period in the expectation that they could lend funds at a higher rate later in the period. Speculation of this type can be expected to reduce the range of possible fluctuation of the overnight rate, except for the very end of the maintenance period, when averaging ceases to be effective.

However, due to financial liberalisation and increase in banking competition, there has been a general tendency to reduce or even totally eliminate mandatory reserve requirements. Given these trends, central banks have started to provide reserve supply facilities, which allow banks to target zero reserves on average. Such 'channel' systems recognise that in a world with fully efficient money market the only reason why banks need to deposit or borrow costly reserves at the central bank is the uncertainty related to daily payment flows. Therefore, predictability of reserves rather than the absolute amount of reserves is crucial for the design of central bank operating procedures. Assuming a symmetric distribution for stochastic payments, the central bank can achieve its target overnight interest rate by supplying on average zero reserves within an interest rate corridor, where banks are allowed to deposit and borrow reserves overnight at constant interest margins to the target rate.

The 'channel' system is an extension of Poole's reserve management model. The central bank chooses a target overnight interest rate r^{on}, which is periodically adjusted in response to changing economic conditions. The discount window is replaced by a marginal lending facility, through which the central bank stands ready to supply an arbitrary amount of settlement cash at a fixed interest rate r^{L}, which is slightly higher than the target rate. The only limitation for the use of this facility is the availability of adequate collateral. Also, commercial banks that clear transactions through the central bank have the right to deposit excess settlement cash overnight with the central bank at a deposit rate r^{D}, which is slightly lower than the target overnight rate. The lending rate on the one hand and the deposit rate on the other define a channel within which overnight interest rates should be contained. Furthermore, the spread between the lending rate and the deposit rate gives banks an incentive to trade with one another.

In the channel model, a representative risk-neutral bank chooses its reserves to maximise profits, π, such that:

$$\pi = r^{on}(D-R) - r^{L}\int_{R}^{\infty}(X-R)f(X)dX + r^{D}\int_{-\infty}^{R}(X-R)f(X)dX \qquad (2.4)$$

The first-order condition with respect to reserves gives:

$$r^{on} = r^{L} \int_{R}^{\infty} f(X)dX + r^{D} \int_{-\infty}^{R} f(X)dX \tag{2.5}$$

Thus, the equilibrium interbank overnight rate of interest is simply the average of the two rates of the standing facilities weighted by the probabilities of the money market being short or in excess of liquidity. We can rearrange equation (2.5) to give:

$$F(-R) = \frac{r^{on} - r^{D}}{r^{L} - r^{D}}, \tag{2.6}$$

where R is the quantity of reserves targeted by the bank as a function of the overnight rate in the money market. The cumulative distribution function F(–R) represents the probability of a reserve deficiency. The fact that the cumulative distribution function F is increasing means that R will be a decreasing function of r^{on}.

Symmetry of the probability distribution of possible levels of net withdrawals implies that each bank will target a zero level of reserves if the overnight rate is exactly halfway between the deposit rate and the lending rate. Hence, a reserve target of zero on the part of the central bank should achieve an overnight rate equalling the target rate, given appropriate positioning of the two standing facility rates. Another prediction of the model is that the demand for reserves should be a function of the location of the overnight rate relative to the lending rate and deposit rate, but independent of the absolute level of any of these rates. This implies that the central bank needs not change the supply of reserves in order to adjust the level of the overnight rate, as long as the location of the lending and deposit rates relative to the target overnight rate do not change.[5]

The channel system facilitates the separation between interest rate policy (ie adjustments of present and signals of future interest rates) and pure liquidity management, where the central bank uses open market operations to supply an aggregate quantity of reserves, which corresponds to the estimated demand for settlement cash at the target overnight rate. By use of the channel system the central bank can control overnight interest rates without having to engage in large transaction volumes through either of the standing facilities; the central bank's willingness to transact in large volume largely eliminates any need to do so. The move to the channel system reflects a response to lower demand for non-interest bearing reserves and higher demand for transparency in implementing monetary policy. Hence, it is no surprise that central banks, which have adopted inflation

[5] This is a reconfirmation of Poole's result where the representative bank's reserve management is dependent on the ratio of the overnight rate to the discount rate, but not on the absolute level of either rate.

targeting and ruled out minimum reserves, have been the first to adopt the channel system in monetary policy implementation.[6]

2.2 Liquidity models and the need for public reserves

The discussion above suggests that nowadays commercial banks' remaining demand for central bank reserves is only due to residual uncertainty in daily payment flows, which is likely to be further reduced by future advances in payment technology. However, the theory of central banking has since its advent suggested a more fundamental precautionary motive for holding central bank liabilities, namely the potential for private market failure, which may render private and public liquidity imperfect substitutes in periods of distress. That issue is closely related to the long discussion of the elasticity of money supply and the need for a public lender of last resort, the history of which can be traced back to England in the latter half of the eighteenth century.[7] At that time, in addition to the Bank of England also private commercial banks were allowed to issue paper notes, which comprised their main liability before deposits became commonplace. The main question was to find mechanisms that would prevent banks from expanding their private note issues excessively. The dominant view had been that banks should restrict their lending to the discounting of bills with a clearly short-term commercial purpose (the so-called real bills doctrine). This policy was believed not only to prevent the oversupply of currency but also to bring about sufficiently elastic supply to meet the fluctuating needs of trade. Moreover, it was generally believed that market discipline would prevent banks from oversupplying their notes, because if they were suspected of doing so the public would want to convert its note holdings back to specie.

However, it was soon recognised that the amount of currency in circulation had nevertheless been excessive from time to time, causing undesirable increases in the price level. Therefore, an alternative policy to anchor the issuance of paper money more closely to the amount of specie gained acceptance. According to this view, which soon became the dominant one, price stability could best be guaranteed by a legislation, which prevented banks from issuing notes in excess of the size of their metallic reserve. However, while accepting this baseline policy, Thornton (1802) argued that there should also be a central authority with discretionary powers in order to guarantee sufficient elasticity of money, especially in times of crises. This was one of the first statements about the need of a public lender of last resort.

---

[6] Those countries include Australia, Canada, Sweden and New Zealand.

[7] See Niskanen (2001) for a more extensive discussion of the history of the concept of the lender of last resort.

The structure of banking changed profoundly during the 1800s, as joint stock banks emerged to provide long term financing for industrial projects, whose ex post outcome was difficult to monitor. In order to reduce those information and monitoring costs, commercial banks started to extend loans on a fixed nominal value basis, irrespective of the contingent outcome of the project (Goodhart, 1987). The initial, and subsequent valuation of the loan by a bank does depend on information that is generally private between the bank and its borrowers, or only known to the borrower. Thus the true asset value of the bank's non-marketed loans is always subject to uncertainty, though their nominal value is fixed. Under these conditions it benefited banks to denominate also their deposit liabilities in fixed nominal terms, as that increased the covariance between the value of bank's assets and its liabilities. However, the combination of long-term assets with uncertainty of their true value, together with nominally convertible deposits rendered banks very vulnerable to liquidity crises in case of adverse news of their unknown asset values.

Indeed, in the leading industrial countries the 19th and early 20th century was a time of frequent banking crises, which involved the actual or expected restriction of the conversion of deposits into currency. The birth of central banks was partly a response to such severe banking crisis. Gradual monopolisation of note issue and legal tender brought the new central banks the capacity to offer liquidity to commercial bank's in case of emergency. Being able to create currency, the new central banks could guarantee the exchange rate between bank deposits and currency against system-wide runs. However, this capacity could not be used if the central bank was required by legislation to strictly anchor note issues to the amount of gold reserves. Indeed, critics of the legislation argued that anchoring the amount of paper notes to the size of gold reserves had in fact increased the propensity of bank runs, because the public could not be certain that the central bank would provide support when other banks had difficulty in redeeming their deposits. Against that background, Bagehot (1873) argued that the central bank should admit its responsibility as holder of the country's bank reserves and to commit, by public announcement, to lend freely in the face of a bank run. In order to increase confidence in the financial system, he advocated the following principles for central banks' lender of last resort support:

1 lend freely during a crisis,
2 assist any and all sound borrowers,
3 lend against all acceptable collateral (evaluated at it's value in normal times),
4 apply penalty rates for assistance,
5 assure the markets in advance.

Bagehot's lender of last resort principles have considerably influenced central bank policy worldwide. However, these principles were never universally

accepted, and the debate on the conditions, under which the central bank should offer liquidity to banks, has continued up to present day. The unresolved issues extend from the need for a lender of last resort at the first place to the compatibility of last resort lending with the price stability objective. Furthermore, it is disputed whether the long-run costs of moral hazard outweigh the short-term benefits of emergency liquidity support. Against this background, it is no surprise that central banks' actual lending policies differ, both as regards regular liquidity support to the banking sector as well as the policy applied in crisis situations. Many central banks have moved towards applying the Bagehotian criteria for regular credit facilities, but this trend is not universal.[8] As regards actual financial crises, the US Federal Reserve was strongly criticised for not providing sufficient amounts of liquidity at the beginning of 1930s, when the public lost its confidence in the country's banking system. In other cases of severe banking crises several central banks have applied lender of last resort criteria, which are actually less stringent than the Bagehotian criteria.

The basic puzzle has been to explain why private markets are prone to episodes of financial crises, characterised by the collapse of activity in the financial sector, along with reductions in real output, consumption, employment and other components of real activity. Diamond and Dybvig (1983) were the first to formalise the idea that the structure of financial intermediation might be inherently unstable and, thereby, could be a cause to economic crises. Their model has an explicit economic role for banks to perform: the transformation of illiquid assets into liquid liabilities. Their model demonstrates that banks issuing uninsured demand deposits can improve on a competitive market by providing better risk sharing among people who need to consume at different random times. But, the demand deposit contract has an undesirable equilibrium (a bank run) in which all depositors panic and withdraw immediately, including even those who would prefer to leave their deposits in if they were not concerned about the bank failing. Such bank runs are costly and reduce social welfare by interrupting production (when loans are called) and by destroying optimal risk sharing among depositors.

As the bank run equilibrium in the Diamond and Dybvig (D–D) model is essentially a coordination failure, it can be easily eliminated by an appropriate correction mechanism. Indeed, it has been shown that under some restrictive assumptions both a temporary closure of the bank, a governmental or other credible insurance mechanism and a central bank acting as lender of last resort can be applied as a way to eliminate the possibility of runs. Therefore, under some

[8] For example, the Eurosystem employs a marginal lending facility, which is accessible for all financially sound credit institutions against eligible securities and at a rate of interest higher than the market rate. All conditions for the use of the marginal lending facility are preannounced. In contrast, lending through the Federal Reserve discount window is of discretionary nature.

restrictive assumptions, the D–D model that focuses on the nature of the deposit contract provides a rationale for government supplied liquidity. However, the D–D model as such is inappropriate to address the issues related to the demand or supply of liquidity in the future e-world, where financial markets are even more developed than today and private banks have the option to issue e-money. However, some recent extensions of the model have some bearing on the demand for private and public liquidity in those surroundings, and we will review those applications briefly in section 4.4.

