Risk, cost and liquidity in alternative payment systems

For its academic workshops and projects, the Bank of England's Centre for Central Banking Studies (CCBS) invites central bankers from as wide a range of countries as possible to analyse and compare their experiences of relevant issues, in a process of learning from diversity. Each workshop is followed by a three-month project, for which three to six foreign central bankers are invited to collaborate with Bank of England staff on research related to the workshop material.

In this article, Maxwell Fry, director of the CCBS, summarises one aspect of the research conducted at the CCBS as part of its first academic workshop and project.(1) *This started with a one-week academic workshop on payment and settlement issues in January 1998, attended by participants from 22 central banks as well as international experts in the subject. After the workshop, six participants—three foreign central bankers and three Bank of England staff—assembled to plan a research programme for the ensuing ten weeks. The research built on the ideas presented at the academic workshop, as well as the specific interests of the team members. The results of the project research were first presented at a conference in March, which was co-hosted by the CCBS and the ESRC-supported Money, Macro and Finance Research Group. The project output also formed the basis for a report prepared for the Bank's 1998 Central Bank Governors' Symposium in June. Routledge will publish the final project output in April 1999.*(2)

Central bank involvement in payment systems

Central and commercial bankers now generally recognise that payment and settlement arrangements cannot simply be left for the 'back office' to sort out. In their role as the 'plumbing' of the financial and banking system, the efficiency and safety of these arrangements have become issues with wider strategic and policy implications for central banks.(3) By way of illustration, the Bank of England's mission statement specifically recognises the promotion of sound and efficient payment and settlement arrangements as an important element of the Bank's core purposes. Gerry Corrigan, former President of the Federal Reserve Bank of New York, also recognised this important role—he referred to the 'trilogy' of central banking functions and responsibilities: monetary policy, banking supervision and payment systems.

Central banks' objectives for payment systems, under both the monetary and financial stability headings, may be summarised as reducing risk and promoting efficiency in payment systems. Risk reduction is paramount, but promoting efficiency is a complementary goal. Efficiency has many dimensions, which can broadly be grouped under cost, speed and robustness. Robustness encompasses both the reliability of the service and the certainty of its effects, which may depend on the clarity of the rules or the precision of the relevant legal framework. It is perhaps obvious that efficiency is a desirable objective in its own right but, in addition, it may well be necessary to achieve the risk-reduction objective. Typically, users have a choice about whether or not they use particular systems. There is no point in developing a very safe system if nobody is prepared to use it. So the risk-reduction and efficiency objectives have to be pursued in parallel, but recognising that, while market participants may have an equal interest in the promotion of efficiency, they may not have as strong an interest in risk reduction if the private and social costs of risk differ. As a result, it is sometimes left to the central bank to highlight the risk-reduction questions.

Central banks have tended to play a more active role in payment systems since the late 1970s than in earlier years. This is largely because of rapid technological changes, dramatic growth of financial activity and the consequent enormous growth in both volumes and values of payment transactions, and the integration or globalisation of financial markets. As a result, liquidity and credit risks for central banks, commercial banks and other participants involved in payment systems have increased dramatically. Furthermore, payment systems have become a serious potential source of domestic and cross-border financial crises.

In this new environment, promoting stability and efficiency of payment systems, developing measures to reduce risk, and ensuring that payment system arrangements and

(1) The author thanks Robert Heath, Joanna Place and David Sheppard for comments and assistance on earlier drafts.
(2) Maxwell J Fry, Isaack Kilato, Sandra Roger, Krzysztof Senderowicz, David Sheppard, Francisco Solis, John Trundle, *Payment Systems in Global Perspective* (London: Routledge, 1999).
(3) Andrew Crockett (1998, page 4) points out that the Bank for International Settlements' (BIS) Committee on Payment and Settlement Systems was transformed into a senior-level body in 1990 after the growing realisation that 'payment systems were not only a technical matter, but also went to the very heart of central bank policy concerns'.

changes in such arrangements do not jeopardise monetary management have become crucial central bank objectives. The efficiency of a country's payment system is one determinant of its rate of economic growth. Here, the speed and certainty of fund transfers from the payer's account to the payee's account are the main elements.

Central banks can promote such efficiency in two primary ways—by operational involvement or via oversight. The degree to which central banks are involved in operational activities differs across countries. Nevertheless, there is a tendency for central banks to play a more active role in developing and running large-value than small-value transfer systems. Quite apart from operational involvement, however, all central banks perform some degree of payment system oversight. In some countries, this amounts to a formal regulatory role for the central bank, often involving responsibility for developing the rules for the operation of the payment system(s). In others, central bank influences are less formal, with day-to-day management of the payment system undertaken by the commercial banks. Where commercial banks have existed for centuries, central banks tend to play a more passive role than in countries that until recently possessed a 'monobanking' system.