Other models use credit market imperfections, resulting from informational asymmetries between borrowers and lenders, to motivate corporate demand for liquid assets. Those models are related to the vast literature on credit rationing, which makes the point that investment will be constrained by the firm's net worth. Due to an information asymmetry, the firm's external value is less than its internal value, resulting in underinvestment and credit constraints. Holmström and Tirole (1998) have applied the same idea to motivate the demand for liquid funds by the private sector. That demand has to do with the illiquidity of long-term investments, and the fact that intermediate investment outlays may be needed to finalise projects. Firms hoard liquid assets to be able to clear such intermediate investment needs. The opportunity cost of holding liquidity is optimally balanced with the costs related to premature termination of investment projects (bankruptcy costs and the like).

Liquidity models complement the traditional money demand literature by providing an additional precautionary reason for private agents to hold liquid assets. However, as such they do not provide a special motive for holding central bank liabilities, if liquid assets in the private market are full substitutes for public funds. Holmström and Tirole (1998) use the liquidity model to demonstrate that when there are aggregate shocks the private sector may have a shortage of liquid assets. In that case the government can improve welfare by providing the private sector with liquid assets (bonds) that they are unable to create themselves. The government should manage debt so that liquidity is loosened when the aggregate liquidity shock is high and is tightened when the liquidity shock is low.

3 Potential implications of e-revolution

3.1 Retail payments and e-cash

Users of payment services consider a wide range of attributes in choosing which payment instrument to use. According to Marquardt (1994), the key attributes are explicit user costs, float benefits, opportunity costs, speed of settlement, complexity and convenience of use, susceptibility to loss or error, privacy, and

wide acceptability. Traditionally, cash has been superior to any other means of payment in several of these attributes. Above all, legal tender provisions have guaranteed total acceptability of cash[9] and, in addition, cash payments provide immediate and final settlement of transactions. In traditional models of money demand the main disadvantage of cash arises from the loss of interest revenue. Indeed, there is some evidence that the high interest rate regimes of the late 1980's and the early 1990's were a spur to the development of cash substitutes (Markose and Loke, 2001). On the other hand, traditional models would predict that consumers cease to substitute away from cash as nominal interest rates on demand deposits fall close to zero.

However, traditional models of money demand have largely overlooked the evolution in the microstructure of the payments technology, which, in the course of years, has also had a major impact on the transaction demand for money.[10] On the retail side, worldwide trend has clearly been towards substitution of non-cash payment instruments for cash, driven by the spread of debit and credit card payment methods (Snellman, Vesala and Humphrey, 2000). Those payment instruments are linked to the payers' bank accounts or credit lines extended by the card issuer. Since cash is most often used for everyday small-value retail purchases, card payments via EFTPOS terminals are its closest substitute in modern payment systems. The incentives for replacing physical notes and coins with alternative means of payment do not only, or perhaps not even primarily, arise from potential savings in interest costs, but from the high costs of handling physical cash.[11] These have to be contrasted with the costs of credit verification, bookkeeping and communications with the central operators of the system in the case of debit and credit cards.

Due to network externalities achievement of wide acceptability is a crucial condition for any new payment media to become a serious rival for physical cash, the use of which is backed by legal tender provisions. It took some 20 years for credit and debit cards to reach wide usage, and even so they have not been able to compete with cash in very low value payments. In addition to verification, bookkeeping and communication costs, the use of EFTPOS instruments is restricted by rather high fixed costs due to restriction to physical point of sale use, non-standardised card transaction infrastructure, high cost of terminals and vertical fragmentation of markets according to customer groups.

---

[9] Goodhart (2000) has emphasised the role of legal tender provisions that facilitate the use of currency as a generally accepted means of payment, making it extremely hard for any alternative means of payment to reach same degree of acceptability.

[10] Recent empirical studies on money demand give strong evidence that institutional change represents an important element in explaining the long-run behaviour of velocity or the demand for money. See Bordo, Jonung and Siklos (1997) for references.

[11] The research and consulting company Ovum has estimated the global cost to banks, retailers and customers of handling, counting, recording, storing and moving physical cash as $30bn.

The smart card, which contains a tamper-proof embedded microprocessor with its own memory, has opened new potential in the development of retail payment media. It is a very secure and flexible method of carrying data, which can be accessed only when it is connected to a separate terminal, which, however, needs not be a physical connection. Next to mobile phones, the payments industry is the second largest user of smart cards, not only for secure credit and debit payments, but also for electronic cash. In addition, smart cards can be used to provide secure access to computer networks. In addition to advanced security, smart payment cards have or will have other attributes, which are likely to give wider acceptability and lower transaction costs compared to traditional magnetic stripe cards. The new technology enables multipurpose cards, which for example carry electronic cash on the same card as the debit and credit card, thereby lowering the cost and increasing the convenience of card usage. In Europe, the creation of a common market for financial services and the arrival of the single European currency have induced card issuers to start developing single European standards for debit and credit cards, as well as for electronic purses.[12] Such standards will allow cardholders to make payments in any country, facilitating positive network externalities for such payment medium.

The latest rival for physical currency is the e-cash, which avoids the physical handling costs associated with currency. Furthermore, just like currency, electronic cash cards carry purchasing power, which is valid independently of holders' bank account, thus avoiding verification and bookkeeping costs associated with debit and credit cards. To some extent, electronic technology has also facilitated the use of cash, mainly via the build-up of ATM (Automated Teller Machine) networks, which have enhanced the convenience yield of cash and reduced potential interest rate losses by increasing accessibility to cash closer to point of sale. However, technological and market development is clearly working for electronic payment medium in several respects. First, electronic payment means may soon outpace physical cash in security. Second, as regards transaction costs, the gap between transfer costs for physical cash and for electronic information is widening on an accelerating pace. Third, with the development of mobile communication technology the use of electronic payment media will no longer be tied to physical terminals, so that it becomes usable 'everywhere', just as physical cash is.[13] Actually, with the rapid internalisation of banking and electronic payment networks, electronic payments and e-money can reach global acceptability, whereas wide acceptability of physical cash is

[12] Debit and credit card applications comply with the EMV standard developed by EuroPay International, Mastercard and Visa International. Electronic cash applications mainly comply with the common electronic purse standard (CEPS).

[13] The leading producers of mobile phones have recently unveiled innovative new phones, utilising GPRS technology, that provide electronic wellets for mobile commerce.

contained within national borders, or within the boundaries of larger currency areas, as in the case of the European Monetary Union.[14] Last but not least, commercial banks have strong incentives for developing e-money schemes, not only due to potential cost savings, but also due to chances of reaping float income from money issues.

As shown by Santomero and Seater (1996), the demand for alternative media of exchange can be studied in a Baumol-Tobin type model of optimal money holdings. Santomero and Seater study the behaviour of a representative agent who can choose to pay for purchases among different generally accepted payment instruments. Their model suggests that media of exchange usage patterns depend on income levels and consumption patterns, which suggests that we should expect different reactions across economic groups to the newly emerging e-money schemes. Various households offered a new medium of exchange with its own implied interest rate, transaction costs, and fixed cost will react differently. Thus, there appears to be room for different combinations of media of exchange. As the government supplies only one type of money, the market creates different types of private money or quasi-money to satisfy the heterogenous demand.

Berentsen (1998) has used a simplified version of Santomero and Seater's model to study specifically the demand for e-money. Assuming that the use of digital money for purchases will be free for consumers, the demand for e-money M_{EM} is reduced to the standard Baumol-Tobin square-root formula:

$$M_{EM} = \left(\frac{a_{EM} A}{2(r_S - r_{EM})} \right)^{\frac{1}{2}}. \tag{3.1}$$

According to (3.1), the demand for digital money depends on the costs of transferring funds into digital money on a smart card or a computer hard drive, a_{EM}, total digital money spending, A, and the interest differential between the savings asset and electronic money balances, $r_s - r_{EM}$.

The costs of conversion, a_{EM}, include opportunity costs of time spent for this activity and per transaction fees charged by the issuer of digital money and/or by the provider of the telecommunication service. Berentsen suggests that these costs are likely to be small and will decrease further as technology improves and smart card readers are more widely distributed. Therefore, e-cash has the potential to dominate physical cash for small value transactions in the near future. On the other hand, the total demand for e-money will likely be small due to low costs of conversion. The demand for e-money also depends on the total amount of digital money, A, spent in each period. Due to that network externality the total demand

[14] Note that the internalisation of government money (legal tender) is a politically driven process, whereas the internalisation of private e-money is a market (demand) driven process.

for e-money is likely to remain small for a long time, but it could eventually grow rapidly as e-money substantially replaces currency. Indeed, numerous pilots for e-cash have not been commercial successes so far, but that has in no way hindered the development of new e-money schemes. Due to the existence of network externalities, estimates on the speed of e-money penetration differ significantly, the most optimistic being that in only 4–5 years electronic cash has achieved usage levels that are common for debit and credit cards today.

We can conclude that smart cards and, above all, e-cash are challenging the superiority of physical cash in regard to several attributes, which users consider important for the choice of payment media. Goodhart (2000), however, has argued that even an extensive advance of information technology would not totally eliminate the use of currency. He has pointed out that currency is a completely anonymous means of payment in the sense that the recipient of a cash payment neither has to know nor learns anything about the counterpart in the process of trade. By contrast card and e-money transfers immediately provide a record of what a customer has bought to the seller and to the underlying financial institution. As currency usage is widely represented by holders who do not wish their activities to be tracked, Goodhart found it implausible that the demand for currency would dry totally. However, even if Goodhart's point would be valid as such, it cannot be used to save physical cash in the case, where it is only used to settle illegal transactions. As a matter of fact, one of the reasons why banks prefer the new common electronic standard for e-cash applications is that it provides an audit trail to protect them against illegal laundering of money.

3.2 Large-value payment systems and demand for bank reserves

As currency is the main component of the monetary base, its replacement by electronic payments and electronic money would have major implications for the central bank.[15] It would shrink the central bank's balance sheet and remove the seignorage income accruing from the issuance of non-interest bearing money. This raises the question whether the central bank would retain its ability to control monetary developments in a future cashless society. Several authors have argued, that the central bank would not lose its control of short-term interest rates in a cashless society, as currency is not a meaningful operative target in the conduct of monetary policy in developed societies (Henckel, Ize and Kovanen (1999), Goodhart (2000), Freedman (2000), Woodford (2000)). Rather, the central bank's ability to move large financial markets through limited open market operations is

[15] In the Euro area banknotes in circulation account for three thirds of the monetary base.

based on its monopoly position as a supplier (and withdrawer) of bank reserves rather that to the supply of banknotes. This monopoly over the supply of bank reserves gives the central bank leverage to the growth of bank deposits and credit, and thereby to the nonfinancial economy as well.

The central bank's monopoly over commercial banks' reserves is based on a historical evolution of payment systems, driven by banks' needs to economise on the cost of liquidity through pooling their reserves on the accounts of a central reserve institution, namely the central bank. Despite far-reaching changes in payment arrangements over the decades, the central bank with the right to issue publicly guaranteed claims and the capacity to lend clearing funds in case of need is still capable of providing value-added for liquidity and safety in large-value payment systems. Provided that the central bank's settlement function continues to guarantee an ongoing demand for reserves, e-money would not seriously threaten the efficacy of monetary policy, which would be implemented very much like today.

However, the central bank's core position as bankers' bank and its monopoly over commercial banks' settlement balances have not remained immune to technological and payment innovation. As emphasised by Goodfriend (1991) the evolution of the payment system has been driven by efficiency gains from substituting credit, ie claims on particular institutions, for commodity money. Indeed, since the time of early clearinghouses, banks have used bank money or clearinghouse money to clear customer and interbank transactions.[16] In modern interbank net settlement systems, banks that net their mutual payments provide liquidity to one another by implicitly accepting claims on each other. It is apparent that banks have been willing to accept some credit risk for the substantial efficiency gains that the use of credit instruments in place of cash has afforded. In a net settlement system, inside clearinghouse money is created continually as banks with net credit positions provide implicit credit to banks with net debit positions. Clearinghouse money is strictly endogenous; it expands or contracts as needed to accommodate the volume of transactions and the changes in the distribution of net debit positions among participants. Such net debit/credit positions remain provisional until banks settle their positions which takes place at discrete intervals.

Interbank payments do not become final until they are settled. The present convention is that mutual interbank positions are settled at the end of each day through banks' accounts with the central bank, ie by transfer of an offsetting

[16] A more recent evidence that private banks have the ability to set up a clearing and settlement mechanism in the absence of the central bank is the creation of the ECU clearing and settlement system in 1985. As there was no central bank for ECU at that time, commercial banks had to set up a system of their own to clear ECU interbank payment orders. EBA Euro 1 is the successor of the ECU clearing and settlement system.

amount of central bank funds. In some countries, the use of central bank funds is a legal requirement for interbank settlements. As regards the EU, Principle 5 of the 1993 Report by the Committee of Governors of the Central Banks of the Member States of the European Economic Community, entitled 'Minimum Common Features for Domestic Payment Systems', stipulates that 'Provided they settle at the central bank, large-value net settlement systems may continue to operate in parallel to real-time gross settlement systems…'. Such a stipulation, which is primarily motivated by risk considerations, is actually a stronger requirement than legal tender. Central bank issued banknotes must be accepted as final payment for debt, but legal tender does in no way prohibit the use of private money (bank deposits, e-cash) for final settlement of payments. In contrast, Principle 5 of the minimum common features stipulates that central bank issued money must be used for final settlement of interbank debt obligations.

Whereas private innovations in payment arrangements have tended to substitute interbank credit for costly clearing balances at central banks, recent public intervention has favoured the use of gross settlement in central bank money. In 1980s, supervisors of payment systems started to pay attention to the fact that claims resulting from the netting process generate interbank credit risks if customers' accounts are credited before corresponding payment cover is transferred between banks. It was noted that net settlement systems give rise to settlement risk, as final settlement of the net payment amounts in not accomplished before the end of the day. As financial liberalisation and integration had led to an explosion in the number and value of payments, interbank overdrafts in net settlement systems had in many cases reached alarming magnitudes. As a way to eliminate settlement risk, supervisors started to advocate final intraday settlement of large-value payments at the central bank.

Availability of liquidity is crucial for smooth real-time gross settlement, as the value of fund transfers that occur during any single day is typically several times the underlying bank reserves available for final settlement.[17] Averaging of reserve holdings for purposes of meeting required reserves and permitting intra-day use of all reserve balances for payment settlement purposes helps in satisfying some of the demand for intraday reserves. However, without a relatively accommodating provision of intraday credit a RTGS system would impose undue costs on banks and on their customers. These costs stem from either the cost of banks' holding liquid assets, or from the time cost associated with delay of payments as the required reserves for settlement are amassed. For this reason, many central banks extend large amounts of intraday liquidity usually at low cost. Thus, the move from net settlement to gross settlement has effected a substitution of public intraday liquidity for private credit. Furthermore, these developments have

[17] For example, the average daily value of TARGET transactions reached EUR 925 billion in 1999, whereas the sum of required and excess reserves amounted to around EUR 110 billion.

enhanced the role of central banks at the core of the payment mechanism as an increasing share of large-value payments is directly settled in central bank money.

3.3 E-money and monetary control

A review of present trends and future prospects for electronic payments and e-money suggests that further innovation in e-technology may well bring about fundamental changes in private means of exchange and settlement, both at the retail and at the wholesale level. Those developments may at the end challenge the unique position of the central bank as the issuer of the ultimate settlement medium. As the central bank's ability to control commercial banks' settlement balances and short-term interest rates is based on the unique characteristics of its liabilities, such prospects have raised an active discussion on the implications of e-payments and e-money for central banking.

A recent essay by Friedman (1999) initiated the debate whether electronic money will threaten the ability of central banks to control the value of their national currencies through conventional monetary policy. Friedman began by contrasting the small volume of bank reserves and central bank operations in the US with the vast volume of financial and nonfinancial transactions in that country. The standard explanation for central banks' ability to affect such large markets through such small operations is their monopoly position as a supplier of base money – cash and bank reserves. Friedman pointed out that the development of new payment and banking technologies is rapidly advancing to the point where there are a variety of visible alternatives to conventional bank money as a means of undertaking transactions. Regarding e-money, he emphasised that the crucial moment might be when different smart card systems, or other forms of e-cash, advance to the point where they would provide not merely payment but also settlement.

Friedman also studied the role played by interbank clearing mechanisms in creating a demand for reserves. Private settlement systems, such as CHIPS in the US or Euro1 in the EU, run along and compete with the large-value payment and settlement systems provided by central banks. Such private mechanisms for clearing interbank accounts could in principle evolve into systems of purely bilateral transfers among private banks or issue clearinghouse money or collateralised clearinghouse credit for settling interbank claims, thereby avoiding the need to use central bank money for final settlement. King (1999) went even further by suggesting a future world where all transactions could be settled by real-time transfers of private wealth from one electronic account to another. Technological advances would then have enabled a move to an electronic barter

economy, where a separate means of exchange (money) would no longer be needed.[18]

Most studies on the implications of e-technology for central banking do not go that far, but assume that some electronic money will still be needed as means of exchange. However, contrary to current world, money will be issued competitively in electronic form by private issuers as well as the central bank. The unit of account (eg one dollar, one euro) remains a national affair and is provided by the state, as there are overwhelming arguments to maintain a common measure of value. The central bank who continues to issue its own money in a competitive environment, tries to practice monetary policy by a Taylor-type rule whereby it adjusts the short-term interest rate in response to movements in expected inflation and the state of economic activity. The crucial question then is whether the central bank will any longer be able to set and move the general interest rate in the economy, or merely to influence the price at which its own liabilities exchange for other circulating monies.

Goodhart (2000) has argued that even in the case where the demand for government base money would completely evaporate, the central bank would still be able to set the country's nominal interest rate. His argument relies on the fact that the central bank is the government's bank, and thus has the power to intervene in financial markets without concern for profitability – a power that no commercial bank has. Even if all payments in the economy were carried out by private e-money, the central bank could bid or ask the rate for this e-money to the desired level, as it can accept more losses than its commercial rivals can. Further, for Goodhart the ability of the central bank to control interest rates is ultimately an issue of political economy. If the government wants to maintain the power of the central bank, it can set up necessary legal restrictions and organise the structure of the financial system to do so.

Freedman (2000) also reasoned that the central bank would be able to exert influence on the very short-term interest rate even in a world with completely private settlement. His argumentation is related to Goodhart's point that the central bank as a public, non-profit oriented institution is always able to keep the overnight rate at the desired level. He emphasised that the incentives facing banks when they have a surplus or deficit of settlement balances at the central bank are crucial for the central bank's influence over the very short-term interest rate. These incentives depend on terms and conditions imposed by the central bank. Referring to channel systems, such as employed by the Bank of Canada, Freedman then pointed out that the central bank can control the policy rate even if the average demand for net settlement balances is close to zero. This can be done by establishing a corridor for the overnight interest rate through unlimited standby

[18] A common unit of account for such an economy could be provided mechanically by regulation, as other weights and measures today.

facilities, where the central bank is prepared to accept overnight deposits at a certain rate of interest, and to extend overnight loans at a higher rate of interest. If need be, the central bank's position could be strengthened if the government would continue to settle its own payments on the books of the central bank.

In contrast, Costa and De Grauwe (2001) argue that the capacity of drawing on the resources of the state alone will not allow the central bank to regain its control over the short-term interest rate in a future world of competing currencies. They point out that in a cashless society where central banks do not have any specific role in the monetary process anymore, there is no apparent reason for banks to hold reserves at the central bank. At present, the central bank can offer in principle unlimited lending and borrowing facilities, as any use of those facilities has an impact on banking liquidity and thereby on interest rates. Hence, in practice the use of those facilities will always remain limited. In contrast, when money will be issued competitively, the central bank's operations will no more affect liquidity of other banks, as it has lost the power to create the ultimate means of payments. If the central bank wished to lower the interest rate, it would need to borrow the funds itself in the market at the market rate and lend them back at the lower target rate. As such an operation would not affect the equilibrium market rate, it would only set in motion a profitable arbitrage by other banks, who would borrow cheaply from the central bank and lend the same funds dearly in the market. The willingness of the treasury to bear the losses of the central bank would only make the size of these arbitrage activities larger, without creating added liquidity. Costa and De Grauwe conclude that if the central bank is only backed by state's financial support, it will lose its traditional instruments of monetary policy in the world where money is issued competitive by private financial institutions.

Woodford (2000) shared the views of Goodhart and Freedman, that even very radical changes in payment technology as might someday develop are unlikely to interfere with the conduct of monetary policy. Like Freedman's, Woodford's analysis is also based on monetary policy operating mechanisms under a channel system such as described in Annex 2, where the adjustment of the level of overnight rate by the central bank does not require any change in the supply of settlement cash. This implies that changes in the level of overnight interest rates can be effected simply by announcing a change in the target overnight rate, and by changing the lending and deposit rates at the central bank's standing facilities in tandem. Such channel-based monetary policy implementation systems do not require the central bank to be able to vary the spread between the return on other assets and that on bank reserves, and therefore do not depend upon bank reserves fulfilling a unique function that gives the central bank monopoly power. From this Woodford draws the conclusion that while advances in information technology may well require changes in monetary policy implementation techniques in countries (eg the United States) where central banks still steer short-term rates via

changes in reserves, the ability of central banks to control inflation will not be undermined. And the method of interest rate control in channel systems of countries like Canada, Australia or New Zealand should continue to be effective, even if the demand for settlement balances falls to zero. Woodford's key explanation that those mechanisms should work in a world where central bank liabilities serve no unique function is that there is no inherent 'equilibrium' level of interest rates to which the market would tend on its own in the absence of central bank intervention.