Payment systems in industrial, transitional and developing countries

Information on payments arrangements in transitional and developing countries is scarce, and not generally available in a form suitable for comparative analysis.[1] So in January 1998, the Bank of England asked central banks in a sample of countries, hereafter referred to as the BoE group, to complete a questionnaire both to supplement published information and to supply comparative data for analytical purposes. The 70 respondent countries are listed in Table A.

These 70 countries were chosen because members of their central banks attended conferences on payment systems at the Bank for International Settlements in December 1997 or at the Bank of England in January 1998, or were invited to the Bank of England's Central Bank Governors' Symposium in June 1998.

Payment systems range from simple cash-dominated systems, as in the Seychelles, to systems involving a range of non-cash payment instruments. The key feature of each payment system is how payments are effected. In a currency-based payment system, payments are concluded by the transfer of currency notes from payer to payee; settlement takes place at the same time as the transaction, because currency represents final payment (currency constitutes 'good funds', ie legal tender or central bank money), so no clearing function is needed. Because all other payment instruments involve at least one third party, the payment process is necessarily more complicated.

Table A
The Bank of England group

Industrial	Transitional	Developing
Australia	Armenia	Bahrain
Austria	Belarus	Barbados
Belgium	Bulgaria	Bermuda
Canada	China	Botswana
Finland	Czech Republic	Brazil
France	Hungary	Colombia
Germany	Latvia	Cyprus
Greece	Poland	Eastern Caribbean
Hong Kong	Russia	Egypt
Iceland	Slovak Republic	Fiji
Italy	Slovenia	Guyana
Netherlands	Tanzania	Jordan
New Zealand	Vietnam	Kenya
Norway		Korea
Portugal		Kuwait
Singapore		Lebanon
Spain		Malawi
Sweden		Malaysia
Switzerland		Malta
United Kingdom		Mauritius
United States		Mexico
		Morocco
		Mozambique
		Namibia
		Nigeria
		Pakistan
		Peru
		Saudi Arabia
		South Africa
		Swaziland
		Tonga
		Turkey
		Uganda
		United Arab Emirates
		Zambia
		Zimbabwe

Processing of cheques, for example, involves some means of clearing; settlement takes place through correspondent balances or by transferring balances of 'good funds' in accounts held at the central bank. The same is true for all non-cash payment instruments.

An important influence on the choice of payment system is the value of the transaction. The most efficient payment system in terms of the cost/risk trade-off for transactions of \$100 may not be the same as for transactions of \$1,000,000. So discussion of alternative payment systems often distinguishes between a large-value transfer system (LVTS) and a small-value transfer system (SVTS). Virtually all LVTSs settle through accounts held at the central bank. For this reason and because LVTSs play such a crucial role in economic affairs, central banks are invariably involved directly or indirectly in their operation. This article concentrates on LVTSs rather than SVTSs.

A major design choice when developing payment systems in general, and LVTSs in particular, concerns the means by which the interbank obligations arising from the transfer of payment instructions are settled. A key distinction is that between real-time gross settlement (RTGS) and deferred net settlement (DNS). Under RTGS, payment instructions are settled individually as they are processed, across the banks' settlement accounts at the central bank. Under DNS, the process of transferring and exchanging payment instructions is separate from, and precedes, the process of settlement. Banks will periodically (often at the end-of-day) calculate their net pay/receive obligations resulting from the

(1) The BIS publishes detailed information about payment systems in the eleven G10 countries (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States), eg Bank for International Settlements (annual) and Bank for International Settlements (1993). Recently, the BIS (1998) has published case studies on payment system issues in 19 transitional and developing countries. The International Monetary Fund (IMF) has also published some useful material on payment systems in transitional and developing countries, eg Johnson *et al* (1998) and Summers (1994).

instructions exchanged during the period in question, and then settle these net amounts across their accounts at the central bank. DNS systems often operate through payment clearing houses.

Since 1980, the majority of industrial countries have adopted RTGS systems as the preferred system for large-value transfers. FedWire, introduced in 1918, was the first RTGS system; its modern version was developed in 1970. In the 1980s, the Netherlands (1985), Sweden (1986), Switzerland (1987), Germany (1987), Japan (1988) and Italy (1989) introduced RTGS systems. Since 1990, many industrial, transitional and developing countries have adopted RTGS systems. All EU countries developed euro RTGS systems linked to the EU-wide RTGS system (TARGET) before it started operations on 4 January 1999.

The BoE group uses a variety of payment systems. Four main groupings can be identified: countries with only RTGS systems; countries with only DNS systems; countries with both RTGS and DNS systems; and countries with other types of payment systems. In countries with both RTGS and DNS systems, three subcategories appear: RTGS for high-value transactions and DNS systems for retail arrangements; RTGS and DNS systems for both wholesale and retail payments; and an arrangement with two RTGS systems, where one is restricted and the other is open, operating alongside net settlement systems. In the group that has other types, the most common is gross systems with deferred batched settlements usually at the end of the day or next day, although occasionally at set times during the day. However, most respondent countries indicated that they are examining the possibility of adopting an RTGS system, mainly for large-value interbank settlement transactions. Net settlement, together with other types of settlement systems, is increasingly used for retail transactions.(1)

Table B shows that within the BoE group, 86% of the industrial countries, 46% of transitional countries and 25% of developing economies use RTGS systems.(2) The high adoption rate of RTGS systems in transitional economies reflects a number of factors: it is a logical development from the deferred gross systems that transitional economies typically possessed in the 1980s; telecommunication and computing costs have fallen worldwide; and the advantages of electronic over paper-based payment instruments are relatively greater for large countries such as China and Russia than for small countries. Preference for RTGS also partly reflects the legal complexity of netting arrangements.

Table B
Payment systems in the Bank of England group

Percentage of countries in each group

Type	Industrial	Transitional	Developing
RTGS	86	46	25
DNS	86	62	83
Other	5	38	22

All G10 countries possess at least one LVTS providing same-day final settlement. Canada uses a DNS system for this; in all other G10 countries, it is provided through RTGS systems, though in some (the United States, France and Spain), it is also provided through DNS systems or, in Germany's case, through a hybrid batched settlement system.

An analytical framework

Given the diversity of payment instruments and systems around the world, is there any analytical framework that can be applied to all countries and to all payment systems? Perhaps two universal characteristics of payment systems can be detected. To do this, one might start with some simple history:

1 Payment preceded money: barter.
2 Credit preceded money: credit barter.

In a small, static, traditional society, such as Europe in the Middle Ages or a Pacific Island before the arrival of Captain Cook, there would be no demand for a means of payment. All transactions could easily be arranged by barter exchanges or credit barter. In such a world of virtual certainty, everyone would know where to send his or her products, and when and where to collect the goods and services provided in exchange.

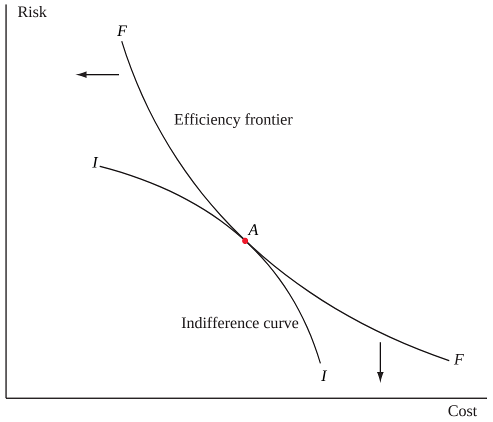
Following Charles Goodhart (1989, Chapter 2), uncertainty and transaction costs constitute the two prerequisites for a demand for money as a means of payment:

- uncertainty produces a preference for immediate rather than postponed payment; and
- transaction costs produce a preference for payment in something that is generally acceptable as a means of payment. A chain of exchanges is more costly.

Uncertainty or risk, on the one hand, and transaction costs, on the other, are still the two main considerations for payment system analysis today. This is recognised in the analytical framework presented by Allen Berger, Diana Hancock and Jeffrey Marquardt (1996). This framework adapts the standard risk-return analysis used in finance by substituting cost for return: on the efficiency frontier, lower risk in a payment system can be obtained only at a higher cost. Chart 1 shows the efficiency frontier *FF*, plotting combinations of risk and cost attached to the most efficient payment systems.(3) Efficiency is measured from a social welfare viewpoint, incorporating all costs of payers and payees, as well as externalities. In other words, efficient

(1) Large international banks have established card networks in the Czech Republic, Hungary, Korea and Saudi Arabia that service retail transactions in a variety of settlement schemes.
(2) Unfortunately, it was impossible to distinguish between LVTSs and SVTSs for this table. Most DNS systems in the industrial countries are SVTSs.
(3) An alternative but less intuitive representation would place a bundle of payment attributes on the horizontal axis, replacing return in the standard risk-return trade-off diagram. Of course, a bundle of 'goods', in contrast with the 'bad' cost attribute used here, would tilt both the efficiency frontier and the indifference curve clockwise by 90°.