Referring to Keynesian IS-LM -framework, Friedman (2000) attacks Woodford's 'indeterminacy' argument that the central bank can fix the overnight rate in any possible future environment since the market on its own has no inherent equilibrium interest rate. In the traditional Keynesian framework the (real) interest rate is indeterminate along the saving-equals-investment schedule (the IS curve), so that the central bank is in principle free to establish the interest rate wherever it wants by appropriately positioning the portfolio equilibrium schedule (the LM curve). Indeed, Friedman interprets Woodford's and Freedman's idea of 'infinitely elastic' provision of loans and deposits at the central bank target rate (or at a minuscule spread) as an effort to impose on the economy a portfolio balance schedule that is approximately horizontal. However, in the traditional Keynesian money demand analysis, the LM curve turns vertical in a situation where the own-rate on money balances is varying exactly in step with the return on alternative assets. If the demand for money is unaffected by the interest rate, the LM curve is vertical, and at given level of aggregate demand the money market clears at any level of interest rates. In a sense Woodford's indeterminacy argument can be turned around: if any possibly interest rate is the 'equilibrium' rate, how can the central bank whose liabilities no more serve other functions than privately issued e-money, to dictate its terms in the money market without resorting to transactions in infinite volume.

4 E-finance and the future of central banking

4.1 Legal restrictions and the demand for reserves

A school of economists, most notably Wallace (1983), have long ago claimed that the demand for money is ultimately a product of various legal restrictions and regulations on money and finance. Without such restrictions and regulations, the distinctions between banks and other non-bank intermediaries would vanish, and the conceptual differences between deposits and other assets would also become meaningless. Those economists go further to argue that legal restrictions are also responsible for the peculiar nature of currency, namely its non-interest bearing

form. They predict that the imposition of a competitive note issue would either bring nominal interest rates to zero or force non-interest bearing central bank currency out of circulation. If commercial banks were free to issue private money, holders of central bank money would exchange their non-interest bearing public notes for interest bearing private notes. The central bank could then by open market purchases force its own non-interest bearing notes back into circulation, since they are legal tender, but holders of those notes would continue to exchange them for private notes until the interest rates of private notes would have fallen to zero. Alternatively, the central bank's non-interest bearing notes would be forced out of circulation, and would be replaced by privately issued interest bearing notes.

Wallace also argued that monetary policy – defined as central bank asset exchanges accomplished through open market operations or discount window lending – matters only in the presence of those legal restrictions on private intermediation. Suppose that government monopoly of currency issue and reserve requirement no longer exist, and a common constant-cost technology for the production and distribution of small-denomination bearer notes is available to the government as well as private intermediaries. Consider now an open market operation, whereby the purchase of Treasury bills is made by issue of currency notes. This would not lead to an increase in the money stock, as private intermediaries will offset one-for-one the government issue in the open market operation by scaling down their note-issue operations. This argumentation suggested that legal tender alone is not sufficient to guarantee effective monetary control by the central bank in conditions of laissez-faire.

We still have non-interest bearing banknotes in circulation, and positive nominal interest rates, which might tempt to the conclusion that the arguments of the legal restrictions school were flawed after all. However, it is interesting to note that in the wholesale bank reserve market where electronic trading and settlement have become the norm years ago, the first prediction of Wallace has been pretty much validated. With the development of the money market and the ability of banks to monitor their intraday balances, commercial banks have largely replaced non-interest bearing reserves at the central bank for interest-bearing market reserves. Indeed, the free demand for non-interest bearing reserves has fallen close to zero in all countries with advanced money markets and payment systems. But contrary to the second prediction, this development has not wiped out the central bank's ability to influence bank liquidity and to steer short-term interest rates.

Following the tradition of the legal restrictions school, one may well argue that even the present interest rate control is due to various restrictions on private intermediation, which force banks to exchange private reserves for public reserves

for the purpose of settling interbank transactions.[19] The force of regulation is most easily seen if one looks at the typical conditions for central banks' regular lending facilities. Let's take the Eurosystem as an example (see Annex 2). The Eurosystem offers a marginal lending facility, through which it stands ready to supply an arbitrary amount of overnight settlement cash at a fixed interest rate, which is considerably higher than the market-clearing overnight rate. The credit is granted against full collateral, which consist of government bills and bonds as well as other low-risk assets. It is easily recognised that in the absence of any restrictions on private intermediation and settlement, such a credit facility would be of no value. A bank in need of funds could simply borrow privately on such collateral at better interest rate terms with no trouble. In that environment there would be demand for central bank money only if it would be provided at competitive terms. For example, the central bank's credit facility would be used only if the interest rate were lowered to the market level or, alternatively, the central bank would lend against riskier collateral than the market practice.

Goodhart and Freedman may be right in arguing that the regulatory power of the Government will be sufficient to maintain the central bank reserve monopoly even in the future e-world. However, it is likely that the costs of regulation will grow over time with increasing sophistication of financial market and payment systems. Such costs are most visible in case of reserve requirements where even a small wedge between the market rate and the remuneration on required reserves can induce delocation and disintermediation effects. In the case of today's settlement obligations distortion effects are less evident, as forced settlement in central bank money is aimed at correcting a serious market failure, namely the threat of systemic risk in payment systems. However, given the advanced state of financial markets and the large availability of liquid funds, there is no fundamental technological or financial obstacle to settle any transactions by

[19] Reserve requirements are another instrument that central banks have used to force a stable demand for their liabilities. Views on the usefulness of this instrument in the e-world differ considerably. Woodford (2000) claims that, in order to maintain the clearing of payments through the central bank, reserve requirements would need to be abandoned when innovations in payment mechanisms have reached the stage, where any cost differential above a small ceiling would result in a complete abandonment of methods of payment requiring the use of central bank balances. On the contrary, Costa and de Grauwe (2001) envisage an enhanced role for legal reserve requirements in the e-money world. They suggest that in order to maintain the power on monetary affairs, the central bank will have to expand its supervisory control of any money issuance, independently of its type or origin. As a part of this extended control reserve requirements would be applied to non-traditional types of money, such as e-money. In practice this means that a certain percentage of high-quality e-money should be deposited at the central bank. Required e-money balances would be remunerated with an interest rate below but close to the market rate. However, Costa and de Grauwe also recognise that in a cashless society characterised by fierce competition and internationalisation of the financial market, the use of this instrument of monetary control will anyway remain limited.

means of other assets than central bank money.[20] One alternative would be to use liquid Treasury securities as a means of exchange in a gross-settlement environment. As Henckel et al. (1999) have pointed out Treasury money is rapidly becoming an alternative monetary unit to central bank money as a liquid reserve asset. In an efficient money market, banks can obtain clearing funds by conducting repurchase operations with Treasury bills, which have same-day settlement, or by selling Treasury bills for liquidity. Given real time information on the price of Treasury securities and further advances in payment and settlement technology, the limitations for using Treasury money to directly settle interbank positions are less and less technological, but just due to common value-day conventions, which are subject to change in case of need. Another option would be to use private e-money, which might be backed by high-quality securities or commodities, for final settlement of transactions.

If private agents are able to provide settlement arrangements, which are as safe and effective as settlement through central banks, there is less base to oblige gross settlement in central bank money. Indeed, payment system regulators are also envisaging new options, as the recently launched Core Principles for Systematically Important Payment Systems by the BIS Committee on Payment and Settlement Systems demonstrate. Namely, the Core Principle 6 of the 2001 recommendations states that 'Assets used for settlement should preferably be a claim on the central bank; where other assets are used, they should carry little or no credit risk and little or no liquidity risk'. In the new principles for payment systems settlement in central bank money is still the preferred option but no more an obligation, as was stipulated by the EU Minimum Common Features for Domestic Payment Systems less than a decade earlier.

4.2 Interest rate determination in a multireserve economy

How then might monetary policy be carried out in tomorrow's economy, where private institutions issue e-money, that can be used not only for payment but also for final settlement of any transactions. It is not easy to see how the economy's

[20] We take the view that finality of payments is ultimately a legal concept rather than something linked to the nature of the medium that is used to settle the transaction. The act of settlement determines an ordering of claims on bank assets. Settlement is final provided that once the transfer of funds from the net debtor bank to the net creditor bank has been executed, remaining creditors of the sending bank cannot recover the transferred funds should the bank fail. Typically, net settlement systems employ complex techniques of contract modification to rearrange the original payment obligations with the aim to achieve higher efficiency in execution and to lower the risk of settlement failure. For example, appropriate collateral and mutual guarantee arrangement in EBA Euro1 insure finality of payments for the clients of Euro1 banks. See Green (2000) for an extensive discussion of the issues involved.

payment infrastructure will be structured at that stage, but the existence of large network externalities suggests that in equilibrium only a few providers of e-money and other settlement services will survive. As a first approximation of the future, we assume that the (few) competing settlement systems will function pretty much like today. The main difference is that the host for each settlement system has the capacity to issue its own e-money, which all users of the system accept for final settlement of all payment orders in the respective system. The systems can be either net or gross settlement systems, and banks as well as other users of payment services are free to choose which system to use. However, a move from one system to another is likely to be a long-run decision, as it includes both time lags and transfer costs. For simplicity, let us assume that only two competing settlement systems are in operation, the first run by the central bank and the second by a private settlement agent, for example a consortium of major commercial banks.

Similarly to today, an individual bank can obtain clearing funds by borrowing from the money market or alternatively by borrowing from the respective settlement agent. In a standard way we assume that the overnight trading is conducted by a walrasian auctioneer at a certain point of time during the day. The clearing rate used by the auctioneer is the representative overnight rate for that day. Prior to the clearing time, banks are free to move funds between the two settlement systems and from money market to settlement accounts and vice versa. Public and private e-money trade at par in the money market, so that a single overnight rate r^{on} exists. Immediately after the clearing the money market and settlement accounts are closed.

Banks face a continuum of distinct and independently distributed liquidity shocks during a banking day. We assume that banks have the ability to monitor their reserve balances in real time. This implies that the uncertainty about the end-of-day reserve balances is entirely due to the net effects of the liquidity shock (X) occurring after the clearance of the markets. In other words, we follow the present practice by assuming that financial markets are effectively closed before the bank knows the whole extent of its reserve gains or losses. The expected value of the shock is zero. The banking system is closed in the sense that a positive liquidity shock for one settlement system implies a corresponding negative shock for the other system. End-of-day credit balances are unremunerated in both settlement systems. Furthermore, overdrafts are forbidden, so banks cannot have debit balances on their settlement accounts with the central bank at the end of the day. End-of-day debit balances need to be cleared by the use of a marginal lending facility, which both settlement agents provide at rates r^{L}_{CB} and r^{L}_{EM}, respectively.