Chart 1
Risk-cost trade-off along the efficiency frontier



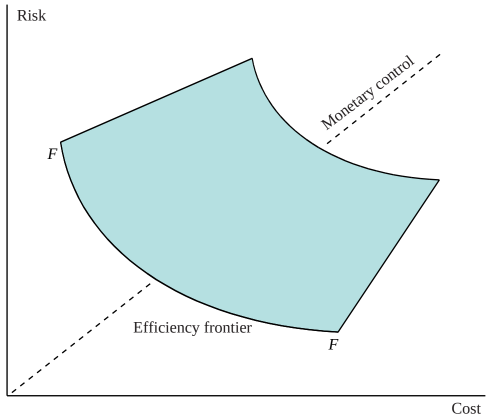
payment systems cannot reduce risk without raising cost, or reduce cost without increasing risk. Many factors (including technological, institutional and legal) determine the position and movement of the efficiency frontier. Over time, innovations in these factors may shift the efficiency frontier towards the origin, so enabling reductions in both cost and risk.

To determine the optimal payment system, Chart 1 must incorporate a social indifference curve. Society would prefer less cost and less risk, but would be indifferent between various combinations involving lower risk and higher cost. The curve *II* connects points of indifference, ie there is no preference to being located at any particular point on the curve. This curve is the social indifference curve, implying that society as a whole holds a view on its preference or trade-off between risk and cost.

When risk is high, society may be prepared to pay more per unit of risk reduction than when risk is low. In this case, the social indifference curve *II* will be convex to the origin; at relatively high risks, society is prepared to incur a relatively large cost for risk reduction, so the slope of the curve is relatively flat. But where risk is already low (towards the bottom right-hand side of Chart 1), society is prepared to incur only a small cost for further risk reduction. Indifference curves nearer the origin offer greater social welfare than indifference curves further away from the origin. So welfare is maximised at the point of tangency between an indifference curve and the efficiency frontier: it is not possible to move from point *A* to a higher indifference curve.

As with any two-dimensional representation of a complex system, Chart 1 omits several crucial factors that determine the position of the efficiency frontier in risk-cost space. For example, monetary policy techniques may affect the position of the efficiency frontier. Chart 2 depicts this in a three-dimensional diagram as a rising plane, such that greater monetary control can be obtained only at the expense of a less favourable risk-cost trade-off in the payment system. Indifference must now also be represented

Chart 2
Risk, cost and monetary control trade-off along the efficiency frontier



as a plane, in which society trades off risk, cost, and monetary control or price stability.

In reality, risk takes a variety of forms, with economic, legal, operational and security risks constituting the main categories. Efficiency also combines speed, reliability and cost. Evidently, therefore, the choice of payment system and design is multifaceted, with trade-offs possible along a number of axes.

Deferred net settlement versus real-time gross settlement

In the 1970s, payment systems in most industrial countries could be characterised as unprotected DNS systems. At that time, the United States was the only country to possess an RTGS system. Both DNS and RTGS systems were unprotected, in that payment risks, ie the various risks that payments would fail to be made, were ignored. In the DNS system, banks provided unlimited (and often unknown) implicit and unsecured credit, from receipt of payment until net settlement after clearing at the end of day or beginning of the next day. In the United States, the Federal Reserve System provided unlimited, free and unsecured intraday credit to all users of FedWire. So in theory, payment risk is borne by the commercial banks in a DNS system, but by the central bank in an unprotected RTGS system. In practice, however, failure in a DNS system may be so severe that the central bank is obliged to bail out banks viewed as too big to fail. In this case, the central bank absorbs part of the risk and, if such action is anticipated, creates a moral hazard in so doing.

Using Robert Lindley's (1998) analysis, a simple but unsatisfactory net settlement system involves:

- end-of-day clearing (or next morning for convenience);
- settlement of net balances through deposits at the central bank (ie with good funds);
- no limits or caps on transfers;
- no collateral or loss-sharing rules;

- weak or non-existent legal basis for netting (creating a potential 'unwind' problem);[1] and
- poor visibility of risk exposures.

In such a simple system, commercial banks provide implicit credit, which is unlimited and unsecured.

A simple RTGS system involves:

- continuous settlement across accounts at the central bank;
- unlimited unsecured intraday liquidity from the central bank; and
- finality.

An RTGS system is a prerequisite for genuine delivery versus payment (DVP) for securities market transactions and payment versus payment (PVP) in foreign exchange transactions. But RTGS systems require more liquidity to settle continuous streams of gross payments. To encourage their adoption, central banks may provide this extra liquidity at what appears to be a subsidised price.

There is a perception that the central bank has a preference for a safe but expensive system, whereas commercial banks prefer a cheaper but riskier system. In terms of the risk-cost trade-off diagram used earlier (see Chart 1), these preferences are illustrated in Chart 3, where I_c is the indifference curve between cost and risk for commercial banks and I_b is the indifference curve for the central bank. In this case, commercial banks prefer point *C*, with greater risk and lower cost, to position *B*, preferred by the central bank. In some countries, the central bank may impose its preference by dictating a maximum acceptable degree of risk.

Chart 3
Different central and commercial bank preferences in terms of risk-cost trade-offs

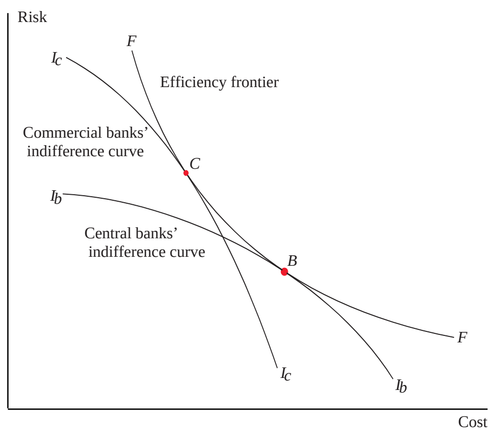
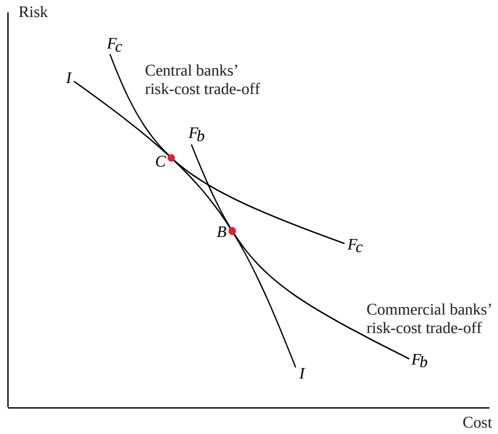


Chart 4 illustrates an alternative explanation for different choices of commercial and central banks. In this case, commercial and central banks have the same indifference curve, but commercial banks face a different risk-cost trade-off F_c from that of the central bank, F_b. In other words, private and social costs differ in Chart 4. Commercial banks still prefer point *C* to *B*, the point preferred by the central bank, but the reason lies not in innate preference towards risk but in some form of price distortion.

Chart 4
Preferences in terms of different central and commercial bank risk-cost trade-offs



Lindley (1998) questions whether the crucial difference between DNS and RTGS lies in a trade-off between 'safe but expensive' and 'cheaper but riskier'. He argues that the key choice lies in the type of RTGS system adopted, basing his case on the observation that liquidity needs in net and gross systems are identical. Table C illustrates a sequence of payments during the day between bank *A* and bank *B*. By the fourth payment, bank *A*'s payments to bank *B* have exceeded bank *B*'s payments to bank *A* by 6. This sequence can occur in either DNS or RTGS systems. The type but not the amount of intraday liquidity differs. If this sequence occurred in a DNS system, bank *B* would provide liquidity to bank *A* in the form of implicit and free credit. In a protected DNS system, liquidity is provided free but some collateral must be posted. If it is provided at all in an RTGS system, liquidity is invariably provided explicitly by the central bank. The cost of such liquidity depends on reserve requirements, interest on reserve balances, collateral requirements and any interest charged on intraday credit facilities.

Table C
Daily payment sequence between bank *A* and bank *B*

Sequence	*A* to *B*	*B* to *A*	*A*'s balance	*B*'s balance
1	3		-3	+3
2	2		-5	+5
3		1	-4	+4
4	2		-6	+6
5		2	-4	+4
6		4	0	0

Maximum overdraft: 6; average overdraft: 3.8.

Risk is generally harder to control with implicit credit than explicit credit arrangements. Indeed, the provision of implicit credit may be unrecognised, or at least unknown.

(1) An unwind involves a recalculation of the net settlement figures, eliminating any payment orders sent or received by a participant that has failed—thereby producing a brand-new set of net settlement positions for the surviving participant.