Let us now consider the representative bank's short-run reserve management problem. The bank has settlement balances (deposits net of loans), D, and needs to decide the allocation of its liquid funds between interbank lending and reserve

balances at the accounts of the two settlement agents. The bank allocates its excess reserves R so that δR are held at the reserve account with the central bank, which leaves (1–δ)R for the private system. The representative bank's optimal policy can be achieved as the first order condition of the bank's profit maximising problem, which can be written as:

$$\pi = r^{on}(D-R) - r^{L}_{CB}\int_{\delta R}^{\infty}[X-\delta R]f(X)dX - r^{L}_{EM}\int_{-\infty}^{-(1-\delta)R}[-X(1-\delta)R]f(X)dX. \tag{4.1}$$

The first order conditions with respect to excess reserves and their allocation for the competing settlement systems are:

$$\frac{\partial\pi}{\partial R} = -r^{on} + r^{L}_{CB}\delta\int_{\delta R}^{\infty}f(X)dX + r^{L}_{EM}(1-\delta)\int_{-\infty}^{-(1-\delta)R}f(X)dX = 0. \tag{4.2a}$$

$$\frac{\partial\pi}{\partial\delta} = r^{L}_{CB}\int_{\delta R}^{\infty}f(X)dX - r^{L}_{EM}\int_{-\infty}^{-(1-\delta)R}f(X)dX = 0. \tag{4.2b}$$

Aggregation over the unitary mass of banks gives the market-clearing overnight rate as:

$$r^{on} = r^{L}_{CB}\delta F(-\delta R) + r^{L}_{EM}(1-\delta)F(-(1-\delta)R), \tag{4.3}$$

where F(–δR) and F(–(1–δ)R) represent the probabilities of the banking system being overdrawn with optimal reserves and their allocation in the public and the private settlement system, respectively. We note that the equilibrium overnight rate is determined by the weighted average of the lending rates set by the competing settlement agents. Weights are influenced by the probabilities of ending at debit positions in competing settlement systems as well as by the allocation of reserves between the two systems. The central bank can still influence the overnight rate by changing its lending rate or by affecting the total amount of reserves, but its control of the overnight rate is only partial, as it has no more monopoly over the supply of clearing funds. The model can be straightforwardly extended into a world with n providers of settlement funds in which case the central bank's influence over the short-term interest rate would become even more limited.

The bank's reserve management is given by the following conditions:

$$F(-\delta R) = \frac{r^{on}}{r^{L}_{CB}} \quad \text{and} \quad F(-(1-\delta)R) = \frac{r^{on}}{r^{L}_{EM}}. \tag{4.4}$$

We see that the optimising bank chooses its reserve allocation in order to balance the probability of ending the day with debit balance with the relative cost of excess vs. borrowed reserves, respectively for both systems.

This simple model is useful in demonstrating that fundamental changes in the economy's transaction technology might indeed endanger the central bank's control over monetary conditions. With a straight-forward extension of Poole's reserve market model it focuses on the precautionary demand for reserves in competitive but almost identical settlement systems, distinguished only by the interest rate applied on borrowed reserves. However, the model is extremely simplistic description of the future reserve market, as it mechanically projects the present payment infrastructure into a future environment with more than one supplier of settlement funds. In order to judge the realism of the model, we first have to consider whether a precautionary demand for reserves will continue to exist in tomorrow's e-world as assumed in the model. Clearly, the precautionary demand for reserves by banks is related to uncertainty of daily payment flows, which will not be totally removed by further advances in technology. One source of uncertainty is changes in the amount of banknotes held by the public. This kind of uncertainty will remain as long as some form of e-cash issued by the banking sector will be circulating in the economy. However, as cash holdings by the public normally follow a seasonal pattern, changes for that liquidity item are relatively easy to forecast. Furthermore, as suggested by the model by Berentsen, the stock of e-cash in circulation is likely to be low (due to its high velocity), so that daily (net) withdrawals of e-cash will only have a limited impact on liquidity. Other source of uncertainty is related to incoming payments, which are not under the control of the receiving bank. As in today's environment, there is always a slight risk that some payments due today are not received in time so that their value date is shifted one day forward. The most simplistic reasons for such a risk are technical or human errors. In some cases a payment is routed via different payment network (eg correspondent banking) implying de facto a change in the value date. At the extreme there is also the risk of the payer bank failing during the trading day.

Another issue concerns whether there will be a significant general shortening of the time lag between trade and settlement and whether that would fundamentally change the nature of the reserve market. Today, we have well-defined value dates for different kinds of financial transactions, closely linked to the present hub-and-spokes structure of the economy's payment systems. Normally, transactions at the spokes (eg customer, securities and forex payments) are effected with value dates t+1 or higher. Only transactions at the hub (the central bank or the private interbank settlement system) are carried out with same day settlement, implying that the reserve market in a narrow sense can also be defined in terms of value dates. In other words, the reserve market is restricted to

overnight and short-term depo trading between commercial banks and liquidity transactions between commercial banks and the central banks, settled at same day value. However, a more efficient securities settlement technology allows a general shortening of value day lags. Indeed, it cannot be excluded that in the future Treasury bill or other liquid securities would be traded at same day value, as interbank deposits today. Though, as long as the present hierarchy of payments networks as well as ultimate settlement in central bank money is maintained, change in value dates will not change the nature of reserve trading even if it clearly adds to the deepness of that market. But the option of trading Treasury bills at same day value is only one step away from starting to settle directly by transfers of those securities rather than first exchanging Treasury bills for central bank money for final transfer of value.

A related and perhaps the most crucial issue concerns the choice of settlement media by private agents. This is clearly the main difference compared to the present environment where we can simply assume a well-defined demand for central bank money due to the structure and regulation of the economy's payment infrastructure. For the future, we have first to model the transaction demand for competing settlement media to see which types of monies are the most likely to be used for settlement. For such an analysis, one has to assume some differences in the quality of competing monies. Furthermore, the transaction demand for money is positively related to the market share of that particular money in the settlement of the economy's transactions, as the use of any settlement medium is clearly associated with positive network externalities. Another interesting extension would be the introduce some risk premiums for circulating currencies, which might render the system asymmetric in the sense that issuers of more credible settlement funds could have relatively higher influence over monetary conditions. As Costa and de Grauwe have pointed out, a society with several monies trading at fixed rates can be paralleled to a system with fixed exchange rates in the absence of capital controls. As we know from the history of fixed rate currency areas, such as the EMS, the 'anchor' country often has disproportional influence over monetary conditions for the whole currency area. To receive that anchor position, the central bank of that country has to accumulate a strong reputation as a supplier of strong currency, that maintains its purchasing power over time.

The discussion above suggests two conditions for the central bank to gain influence over interest rates in a multireserve world. First, the central bank should have a large market share in the supply of the economy's settlement funds. Second, and surely as a precondition for the first approach to have any success, the central bank needs to have a reputation as an issuer of solid money. We will next preliminarily review a few factors, which might increase the transaction demand for central bank money as well as enhance its credibility in relation to privately issued currency in the future e-world. The discussion is very tentative,

just highlighting a few issues, which might be of relevance for the central bank's position in a society with competitive supply of money.

4.3 The central bank as banker to the Government

In many countries, especially in Europe, central banks that emerged in the 18th and the 19th century were initially very closely tight to Government finance (Kindleberger, 1984). They acted as the bank of issue for the Government, and in many cases they issued notes that were, in effect, state debt. Also, in a historical perspective, there is a clear correlation between the status of the central bank and the role of the central government in the economy. Therefore, if we are returning to a competitive money economy, it is natural to consider whether the position of the central bank as the Government's bank will again distinct it from its private competitors. In principle, the Government can back the central bank's position at the core of the banking system in several interrelated ways. As pointed out by Goodhart, one distinctive feature is the central bank's ability to bear higher losses than private banks as those losses can be covered through state budget finance. Indeed, in a competitive environment this element might become quite crucial, as the central bank could only induce a large demand for its liabilities by supplying its money at preferential terms in comparison to market price. This is in sharp contrast to the present situation, where legal tender provisions, reserve requirements and settlement regulations guarantee a large demand for central bank liabilities at zero or low interest rates.

However, it is very questionable whether the central bank in practice could ever intervene in large volumes without any concern for profitability. As noted by Friedman, the central bank's balance sheet is already limited in relation to vast financial markets and the gap between the two is to widen considerably, if public banknotes are replaced by private e-cash. If the future central bank, a small player in the market by that time, tries to move the market price through its own operations, it could easily be engaged in unfavourable large-scale arbitrage against private players, as has been suggested by Costa and De Grauwe. It is indeed questionable whether the taxpayers would be willing to bear the costs of such a game.[21] And even it the central bank could gain some influence over the short-term interest rate by means of limited unprofitable intervention, running financial support by the Government is a double-edged measure, as it could threaten the independence of the central bank.

[21] Numerous unsuccessful defences of fixed exchange rates against private speculators demonstrate that central banks are normally not willing to pursue unlimited intervention to support their monetary policy goals.

Another common argument in favour of a public currency is that claims on the central bank are not subject to a solvency risk, which makes the public more willing to hold central bank liabilities than private ones for ultimate settlement of transactions. For this reason, only private monies with no possibility of default are likely to be successful in competition with government money. Indeed, issuers of private money seem to be using two principal ways to de facto remove the possibility of default for their money. The first way is to issue private money by a consortium of trustworthy deposit banks, which are more or less directly insured by the government (eg through a deposit insurance scheme).[22] The second way is that privately issued money is backed by tangible assets, such as precious commodities.[23]

If the public is only willing to accept default-free monies, there is no obstacle in principle for financial intermediaries to issue money against the full backing of riskless government debt. In that case, the money-issuing institution could be organised as a mutual fund with simultaneous payment facilities. Its assets would consist of risk-free government securities, against which it would issue interest-bearing small-denomination unit shares, which could be used for payments. Actually, such mutual funds have existed for some time, but the idea of incorporating payment facilities to mutual funds has not caught on yet to any great extent. As pointed out by Goodhart (1993), the reason for that might be that bank clients prefer their assets to possess nominal certainty, so they know what potential outward cash flows they can meet without difficulty. This argument may indeed be valid for retail customers, who are only used to accounting in nominally certain units. Nominal certainty is less relevant for wholesale payments, and particularly for interbank payments, as bank are used to mark-to-market accounting and have cash management facilities that can easily incorporate the use of market-valued money.[24]

---

[22] For example, in Finland the Avant Electronic Cash system is operated by Automatia Ltd., owned by the three largest banks of Finland, which jointly have nearly a 90 per cent market share in deposits.

[23] E-gold and GoldMoney are examples of commodity backed payment systems, in which payments made on the internet are completely backed by gold or, in the case of e-gold, also other precious metals. A quantity of e-gold or, in the case of GoldMoney, GoldGrams, constitutes title to a precise weight of the physical metal which can be used to purchase goods and services. These systems enable their users to make instant, non-repudiable payments to anyone around the world at any time via the Internet.

[24] The idea of using money backed by government securities for the settlement of interbank transactions is not far from present-day practice. As commercial banks are no more willing to hold non-remunerated clearing reserves at central bank accounts, the liquidity for gross settlement of transactions is mainly provided by the central bank in the form of intraday credit against full collateral, most of it consisting of public debt securities. In principle, a private settlement agent could easily replicate such a collateral system, and provide intraday liquidity for settlement of transactions on its accounts.

The discussion above suggests that the default-free argument alone might be inadequate to safeguard the dominance of central bank money in an economy with a competitive money supply. However, as Goodhart has emphasised, there is another avenue for the Government to promote the status of its own bank as the prime settlement agent in the economy. If the Government always requires payment in the form of a claim on its own bank, there will be a strong reason for the commercial banks to keep settlement accounts and reserve balances with the central bank. The Government is the largest financial operator in any modern society, and due to tax collection and social security transfers it carries out financial transactions in practice with every economic agent within its own national territory. Therefore, an obligation to settle all public sector payments in central bank money would immediately give the central bank a large market share as supplier of settlement funds. With positive network externalities, that would also enhance the value of public money in clearing private transactions.