In a paper-based debit transfer system, for example, the net amount of intraday credit provided between banks cannot be known: though bank *A* may know how much it is owed by bank *B*, it cannot know until clearing how much it owes to bank *B*. So the provision of free implicit credit is an inevitable component of such a netting system. But if commercial banks are willing to provide intraday free credit in a DNS system, why are they unwilling to do so when operating in an RTGS system, if the central bank declines to provide it?

The Swiss National Bank does not provide any intraday liquidity for its RTGS system—Swiss Interbank Clearing (SIC). The commercial banks are unwilling to provide intraday liquidity, so the lack of liquidity produces payment queues. Payment instructions submitted to SIC are executed only if the bank has sufficient funds. Otherwise, the payment instruction is queued and can be delayed for several hours. Such delays inevitably introduce settlement risk for some party to the transaction, so destroying one of the main virtues of RTGS. At the end of each day, remaining payment instructions incur a penalty and are cancelled. The alternative is for the commercial banks to obtain overnight credit from the Swiss National Bank at 2% above the market rate.

One solution to this liquidity shortage problem lies in payment management. With payments that require only a specific date (value date) but not a specific time for the settlement, Table D shows that payment prioritisation/queue management can reduce liquidity needs. In this case, which uses the same set of payments as in Table B, bank *A* needs a balance of 3 rather than the balance of 6 that was required in the previous example, where there was no queue management.

Table D
Daily payment sequence between bank *A* and bank *B* with queue management

Sequence	*A* to *B*	*B* to *A*	*A*'s balance	*B*'s balance
2	2		-2	+2
5		2	0	0
1	3		-3	+3
6		4	+1	-1
4	2		-1	+1
3		1	0	0

Maximum overdraft: 3; average overdraft: 1.2.

Another apparently obvious solution is for bank *B* to provide intraday credit to bank *A*. It does so implicity in the DNS system, so why is it so unwilling to do so explicity in the RTGS system? Why is the preferred solution to delay payments in RTGS systems without central bank liquidity, eg in SIC? One answer may lie in the open access to most RTGS systems, as opposed to the closed access in many high-value DNS systems. For example, there are more than 10,000 participants in FedWire and more than 5,000 in Germany's ELS system, but there are only 16 direct settlement banks in both New York's Clearing House Interbank Payments System (CHIPS) and London's Clearing House Automated Payment System (CHAPS).(1)

So monitoring of each counterparty's creditworthiness is impossible in the American and German RTGS systems, but feasible in both CHAPS and CHIPS. While restrictive membership criteria facilitate risk management, if all settlement members are too big to fail, the DNS system acquires the ultimate risk protection of the central bank. So one argument in favour of an RTGS system is that it reduces moral hazard and so improves incentives to monitor counterparty risk. An RTGS system can enhance credibility of the central bank's claim that no bank is too big to fail: failure of even the biggest bank in an RTGS system has no direct implications in terms of credit risk for any other participant.

According to Lindley (1998), RTGS is superior to DNS because:

- it keeps the payment system simple;
- it separates the payment process from liquidity provision; and
- the form of liquidity provided (central bank balances, central bank credit, explicit interbank credit) depends on central bank and market preferences.

Schoenmaker (1995) reaches the opposite conclusion, because he assumes that the social costs of liquidity are positive and substantial. However, if a central bank satiates the payment system with liquid assets that banks have to hold for prudential purposes (as in the United Kingdom), this cost evaporates. In this case, the central bank ensures that eligible liquid assets produce the same risk-adjusted yield as all other assets.

Liquidity is economised in a DNS system through the substitution of credit for immediate settlement. A typical large-value net payment system accomplishes $100 in payments for a deferred settlement in 'good funds' of $1. Immediate settlement incurs the opportunity cost of holding larger reserve balances (Goodfriend 1990, page 10). So one way of counteracting commercial banks' reluctance to use a liquidity-intensive RTGS system is for the central bank to subsidise liquidity. As Mark Flannery (1996, page 807) points out, subsidising transaction costs reduces social welfare.

Flannery's (1996) case against subsidising transaction costs because it reduces social welfare does not hold if private costs of transactions exceed their social costs. Scott Freeman (1996) shows that welfare is maximised when liquidity constraints in a payment system are eliminated through central bank provision of an elastic currency:

'the monetary authority must temporarily supply enough currency to clear all debts at par [a condition that would not

(1) CHAPS evolved from a DNS to an RTGS system in April 1996.

occur under liquidity constraints]. This temporary injection of fiat money may take the form of a discount window offering central-bank loans equal to the nominal amount of debt presented to it. Once all debts are cleared, the optimal rediscounting policy requires that the central-bank loans be repaid with fiat money, which is then removed from circulation in order to return the fiat-money stock to its initial level, thereby maintaining a constant price level' (Freeman 1996, page 1,127).