Due to historical evolution, central banks normally have a large role as settlement agents for their Government. In most countries central banks act as the Government's debt agent, in charge of debt management for the State, even if there has been some tendency to outsource such tasks from the central bank to specialised State debt offices. As regards other financial transactions of the Government, the involvement of the central bank varies considerable from country to country. As regards Euro countries, in Spain, France, Ireland, Italy and Portugal practically all Government transactions, such as debt issuance, redemption and coupon activity, the collection of tax and social security contributions, the acquisition of goods and services, the payment of public wages, pensions and other social security benefits, are settled in central bank money (ECB, 2000). In other Euro area countries, the Government has a settlement account both at the central bank and at one or several commercial banks, and public sector transactions are settled in central bank money in varying degree. State debt management transactions are normally settled in central bank money in all countries, whereas tax and social security contributions as well as wages, pensions and other social security benefits are in many countries cleared through commercial banks.

If state operations are settled in central bank money, the balance of Treasury deposits at the central bank is affected by any operation conducted by the Treasury. Indeed, at the aggregate Euro-area level, Treasury deposits with the central bank are the most volatile item among the so-called autonomous factors (ie the changes of the balance sheet of central banks neither related to monetary policy operations nor to current account holdings of commercial banks with the central bank). Even if central banks have devoted considerable resources to estimate the net liquidity flows resulting from all transactions of the Government with the private sector, volatility of Treasury deposits is sometimes problematic for the Eurosystem's overall liquidity management. Thus, there has been a

tendency to lower the Governments' deposit balances held at central banks. This can be done by lower remuneration of these balances, which gives the Treasury an incentive to invest excess funds in the money market, while continuing to settle Government transactions in central bank money. A more radical way is outsourcing the settlement of payments into the private banking sector, which several Euro countries have partially done. For retail transactions, such as taxes and wages, an outsourcing is also motivated by cost considerations, as maintaining the necessary infrastructure for collecting and clearing payments may be very expensive. However, the prospect of private e-settlement suggests that the Government should continue to settle its securities, money market and forex transactions in central bank money, if it wishes to safeguard the central bank's position at the centre of the economy's settlement activity.

4.4 Market failure and central banking

An additional way to motivate a need for public liquidity starts from the premise that private markets are inherently unstable, ie prone to systemic liquidity crisis, where an abundant supply of legal tender money is the best remedy. Most models, such as the Diamond-Dybvig one, motivate such market failure by microeconomic financial market imperfections, which somehow render the macroeconomy more vulnerable to unanticipated shocks. In many of those models, the central bank's liquidity intervention can be used to make the functioning of the private financial market more complete. However, in the classic Diamond-Dybvig model a government deposit insurance system is also an effective policy to solve the co-ordination problem of depositors. As deposit insurance schemes are nowadays compulsory in most countries, the modern financial system is hardly posed to classic deposit runs involving a massive flight to currency. Furthermore, during the last decades the development of modern money markets has greatly enhanced commercial banks' options for liquidity management. Banks are increasingly using wholesale markets like the overnight market or the CD (certificate of deposit) market to adjust their liquidity positions. Due to the growth of repo markets banks can now obtain funds by selling or repoing a vast range of assets. Even less liquid assets can be exchanged for liquidity by means of securitisation. Thus, in principle there should be no limit to the amount of liquidity that a bank can raise from the market against the value of its assets. Under such circumstances one may well assume that markets should be able to supply banks with sufficient liquidity without a need for a special lender of last resort.

However, even if the development of money market trading and market instruments has greatly enhanced banks' options for liquidity management, it has

not removed the liquidity mismatch in banks' balance sheet structure, as the amount of liquid assets generally falls short of the amount of liquid liabilities (Herrala, 2001a). Furthermore, a considerable proportion of bank assets, notably those which do not have full collateral or which cannot easily be securitised, are of uncertain and state contingent value. In a bank specific crisis banks can use all tradable assets, whether public or private, as liquidity because an idiosyncratic shock does not affect market pricing. However, an aggregate shock may result in a breakdown in market liquidity, which turns tradable assets into non-marketable loans or at least induces large changes in prices. Therefore, in a systemic crisis the continuation value of a bank may not be fully pledgeable to depositors and other investors, and a bank can fail due to insufficient liquidity even if its continuation is valuable to the society as a whole.

Indeed, some extensions of the D-D bank run model suggest that interbank market could be akin to contagion where liquidity problems may be transferred from one bank to another (Allen and Gale, 2000). In such models, an idiosyncratic shock is amplified because there is an additional loss due to the costly liquidation of the failed bank's loan portfolio. In other models, incentive effects provide an explanation for the deficiency of the interbank market (Bhattacharya and Gale, 1987; Bhattacharya and Fulghieri, 1994). In those models banks use interbank assets as reserve assets to free ride on other banks which leads to undesirably low levels of liquidity and too much fragility in the banking sector. The breakdown of the interbank market in those models gives a rational for a central bank lending facility. Another strand of literature explains bank runs and interbank failure as a consequence of sharp declines in asset positions rather than pure liquidity shocks (Calomiris and Gorton, 1991; Köppl and MacGee, 2001). Such models are especially relevant in explaining the potential for failure in modern financial markets, where more and more trading is carried out against collateral. Finally, in Cooper and Corbae (2001) fluctuations in confidence is the key source of financial collapse. The central bank can eliminate confidence driven financial collapse through liquidity provision.

The liquidity model by Holmström and Tirole also suggests a rational for government-supplied liquidity and for its active management, but does not link firms' demand for liquid assets directly to central banking. Herrala (2000) has extended this model to address the issue whether markets can supply banks with sufficient liquidity or whether markets should be complemented with a lender of last resort. Herrala applies the liquidity model framework to banking and extends the framework to admit the analysis of problems associated with transitory liquidity outflows, even absent any change in a bank's value. The model suggests two interesting results about the sufficiency of markets as a source of liquidity, and the role of the lender of last resort. First, banks may find it hard to finance even transitory liquidity shocks from the markets if moral hazard problems are amplified by liquidity shocks. Moral hazard, interpreted as the possibility of laxity

in banks' monitoring of firms, may increase with outflows of liquidity because in that case banks would need to increase their monitoring efforts in order to safeguard their own interests. Second, there are economies in reserve pooling that arise from the ability of a pool to implement soft budget constraints for banks experiencing liquidity shocks. An ability to issue legal tender reduces liquidity costs further, as the need to prehoard costly reserves vanishes. A lender of last resort (LOLR) can economise on reserve holdings when market transactions are constrained by moral hazard.

Proponents of public money issue often refer to the perceived instability of eighteenth and nineteenth century free banking experiences, when private banks competed against each other to provide the public with currency. In contrast, Hayek (1976) and other supporters of free banking claim that the instability of banking systems is ultimately due to government regulation, such as legally enforced fixed exchange rates between different kinds or money, which inhibits the natural selection process towards the best sort of money among those issued by the various agencies. They predict that, if not distorted by government regulation, private incentives would guarantee an optimal response to liquidity pressures. Indeed, private market has not been totally unable to innovate responses to banks' high need for liquidity during periods when banks experienced liquidity runs. Bank runs originate from an information asymmetry, which makes it impossible to convince depositors or other creditors of the value of bank portfolios. The banks themselves have some prerequisites to cope with the problem, as they have special knowledge to value bank assets. Furthermore, as banks have developed interbank relationships and offered lines of credit to their correspondent banks, they also have expertise in monitoring and managing loans to each other. Banks have also an incentive to avoid other members' failures because with asymmetric information the failure of an individual bank can cause changes in depositors' conditional expectations so that other banks also become vulnerable to runs. For those reasons, banks tend to make arrangements to support weaker members during panics.[25]

Some models of the banking system indeed suggest that banking panics ultimately result from existing regulatory restrictions on banking, rather than being inherent to private financial contracting. For example, in Champ, Smith and Williamson (1996) panics occur when there are restrictions on the issue of currency by private banks, but they do not occur if banks are unrestricted. Alike,

[25] For example, during the Free Banking Era in the United States the New York Clearinghouse authorised the issuance of loan certificates during banking panics. The member bank needing currency to satisfy depositors' demands submitted part of its portfolio as collateral, and certificates were issued amounting to a percentage of the market value of the collateral. The loan certificates were acceptable in the clearing process not only because they were backed by discounted securities, but also because they were claims on the clearinghouse, a joint liability of the members.

in Calomiris (1999) protection against systemic shocks can be provided more efficiently through private institutional arrangements such as clearing houses. However, Aghion, Bolton and Dewatripont (2000) argue that while an unregulated banking system based around a private clearing house arrangement may dominate public safety nets in reducing moral hazard and therefore the scope for individual bank insolvency, it also increases the likelihood of contagious bank failures following a systemic shock. Herrala (2001b) compares private and public schemes for liquidity provision by investigating how an idealised LOLR formulates policy under alternative, public and private governance structures. In the model, the first best LOLR-scheme always covers the whole banking sector and offers full insurance to the participants. The model suggests that voluntary schemes succeed relatively well as lender of last resort in situations where recipients of LOLR assistance can repay the LOLR loan with interest. The conclusion changes when the ability of banks to repay the LOLR credit is limited. When lending is associated with losses for the LOLR, good quality banks will tend to stay out of the LOLR scheme. In that case, a compulsory scheme such as a central bank, which can impose a reserve requirement on banks, has an advantage over voluntary schemes.

5 Conclusions

Advances in information processing technology and in communications are transforming the financial landscape. Real-time access to financial information, electronic trading and electronic means of payment are nowadays standard for wholesale financial markets. Even in the retail side electronic card payments have largely substituted for traditional cash, whose position is further challenged by the latest innovation for retail payments – the e-cash. Those innovations are contributing to the microeconomic efficiency of the finance and payment industry, and should therefore be welcomed by central banks and other authorities. On the other hand, such innovations are also threatening to erode the private sector demand for the monetary base, which is often seen as the cornerstone for effective monetary control in the economy. The potential conflict between the goals of microeconomic efficiency and macroeconomic stabilisation raises several crucial questions for central bankers world-wide. For example, how real is the threat that innovations in payment technology will ultimately lead to erosion of private-sector demand for monetary liabilities of the central bank? Does it matter for the conduct of monetary policy? If it does, should the central bank use some regulatory measures to safeguard its power for monetary control? Which measures are likely to be the most effective in safeguarding the public monetary control and at the same time the least distortive in terms of resource allocation?

At present, the research community is offering mixed answers to such questions. Our preliminary analysis of the issue makes no difference in this regard. On one hand, money can be viewed as a communication device invented to facilitate the exchange of goods and services between economic agents. In this sense, advances in information and communication technology are clearly challenging the role of central bank money by providing speedier and more sophisticated devices to record private transactions. On the other hand, it can also be argued that the provision of money is a natural monopoly, which complements the imperfect functioning of private financial markets. Those competing views on the nature of money suggest quite different future for central banking.

If central bank money is simply seen as a unit of account that most people use to record mutual or multilateral exchange, it is easy to imagine a future where private entities use other monetary standards to contract with each other. In such a world, the degree of control that the central bank has over the nation's monetary conditions depends upon how many economic agents still choose to contract in terms of the public currency issued by the central bank. Clearly, if need be, the government has at its disposal several instruments to foster the use of public money. Such measures include an obligation to use central bank money to settle some vital transactions (eg interbank liabilities) in central bank money, or an exclusive use of public money for the settlement of government payments. However, the costs of coercive regulation are likely to increase with increasing sophistication of private financial markets. Therefore, similarly to other public services, microeconomic efficiency considerations are pressing for further 'privatisation' of the payment and settlement industry.

On the other hand, if the provision of (base) money is seen as a natural monopoly, there need not be any conflict between microeconomic efficiency and macroeconomic policy considerations. The use of money is clearly subject to large network externalities, as the settlement value of money increases with the number of other agents who accept it for exchange. Clearly, both theory and evidence seem to suggest that in the absence of regulation money, as other types of medium of exchange, are oligopolistically supplied. However, there are also arguments, both theoretical and empirical, suggesting that such oligopoly markets for money issue are inherently unstable, and need to be complemented by publicly regulated supply of ultimate clearing funds. In this case, some degree of public monopoly in the provision of payment and settlement services would serve both a structural and governmental need, and would be beneficial for an orderly functioning of private financial markets.

The importance of the issue and the present state of the debate advocate further research to model the implementation of monetary policy in an environment of competitive money supply, taking into account the perceived future infastructure for payment and settlement services. As the ability to set the economy's short-term interest rate is the core of modern central banking, the

modelling approach could focus on the determination of the overnight interest rate in a system, where competing private and public monies are available for settlement. By adding the demand for competitive settlement funds, the model would allow an analysis of factors that may have an impact on the public sector's chances to control the level of interest rates in the future economy. Such an analysis might also bring about useful insight into the future role of the central bank in the payment system, both as a provider and as a regulator of payment services.

References

Aghion, P. – Bolton, P. – Dewatripont, M. (2000) **Contagious Bank Failures in a Free Banking System.** European Economic Review 44.

Bagehot, W. (1873) **Lombard Street – A Description of the Money Market.** John Wiley and Sons, Inc.

Baumol, J. (1952) **The Transaction Demand for Cash: An Inventory-Theoretic Approach.** Quarterly Journal of Economics 66.

Berentsen, A. (1998) **Monetary Policy Implications of Digital Money.** Kyklos, Vol. 51.

Bindseil – Seitz (2001) **The Supply and Demand for Eurosystem Deposits: The First 18 Months.** ECB Working Paper No. 44.

BIS Committee on Payment and Settlement Systems (2001) **Core Principles for Systematically Important Payment Systems.**

Bordo, M.D. – Jonung, L. – Siklos, P.L. (1997) **Institutional Change and the Velocity of Money: A Century of Evidence.** Economic Inquiry, Vol. XXXV.

Calomiris, C. (1999) **Building an incentive compatible safety net.** Journal of Banking and Finance 23.

Calomiris, C. – Gorton, G. (1991) **The Origin of Banking Panics: Models, Facts and Bank Regulation.** In Financial Markets and Financial Crises, R.G. Hubbard (ed.), University of Chicago Press.

Champ, B. – Smith, B.D. – Williamson, S.D. (1996) **Currency Elasticity and Banking Panics: Theory and Evidence.** Canadian Journal of Economics, XXIX, No. 4.

Cooper, R. – Corbae, D. (2001) **Financial Collapse and Active Monetary Policy: A Lesson from the Great Depression.** Federal Reserve Bank of Minneapolis Staff Report 289.

Costa, C. – De Grauwe, P. (2001) **Monetary Policy in a Cashless Society.** CEPR Discussion Paper No. 2696.

Diamond, D.W. – Dybvig, P.H. (1983) **Bank Runs, Deposit Insurance, and Liquidity.** Journal of Political Economy, 91, no. 3.

Edgeworth, F.Y. (1888) **The Mathematical Theory of Banking.** Journal of the Royal Statistical Society.

Freedman, C. (2000) **Monetary Policy Implementation: Past, Present and Future – Will Electronic Money Lead to the Eventual Demise of Central Banking?** International Finance 3:2.

Frenkel, J.A. – Jovanovic, B. (1980) **On Transactions and Precautionary Demand for Money.** Quarterly Journal of Economics 95.

Friedman, B.M. (1999) **The Future of Monetary Policy: The Central Bank as an Army with only a Signal Corps?** International Finance 2:3.

Friedman, B.M. (2000) **Decoupling at the Margin: The Threat to Monetary Policy from the Electronic Revolution in Banking.** NBER Working Paper 7955.

Goodfriend, M. (1991) **Money, Credit, Banking, and Payments System Policy.** Economic Review.

Goodhart, C.A.E. (1987) **Why Do Banks Need a Central Bank?** Oxford Economic Papers.

Goodhart, C.A.E. (1993) **Can We Improve the Structure of Financial Systems?** European Economic Review, 37.

Goodhart, C.A.E. (2000) **Can Central Banking Survive the IT Revolution?** International Finance 3:2.

Gorton, G. (1985) **Clearinghouses and the Origin of Central Banking in the United States.** The Journal of Economic History, Volume XLV.

von Hayek, F.A. (1977) **Entnationalisierung des Geldes.** Mohr, Tubingen.

Henckel, T. – Ize, A. – Kovanen, A. (1999) **Central Banking without Central Bank Money.** IMF Working Paper 99/92.

Herrala, R. (2000) **Markets, Reserves and Lenders of Last Resort as Sources of Bank Liquidity.** Bank of Finland Discussion Papers 3/2000.

Herrala, R. (2001a) **Liquidity in Banks and the Central Bank: a Survey of Selected Empirical Issues and Theoretical Developments.** Bank of Finland Discussion Papers x/2001.

Herrala, R. (2001b) **An Assessment of Alternative Lender of Last Resort Schemes.** Bank of Finland Discussion Papers 1/2001.

Holmström, B. – Tirole, J. (1998) **Public and Private Supply of Liquidity.** Journal of Political Economy, Volume 106.

Kindleberger, C.P. (1984) **A Financial History of Western Europe.** George Allen & Unwin, London.

King, M. (1999) **Challenges for Monetary Policy: New and Old.** Bank of England Quarterly Bulletin, Vol. 39.

Korpisaari, P. (1920) **Suomen Pankit: Niiden Kehitys, Rakenne ja Toiminta-muodot.** Helsinki.

Köppl, T.V. – MacGee, J.C. (2001) **Limited Enforcement and Efficient Interbank Arrangements.** Federal Reserve Bank of Minneapolis Working Paper 608.

Markose, S.M. – Loke, Y.J. (2001) **The Microstructure of Recent Trends in Cashlessness: UK and USA Compared.** University of Essex.

Marquardt, J. (1994) **Payment System Policy Issues and Analysis.** In Summers, B. (ed.), The Payment System: Design, Management and Supervision, IMF.

Miller, M.H. – Orr, D. (1966) **A Model of the Demand for Money by Firms.** Quarterly Journal of Economics 80.

Niskanen, M. (2000) **Lender of Last Resort and the Moral Hazard Problem.** Unpublished Manuscript.

Olivera, J.H.G. (1971) **The Square-Root Law of Precautionary Reserves.** Journal of Political Economy 79.

Pauli, R. (2000) **Payments Remain Fundamental for Banks and Central Banks.** Bank of Finland Discussion Papers 6/2000.

Poole, W. (1968) **Commercial Bank Reserve Management in a Stochastic Model: Implications for Monetary Policy.** Journal of Finance 23.

Santomero, A.M. – Seater, J.J. (1996) **Alternative Monies and the Demand for Media of Exchange.** Journal of Money, Credit and Banking, Vol. 28.

Snellman, J. – Vesala, J. – Humphrey, D. (2000) **Substitution of Noncash Payment Instruments for Cash in Europe.** Bank of Finland Discussion Papers 1/2000.

Thornton, H. (1802) **An Enquiry into the Nature and Effects of the Paper Credit of Great Britain.** London: Hatchard.

Timberlake, R.H. (1984) **The Central Banking Role of Clearinghouse Associations.** Journal of Money, Credit and Banking, Volume XVI.

Tobin, J. (1956) **The Interest-Elasticity of Transactions Demand for Cash.** Review of Economic Studies 38.

Tobin, J. (1958) **Liquidity Preference as Behaviour Towards Risk.** Review of Economic Studies.

Wallace, N. (1983) **A Legal Restrictions Theory of Money and the Role of Monetary Policy.** Federal Reserve Bank of Minneapolis Quarterly Review.

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

Woodford, M. (2000) **Monetary Policy in a World without Money.** NBER Working Paper 7853.

Annex 1.

Financial Magnitudes in the Euro Area

Due to technological advances and financial innovation the size of central bank liabilities has steadily declined relative to other financial magnitudes. As shown in Table 1, the largest liability item of the Eurosystem, currency in circulation, only accounts for 7.1 per cent of Euro area broad money (M3). Even the size of total monetary base does not exceed 10 per cent of broad money. Still more striking is the disparity between the magnitude of commercial banks' settlement reserves held at Eurosystem central banks and the volume of outstanding liquid market instruments, such as government securities, which banks can hold in their portfolios as secondary reserves. Also, looking at the asset side of central banks, the total central bank credit in the Euro area only accounts for a tiny part of gross funding requirements by all Euro area Monetary Financial Institutions.

Table 1. **Comparison of Financial Magnitudes in the Euro Area, EUR billion**

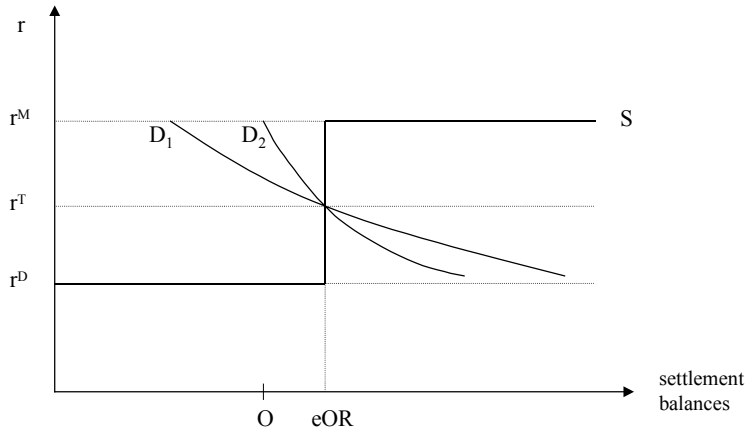
	December 1999	December 2000
Free reserves	1.2	0.4
Total bank reserves	106.6	117.6
Currency in circulation	354.2	360.4
Monetary base	460.8	478.0
Gross Eurosystem credit to MFIs	250.1	268.6
Net Eurosystem credit to MFIs	132.7	144.0
Narrow money (M1)	1964.0	2074.3
Broad money (M3)	4791.0	5080.0
Government paper held by Euro are MFIs	1124.6	993.0
Total short-term Treasury securities	258.5	263.8
Total long-term Treasury securities	2974.8	3088.5
Aggregated balance sheet of MFIs	15534.6	16711.4

Annex 2.