'Fiat money is needed both to purchase goods and to repay debt. As a result, the real stock of currency, determined by the demand for money to purchase goods, may be insufficient to permit the unconstrained clearing of credit markets. The selling of debt at a discount indicates a nonoptimal equilibrium. The model of this paper therefore suggests that the optimal central-bank policy includes the elastic provision of a stock of fiat money. Central-bank loans that temporarily increase the stock of central-bank money permit the clearing of debt at par (or at its risk-adjusted price), thus restoring economic efficiency. Therefore, the two roles of money require two distinct central-bank policies: the central bank must not only choose the end-of-period fiat money stock but must also provide within-period central-bank loans sufficient for the clearing of debt unconstrained by a need for liquidity'. (Freeman 1996, pages 1,137–38.)

This finding resembles Milton Friedman's (1969) optimum quantity of money. His basic argument is that, because the marginal cost of increasing the real quantity of money is virtually zero, welfare is maximised when real money balances are provided up to the point of satiety. The optimum real quantity of money is that which makes the marginal benefit equal to the zero marginal cost. From the social welfare viewpoint, too much is consumed if private costs fall below social costs, and too little if private costs exceed social costs. The optimum quantity of money, ie the quantity at which private and social costs are equated at zero, can be achieved by engineering a continuous decrease in the price level. This deflation should reduce the nominal interest rate to zero. Alternatively, the central bank could pay the risk-adjusted nominal interest rate on money balances (Howitt 1992, pages 81–3). In the case of intraday liquidity, the optimal arrangement from the social welfare perspective is to eliminate liquidity constraints through central bank provision of an elastic supply of liquidity. Then banks will satiate their desire for liquidity for payment purposes, because the opportunity cost of holding such liquidity is zero.[1]

For protection against payment risk, the prudential requirements in terms of liquid asset ratios are similar for both RTGS and DNS systems; payment risks are certainly no greater in an RTGS system than in a DNS system. An RTGS system spreads risk more evenly over the day than a DNS system, which bunches risk at the end of the day.

The form in which liquid assets are held against payment risk is irrelevant, ie they serve the same purpose whether they are held as Treasury bills or balances in accounts at the central bank. Since the introduction of the United Kingdom's RTGS system in April 1996, the Bank of England has used repurchase agreements (repos) to convert banks' liquid assets into payment balances every morning. The Bank sells the assets back to the commercial banks at the same price at the end of the day. In other words, the Bank's intraday interest rate is zero. Because banks must hold these liquid assets for prudential purposes under any alternative payment system arrangements, these intraday balances acquired through intraday repos with the Bank of England incur no additional opportunity costs to satisfy the higher liquidity demands of the RTGS system. In fact, they are well in excess of any likely liquidity needs. Though holding liquid assets for prudential purposes is not costless, what is costless is the extra liquidity requirement of the RTGS environment. So the United Kingdom follows the theoretical precepts of Friedman and Freeman in terms of providing costless liquidity for intraday payment purposes.

An alternative way to deal with this central bank payment risk exposure is to substitute an insurance premium for a liquid asset ratio requirement. Private and social costs of liquidity can still be equated at zero through a zero intraday interest rate. Then a risk premium can be charged appropriately for the risk incurred by the central bank in its provision of intraday liquidity. In effect, this is the Federal Reserve's approach in charging a small fixed interest rate for intraday overdrafts. This interest rate can be considered the risk premium over a zero rate for risk-free intraday liquidity.

No discussion of intraday liquidity provision is complete without some mention of the possibility of a spillover of intraday payment system credit into overnight credit, and the potential effect of such an event on overall monetary conditions. Among central bankers, it is generally accepted that (a) explicit provision of secured intraday credit to RTGS systems is a 'good thing' on payment system efficiency grounds, and (b) despite the potential for spillover, central banks can introduce safeguards such that, on the rare occasions when it does occur, the effect is negligible. In other words, intraday and overnight/interday markets can be effectively segmented by, for example, imposing an early cut-off time for customer payments (so that banks can use the last period before the payment system closes to square their positions) and a penal regime for any 'spillover' lending. So monetary policy can still operate effectively in the context of end-of-day balances and overnight (or longer) interest rates (Dale and Rossi 1996).