The channel system applied by the Eurosystem

The ECB has also adopted the channel framework for implementing monetary policy for the Euro area, despite the fact that it also uses a minimum reserve system with averaging provisions. This might partly reflect lower willingness to use open market operations to accommodate daily shifts in reserve demand, due to highly decentralised operational set-up for the Eurosystem. The Eurosystem offers a marginal lending facility, through which it stands ready to supply an arbitrary amount of overnight settlement cash at a fixed interest rate (r^M), which is higher than the target overnight interest rate. The Eurosystem also applies a deposit facility where commercial banks have the right to deposit excess settlement cash over-night with national central banks at a deposit rate (r^D), which is lower than the target rate. Open market operations are then used to supply an amount of settlement cash (eOR), which the ECB estimates to clear the overnight market at the target interest rate. In practice, the target overnight rate is indicated through the average or minimum tender rate applied in weekly main refinancing operations (r^T), which have normally stayed at the middle of the band whose upper and lower bounds are set by the marginal lending rate and the deposit rate.

Figure 1. **The market for settlement balances (Euro area)**



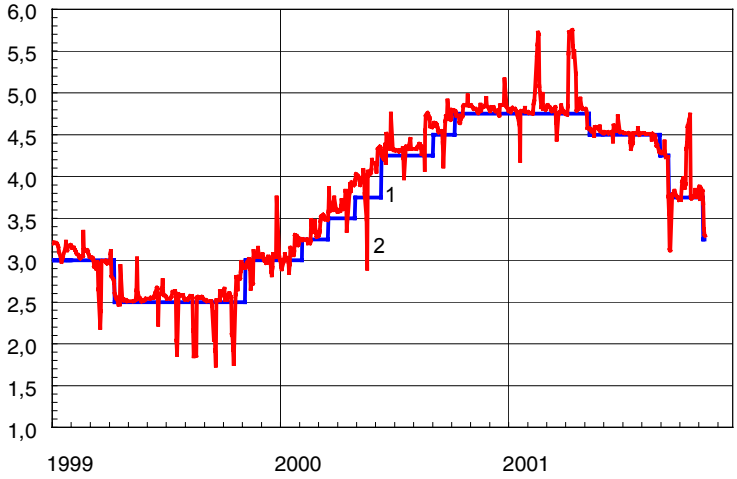
The main function of ECB reserve requirements is through averaging provisions to render the demand for reserves in the euro reserve market more interest-elastic (like D_1), whereas the demand curve tends to be relatively steep (like D_2) in a system without averaging provisions. The use of averaging provisions also allows for a relatively large width of the band between the lending rate and the deposit rate in the Euro-system framework. However, neither of these features changes

the basic functioning of the channel system. The vertical segment of the reserve supply curve (S) in Figure 1 corresponds to the ECB's settlement cash target, ie the average level of settlement cash that banks demand at the target overnight rate. In the euro reserve market, the settlement cash target has been around EUR 700 million (Bindseil and Seitz, 2001).

The theory suggests that the demand for settlement balances is a function of the location of the overnight rate relative to the marginal lending rate and deposit rate, but independent of the absolute level of these rates. Therefore, the adjustment of the level of the overnight rate by the central bank need not require any change in the supply target for settlement cash, as long as the location of the lending and deposit rates relative to the target overnight rate do not change. This result allows the Governing Council of the ECB to move market rates by changes in standing facility rates without a need to frequently modify its instructions on open market operations. Indeed, since April 1999, the ECB has applied a symmetric corridor where the deposit rate has stayed one percentage point below and the marginal lending rate one percentage point above the tender rate, ie the target overnight rate. The Governing Council has implemented interest rate policy by changing the three key central bank rates in tandem, whereas the Executive Board has run liquidity management with the aim to achieve the target amount for settlement cash.

Figure 2 demonstrates that the actual overnight rate (EONIA) has normally closely followed the ECB tender rate. However, in some periods, acute expectations of changes in central bank rates have tended to push the overnight rate apart from the prevailing tender rate. Also, unexpected shifts in reserve demand at the end of the reserve maintenance period have effected transitory changes in overnight rates. However, transitory changes in the overnight rate do not compromise the transparency of the ECB monetary policy, as they do not convey any signals on the future path of interest rates.

Figure 2. **The ECB tender rate and the overnight rate (EONIA) in the Euro money market**



1 The ECB tender rate (main refinancing rate/ minimum bid rate)
2 The overnight rate (EONIA)

Annex 3.

Payment instructions processed by selected interbank funds transfer systems in Europe

Volume of transactions (number of payments), daily average

	1999	2000	2001 (m1–m6)
TARGET			
– domestic	134312	148725	159383
– cross-border	28704	39899	44489
Euro 1 (EBA)	67895	97067	111525
EAF (Euro Access Frankfurt)	46705	51041	52238
PNS (Paris Net Settlement)	20083	21759	32172
SEPI (Servicio Espanol de Pagos Interbancarios)	4261	3837	4620

Value of transactions (EUR billions)

	1999	2000	2001 (m1–m6)
TARGET			
– domestic	565,7	602,4	751,1
– cross-border	360,0	432,2	513,2
Euro 1 (EBA)	170,8	195,0	214,9
EAF (Euro Access Frankfurt)	151,2	163,2	169,2
PNS (Paris Net Settlement)	93,1	86,0	91,4
SEPI (Servicio Espanol de Pagos Interbancarios)	3,7	1,6	1,5

BANK OF FINLAND DISCUSSION PAPERS

ISSN 0785-3572, print; ISSN 1456-6184, online

1/2001 Risto Herrala **An assessment of alternative lender of last resort schemes.** 2001. 28 p. ISBN 951-686-701-4, print; ISBN 951-686-702-2, online. (TU)

2/2001 Esa Jokivuolle – Karlo Kauko **The new basel accord: some potential implications of the new standards for credit risk.** 2001. 23 p. ISBN 951-686-703-0, print; ISBN 951-686-704-9, online. (RM)

3/2001 Mika Kortelainen **Actual and perceived monetary policy rules in a dynamic general equilibrium model of the euro area.** 2001. 76 p. ISBN 951-686-705-7, print; ISBN 951-686-706-5, online. (TU)

4/2001 Martin Ellison **Stabilisation bias in monetary policy under endogenous price stickiness.** 2001. 20 p. ISBN 951-686-707-3, print; ISBN 951-686-708-1, online. (TU)

5/2001 Erkki Koskela – Rune Stenbacka **Equilibrium unemployment with credit and labour market imperfections.** 2001. 35 p. ISBN 951-686-709-X, print; ISBN 951-686-710-3, online. (TU)

6/2001 Jarmo Pesola **The role of macroeconomic shocks in banking crises.** 2001. 61 p. ISBN 951-686.713-8, print; ISBN 951-686-714-6, online. (TU)

7/2001 Anssi Rantala **Does monetary union reduce employment?** 2001. 36 p. ISBN 951-686-715-4, print; ISBN 951-686-716-2, online. (TU)

8/2001 Tuomas Välimäki **Fixed rate tenders and the overnight money market equilibrium.** 2001. 72 p. ISBN 951-686-717-0, print; ISBN 951-686-718-9, online. (TU)

9/2001 Morten L. Bech – Kimmo Soramäki **Gridlock resolution in interbank payment systems.** 2001. 34 p. ISBN 951-686-719-7, print; ISBN 951-686-720-0, online. (RM)

10/2001 Antti Ripatti – Jouko Vilmunen **Declining labour share – Evidence of a change in the underlying production technology?** 2001. 43 p. ISBN 951-686-721-9, print; ISBN 951-686-722-7, online. (TU)

11/2001 Michael Ehrmann – Martin Ellison – Natacha Valla **Regime-dependent impulse response functions in a Markov-switching vector autoregression model.** 2001. 24 p. ISBN 951-686-723-5, print; ISBN 951-686-724-3, online. (TU)

12/2001 Jenni Koskinen **Yksityisasiakkaiden maksuliikepalvelujen hinnoittelu Suomessa.** 2001. 46 p. ISBN 951-686-725-1, print; ISBN 951-686-726-X, online. (RM)

13/2001 Nico Valckx **Factors affecting asset price expectations: fundamentals and policy variables.** 2001. 42 p. ISBN 951-686-727-8, print; ISBN 951-686-728-6, online. (TU)

14/2001 Jan Annaert – Marc J.K. DeCeuster – Nico Valckx **Financial market volatility: informative in predicting recessions.** 2001. 21 p. ISBN 951-686-729-4, print; ISBN 951-686-730-8, online. (TU)

15/2001 Esa Jokivuolle – Samu Peura **A value-at-risk approach to banks' capital buffers: An application to the new Basel Accord.** 2001. 22 p. ISBN 951-686-731-6, print; ISBN 951-686-732-4, online. (TU)

16/2001 Juha-Pekka Niinimäki **Should new or rapidly growing banks have more equity?** 2001. 36 p. ISBN 951-686-733-2, print; ISBN 951-686-734-0, online. (TU)

17/2001 David Mayes – Matti Virén **Financial conditions indexes.** 2001. 31 p. ISBN 951-686-735-9, print; ISBN 951-686-736-7, online. (TU)

18/2001 Angela Huang – Dimitri Margaritis – David Mayes **Monetary policy rules in practice: Evidence from New Zealand.** 2001. 34 p. ISBN 951-686-737-5, print; ISBN 951-686-738-3, online. (TU)

19/2001 Erkki Koskela **Labour taxation and employment in trade union models: A partial survey.** 2001. 28 p. ISBN 951-686-739-1, print; ISBN 951-686-740-5, online. (TU)

20/2001 Maria Antoinette Dimitz **Output gaps and technological progress in European Monetary Union.** 2001. 29 p. ISBN 951-686-741-3, print; ISBN 951-686-742-1, online. (TU)

21/2001 Heiko Schmiedel **Technological development and concentration of stock exchanges in Europe.** 2001. 37 p. ISBN 951-686-749-9, print; ISBN 951-686-750-2, online. (TU)

22/2001 Oz Shy – Juha Tarkka **Stock exchange alliances, access fees and competition.** 2001. 37 p. ISBN 951-686-751-0; print, ISBN 951-686-752-9, online. (TU)

23/2001 Saarenheimo Tuomas **Should unemployment benefits decrease as the unemployment spell lengthens?** 2001. 27 p. ISBN 951-686-753-7, print; ISBN 951-686-754-5, online. (KT)

24/2001 Korhonen Kari **Securities market ATSs. Concepts, their roles and related policy issues.** 2001. 69 p. ISBN 951-686-755-3, print; ISBN 951-686-756-1, online. (RM)

25/2001 Tapio Korhonen **Finnish monetary and foreign exchange policy and the changeover to the euro.** 2001. 46 p. ISBN 951-686-757-X, print; ISBN 951-686-758-8, online. (KT)

26/2001 Harri Lahdenperä **Payment and financial innovation, reserve demand and implementation of monetary policy.** 2001. 56 p. ISBN 951-686-761-8, print; ISBN 951-686-762-6, online. (TU)