The spillover issue has featured prominently in discussions about the terms on which the United Kingdom and the other 'out' countries not adopting the euro from 4 January 1999

(1) See also Bengt Holmström and Jean Tirole (1998).

can connect to the Trans-European Automated Real-time Gross settlement Express Transfer system (TARGET) euro payment system. The TARGET system has been designed with the twin objectives of supporting the single monetary policy in the euro area and of providing a sound and efficient same-day payment mechanism across the whole European Union. It is essentially made up of interlinked national RTGS systems, and so its efficiency relies on the provision of sufficient intraday credit. Despite the conclusions reached in the previous paragraph, however, there was a reluctance on the part of a number of the 'in' countries to extend intraday euro credit to 'out' countries such as the United Kingdom, because of a perceived risk of such credit spilling over into overnight credit and so affecting monetary conditions in the European Monetary Union (EMU) area. Fortunately, a practical solution to this issue was reached that both supported the TARGET system's need for adequate intraday credit and avoided the perceived risks to the EMU area's monetary policy stance.

Conclusion

Because the existence of money depends on the existence of uncertainty and transaction costs, a useful framework for analysing payment systems is a variant of the risk-return paradigm used in finance. With cost substituting for return, an efficient payment system can only reduce risk at an increased cost. Where private and social costs diverge, as they do in the case of costly liquidity, central banks can improve social welfare by reducing the cost of liquidity to zero.

Once costs of risk and costs of liquidity are distinguished, the socially optimum strategy appears to be one of providing unlimited intraday liquidity at zero cost, but charging a risk premium assessed on each borrower based on standard actuarial principles. This can be achieved either by prudential ratio requirements set on the basis of the payment risk created by each bank, or by assessing an insurance premium on users of the payment system.

References

Bank for International Settlements (annual), *Statistics on Payment Systems in the Group of Ten Countries* (Basle: Bank for International Settlements).

Bank for International Settlements (1993), *Payment Systems in the Group of Ten Countries* (Basle: Bank for International Settlements).

Bank for International Settlements (1998), *Managing Change in Payment Systems* (Basle: Bank for International Settlements, BIS Policy Papers 4, May).

Berger, A, Hancock, D and Marquardt, J (1996), 'A Framework for Analyzing Efficiency, Risks, Costs, and Innovations in the Payments System,' *Journal of Money, Credit and Banking*, 28(4, ii), November, pages 696–732.

Crockett, A (1998), welcoming presentation in 'Managing change in payment systems,' Basle: Bank for International Settlements, BIS Policy Papers 4, May, pages 1–8.

Dale, S and Rossi, M (1996), 'A market for intra-day funds: does it have implications for monetary policy?, *Bank of England Working Paper No 46*, March.

Flannery, M J (1996), 'Financial Crises, Payment System Problems, and Discount Window Lending,' *Journal of Money, Credit and Banking*, 28(4, ii), November, pages 804–24.

Freeman, S (1996), 'The Payments System, Liquidity, and Rediscounting,' *American Economic Review*, 86(5), December, pages 1,126–138.

Friedman, M (1969), *The Optimum Quantity of Money and Other Essays* (Chicago: Aldine).

Goodfriend, M (1990), 'Money, Credit, Banking, and Payment System Policy' in *The US Payment System: Efficiency, Risk and the Role of the Federal Reserve*, edited by David B Humphrey (Boston: Kluwer Academic Publishers), pages 247–84.

Goodhart, C A E (1989), *Money, Information and Uncertainty*, 2nd edn (Basingstoke: Macmillan).

Holmström, B and Tirole, J (1998), 'Private and Public Supply of Liquidity,' *Journal of Political Economy*, 106(1), February, pages 1–40.

Howitt, P (1992), 'Optimum Quantity of Money' in *The New Palgrave Dictionary of Money and Finance*, edited by Peter Newman, Murray Milgate and John Eatwell (London: Macmillan), pages 81–3.

Johnson, O E G, Abrams, R K, Destresse, J-M, Lybek, T, Roberts, N M and Swinburne, M (1998), 'Payment Systems, Monetary Policy, and the Role of the Central Bank', (Washington, DC: International Monetary Fund).

Lindley, R (1998), 'RTGS versus DNS: The Wrong Debate?', (London: Bank of England, Centre for Central Banking Studies, Paper prepared for the Academic Workshop on Payment and Settlement Systems, 12–16 January).

Schoenmaker, D (1995), 'A Comparison of Alternative Interbank Settlement Systems' (London: London School of Economics, *LSE Financial Markets Group Discussion Paper 204*, March).

Summers, B J, ed (1994), *The Payment System: Design, Management, and Supervision* (Washington, DC: International Monetary Fund).